University of Agronomic Sciences
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Faculty of Land Reclamation
and Environmental Engineering

SCIENTIFIC PAPERS

Series E

LAND RECLAMATION, EARTH OBSERVATION & SURVEYING, ENVIRONMENTAL ENGINEERING

Volume IX

2020
BUCHAREST

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PUBLISHERS:
University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania - Faculty of Land Reclamation and Environmetal Engineering
Address: 5 9 Marasti Blvd., District l, Zip code 011464 Bucharest, Romania
Phone: + 40 213 1830 75, E-mail: conference@fifim.ro, Webpage: www.fifim.ro

CERES Publishing House
Address: 29 Oastei Street, District 1, Bucharest, Romania
Phone: + 40 21 317 90 23, E-mail: edituraceres@yahoo.com, Webpage: www.editura-ceres.ro

To be cited: Scientific Papers. Series E. LAND RECLAMATION, EARTH OBSERVATION & SURVEYING, ENVIRONMENTAL ENGINEERING, Vol. IX, 2020

Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

International Database Indexing:
Web of Science Core Collection (Emerging Sources Citation Index)
Index Copernicus; Ulrich's Periodical Directory (ProQuest); PNB (Polish Scholarly Bibliography); Scientific Indexing Service; Cite Factor (Academic Scientific Journals) Scipio; OCLC; Research Bible

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

HEAVY METAL EVALUATION IN THE LOWER SECTOR OF DANUBE RIVER

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Abstract

Danube River is considered one of the most important European rivers and it flows for a total distance of 2,860 km. The river plays an important role in activities such as transport and commercial fishing, which makes it permanently subjected to anthropogenic pressures. Metals are the main pollutants in Danube River and most of the pollution sources in the basin are found in Romania. The aim of the study was to evaluate water quality of Danube River Lower Sector in terms of heavy metals concentration (Cd, Pb, Ni, Cu, Fe, Zn) and to evaluate the environmental risk assessment, by calculating the pollution index for each analysed metal. Water samples were collected from the lower sector of Danube River, at river kilometres 150 and 170. The main conclusion of this research is that Danube River water in the lower sector is classified as a class I in the national quality ranking of surface waters in case of Zn, Cu, Ni, Pb, Cd concentrations, except for Fe concentration that classified Danube River water as a class V in the ranking.

Key words*: Danube River, heavy metals, pollution, water quality.*

INTRODUCTION

Danube River is considered one of the most important European rivers, being the second largest river in Europe. Thus, it is subjected to anthropogenic pressures caused by the large quantities of waste water introduced into the water column (Ilie et al., 2014; Milanov et al., 2016; Subotic et al., 2013). Danube flows for a total distance of 2,860 km and it plays an important role in activities such as transport and commercial fishing, which makes it permanently subjected to natural and anthropogenic pressures (Milanov et al., 2016; Gasparotti, 2014). The pollution along the Danube is determined by the following: point sources (municipal, industrial and agricultural), diffuse sources (agricultural and agglomerations), effects of modifying the water flow regime through abstraction or regulation, morphological changes (Gasparotti, 2014). One of the most important factors affecting the water quality in the Danube river basin is the pollution with hazardous substances (Gasparotti, 2014). Most of the pollution sources in the Danube river basin are found in Romania (125), followed at a great distance by Bulgaria (41), Hungary (36) and Croatia (36) (Gasparotti 2014). Metals are considered to be among the main pollutants in Danube River in Serbia, especially in the area of Belgrade and Novi Sad. The Tisa River, the second tributary of the Danube River, is also contaminated by numerous industrial accidents in the Carpathian mountain region of Romania, which has a long tradition in mining, especially gold (Au), silver (Ag), lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd) and manganese (Mn) (Miloskovic et al., 2016).

Metallic or metalloid ions pollution is a major environmental burden due to their flexibility, accumulation, non-biodegrability and endurance (Femina Carolin et al., 2017). In 2004, the amount of lead and zinc directly discharged in Danube River was 138 t/year, respectively 171 t/year (Dobrogea Waters Administration Administrative Basin, 2010). Transport activities are important sources of oil pollution and are the main source of lead in the Danube and its tributaries (Gasparotti, 2014). As well, intensive agricultural activities can act as a diffuse source of heavy metal pollution and can generate potentially toxic elements through the excessive use of agrochemicals substances

and fertilizers (Mico et al., 2006; Shan et al., 2013; Karishma et al., 2014; Ning et al., 2017; Shi et al., 2018).
Several studies have been conducted regarding heavy metal concentration in different components of Danube River (Visnjic-Jeftic et al., 2010; Ionita et al., 2014; Zrncic et al., 2013; Milanov et al., 2016; Subotic et al., 2013; Miloskovic et al., 2016; Jaric et al., 2011, Gati et al., 2013; Ionescu et al., 2014; Ilie et al., 2017; Ilie et al., 2014) but given the fact that the river is continuously subjected to anthropogenic pressures, constant monitoring is necessary. Therefore, the aim of the study was to evaluate water quality of Danube River Lower Sector in terms of heavy metals (Cd, Pb, Ni, Cu, Fe, Zn) in the water component.

MATERIALS AND METHODS

Sampling was conducted in the lower sector of Danube River, at river kilometer 150 (Galati city) - S1 and river kilometer 170 (Braila city) - S2 (Figure 1). In Galati city, water samples were collected from Danube River between coordinates 45.438301, 28.084317 - 45.418906, 28.044748. In Braila city water samples were collected between coordinates 45.270364, 27.983139 - 45.251696, 27.969320. Both cities carry out intensive riverine transport and dockyard activities along the water course. Gasparotti (2014) mentioned that the pollution point sources discharges are higher in the lower sector compared to the upper Danube region.

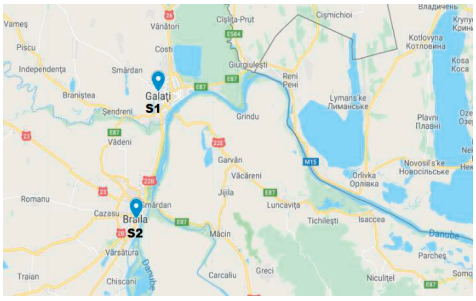

Figure 1. Sampling locations (source maps.google.com)

A total number of 50 water samples were collected, according to SR ISO 5667-6/1998, during spring season (April-May) 2018. Each station was divided into 25 collection points along the station and the water samples were collected from center of the river course, at a depth of 0.5 m.
The water samples were collected in 50 ml decontaminated polyethylene flasks and acidified in situ with 200 µl HNO_3 Suprapur 65% and analysed within the Ecotoxicology Laboratory, "Alexandru Ioan Cuza" University of Iasi, Faculty of Biology. Parameters such as temperature (T°C), dissolved oxygen (DO) and pH were measured in situ, using the WTW multiparameter portable set.
Water samples were filtered with ashes filter paper (70 mm diameter) for quantitative analysis and mineralized with HNO_3 Suprapur.
The method was described by Strungaru et al. (2015). The measurements of Zn and Fe were carried out with flame atomic absorption spectrometer GBC Avanta Australia and for the quantification of Cu, Cd, Pb, Ni the atomic absorption spectrometer, with continuum source of high-resolution, graphite furnace with platform (HR-CS-GF-AAS) ContrAA 600 model, Analytic Jena Germany, was used.
The results were compared with the present national legislation (Ord. 161/2006) in terms of quality classification of surface water (Table 1).

Table 1. Classification of surface waters, according to Ord. 161/2006 (µg L^{-1})

Quality class	Fe	Zn	Cu	Ni	Pb	Cd
I	0.3	100	29	10	5	0.5
II	0.5	200	30	25	10	1
III	1	500	50	50	25	2
IV	2	1000	100	100	50	5
V	higher values than class IV					

As well, in order to evaluate the environmental risk assessment, the pollution index (PI) was determined for each analysed element, following the formula:

$$PI = \frac{\sqrt{\left(\frac{C_i}{S_i}\right)^2_{max} + \left(\frac{C_i}{S_i}\right)^2_{min}}}{2}$$

where:

- PI = Pollution Index;
- C_i = Measured Value;
- S_i = Standard Value.

Evaluation of PI is as it follows: PI < 1: no effect, PI < 2: slightly affected, PI < 3:

moderately affected, PI < 5: strongly affected, PI > 5: seriously affected (Al-Hussaini et al., 2018).

Statistical analysis was performed by using Origin Pro Software. In order to evaluate the normality of data distribution, Kolmogorov-Smirnov normality was performed, followed by the variance test One-Way Anova and Tukey test.

RESULTS AND DISCUSSIONS

The variations of physio-chemical parameters between sampling stations are represented in Table 2 (mean values ± SD). The differences between the registered values in S1 and S2, in case of temperature and pH were not significant ($p > 0.05$).

Table 2. Registered values for water physio-chemical parameters

Location	pH	DO	T°C
S1	7.92 ± 0.19	7.11 ± 0.15	19.08 ± 1.67
S2	7.88 ± 0.14	7.32 ± 0.13	18.55 ± 1.56

In case of DO, the differences of the recorded values between S1 and S2 were significant ($p < 0.05$), with higher mean values in S2.

In case of Cd concentration (Figure 2) in water samples, the values had a normal distribution in both S1 and S2 ($p = 0.9780$, respectively $p = 0.7101$), with mean values of 0.243 ± 0.03 μgL^{-1}, respectively 0.158 ± 0.02 μgL^{-1}.

The variance test revealed significant differences ($p > 0.05$) in Cd concentration between S1 and S2, registering higher values in S1.

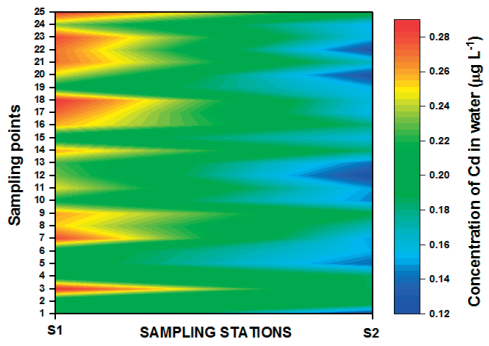

Figure 2. Concentration of Cd in sampling area

Nevertheless, the mean values for Cd concentration in S1 and S2 were lower compared to the maximum established concentration of Cd for quality class I waters by the present national legislation.

In case of Pb concentration (Figure 3) in water samples, the values had a normal distribution in both S1 and S2 ($p = 0.3727$, respectively $p = 1$), with mean values of 3.67 ± 0.11 μgL^{-1}, respectively 2.76 ± 0.14 μgL^{-1}.

The variance test revealed significant differences ($p > 0.05$) in Pb concentration between S1 and S2, registering higher values in S1. Nevertheless, the mean values for Pb concentration in S1 and S2 were lower compared to the maximum established concentration of Pb for quality class I waters by the present national legislation.

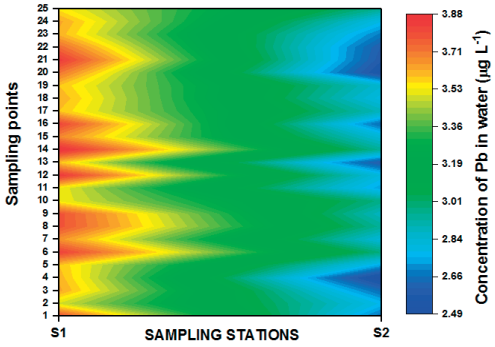

Figure 3. Concentration of Pb in sampling area

In case of Ni concentration (Figure 4) in water samples, the values had a normal distribution in both S1 and S2 ($p = 0.6687$, respectively $p = 1$), with mean values of 7.20 ± 0.57 μgL^{-1}, respectively 5.65 ± 0.83 μgL^{-1}. The variance test revealed significant differences ($p > 0.05$) in Ni concentration between S1 and S2, registering higher values in S1.

Nevertheless, the mean values for Ni concentration in S1 and S2 were lower compared to the maximum established concentration for Ni for quality class I waters by the present national legislation.

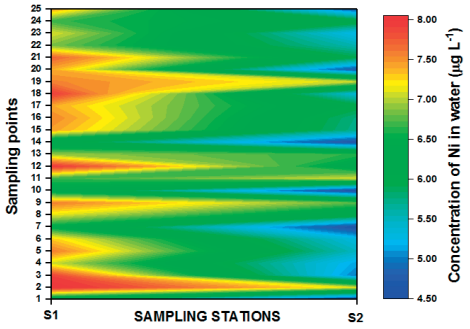

Figure 4. Concentration of Ni in sampling area

In case of Cu concentration (Figure 5) in water samples, the values had a normal distribution in both S1 and S2 ($p = 0.5959$, respectively $p = 1$), with mean values of 5.70 ± 0.65 μgL^{-1}, respectively 9.59 ± 1.05 μgL^{-1}. The variance test revealed significant differences ($p > 0.05$) in Cu concentration between S1 and S2, registering higher values in S2. Nevertheless, the mean values for Cu concentration in S1 and S2 were lower compared to the maximum established
concentration for Cu for class I waters by the present national legislation.

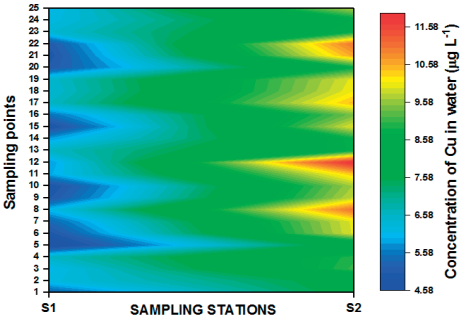

Figure 5. Concentration of Cu in sampling area

In case of Fe concentration (Figure 6) in water samples, the values had a normal distribution in both S1 and S2 ($p = 0.9100$, respectively $p = 1$), with mean values of 722.65 ± 149.39 μgL^{-1}, respectively 1244.68 ± 131.15 μgL^{-1}. The variance test revealed significant differences ($p > 0.05$) in Fe concentration between S1 and S2, registering higher values in S2. The mean registered values for Fe concentration in S1 and S2 assigned the water in the quality class number 5.

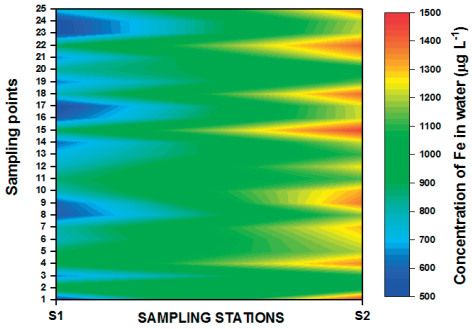

Figure 6. Concentration of Fe in sampling area

In case of Zn concentration (Figure 7) in the water samples, the values had a normal distribution in both S1 and S2 ($p = 1$, respectively $p = 0.5340$), with mean values of 16.27 ± 3.59 μgL^{-1}, respectively 38.90 ± 3.22 $\mu g L^{-1}$. The variance test revealed significant differences ($p > 0.05$) in Zn concentration between S1 and S2, registering higher values in S2. Nevertheless, the mean values for Zn concentration in S1 and S2 were lower compared to the maximum established concentration for Zn for class I waters by the present national legislation.

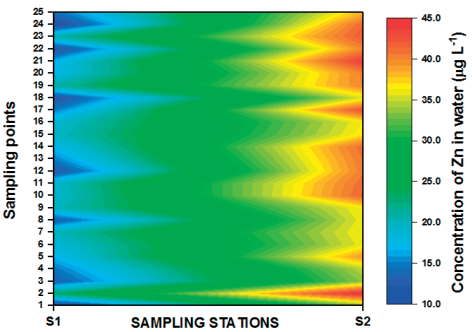

Figure 7. Concentration of Zn in sampling area

From the evaluation of PI (Table 3), it was observed that the values recorded for the concentration of all analysed metals had no effect ($PI < 1$) on both sampling sites, except for Fe concentration, which seriously affected ($PI > 5$) the water of Danube River in both sampling sites (S1 and S2). Similar results regarding the concerning values for Fe concentrations in Danube River water were reported by Enache et al. (2009) in Braila city.

Table 3. Pollution Index evaluation of each metal

Location	Pollution Index (PI)					
	Cd	Pb	Ni	Cu	Fe	Zn
S1	0.3	0.5	0.5	0.1	1863	0.1
S2	0.2	0.4	0.4	0.2	3004	0.3

The accumulation trend of metals in Danube River, lower sector, was as it follows: Fe>Zn>Ni>Cu>Pb>Cd.

Cd, Pb and Ni concentrations recorded the highest values in S1 (Galati city). This can be attributed by the anthropogenic pressure exercised by the dockyard situated on the river bank.

In case of Cu, Fe and Zn concentrations, the recorded values were highest in S2 (Braila city). This can be attributed to the intensive agricultural farming activities conducted in the Small Island of Braila located upstream the sampling area. According to Mico et al. (2006), Cu is released by the use of fungicidal substances, specific to agricultural activities, and also, by the use of copper sulphat, used as algaecide for the irrigation channels. Peng et al. (2019) mentioned that 75% of the Cu concentration in agricultural soils comes from the use of natural manure. As well, high amounts of Zn can be generated by the use of phosphate fertilizers (Mico et al., 2006).

CONCLUSIONS

The main conclusion of this research is that Danube River water in the lower sector is classified as a class I in the national quality ranking of surface waters in case of Zn, Cu, Ni, Pb, Cd concentrations, except for Fe concentration that classified Danube River water as a class V in the ranking.

Fe was the most abundant metallic element in both sampling sites of Danube River water and Cd was the least abundant.

This paper can contribute for the development of different sustainable management plans in water pollution.

Further research is needed in order to assess the possible impact of agriculture, in terms of heavy metals, on river systems.

ACKNOWLEDGEMENTS

The authors are grateful for the technical support offered by MoRAS through the Grant POSCCE ID 1815, cod SMIS 48745 (www.moras.ugal.ro).

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

AN ENERGY EFFICIENCY PROJECT FOR A GLASS GREENHOUSE

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Abstract

Increasing energy efficiency and reducing greenhouse gases is a central issue in the European energy strategy. The challenge of significantly reducing in primary energy consumption is great. It can only be achieved if we all work together and share good experiences and practices. Vegetables are undoubtedly one of the healthiest foods with high energy content. They are rich in amino acids, easily digestible sugars, enzymes, minerals, vitamins, chlorophyll, organic water and other nutrients. Therefore, the production of fresh vegetables is a vital necessity, even in winter. Naturally, winter production of vegetables requires that they be grown in heated greenhouses. Energy costs for greenhouse heating and ventilation form a significant share of their total production costs. The purpose of this paper is to identify the incoming and outgoing energy flows from a glass greenhouse for vegetables production and to propose a methodology for defining the energy for the greenhouse heating while providing the necessary parameters of the environment for fresh vegetables growing.

Key words*: energy consumption, glass greenhouses, microclimate, vegetables.*

INTRODUCTION

A global warming becomes too serious problem recently. Because of the need for urgent actions to combat climate change, the European Council supports the goal of achieving the climate-neutral EU by 2050, in line with the Paris Agreement. However, achieving climate neutrality will require overcoming serious challenges and considerable investments. The European Council recognizes the need to ensure energy security and respects the right of Member States to choose the most appropriate energy technologies (European Council meeting, 2019).

Europe's energy policy forms part of the overall objectives of the EU's economic policy. The starting points of the European energy policy are three: limiting climate change, promoting growth and jobs, and limiting EU dependence on imported natural gas and petroleum products. European policy is geared towards ensuring security of energy supply and introducing an integrated approach to energy efficiency. Energy saving is the most direct and economically effective way to address these energy challenges (energy strategy 2030; www.seea.government.bg). That is why the Bulgarian national policy follows the priorities and the long-term goals of the European policy for sustainable energy development (*Law of energetics*; *Law on energy efficiency*).

The sector of greenhouse farming in the EU faces a trend that meets the changing needs of consumers in society. This global trend is having a negative impact - high demand for fossil fuels, increasing energy consumption and carbon dioxide emissions (Bibbiani et al., 2016).

Greenhouses are the commonly used systems for growing plants under cold climatic conditions. In winter months when the agricultural production cannot be climatically performed, plants are cultivated under optimal conditions set up in greenhouses. Greenhouse cultivation, in this respect, has an important function for the agricultural economy. Nevertheless, under the climatic conditions with low daylight and night temperatures, the greenhouses are heated up by means of commercial heating systems. Apart from the installation and labor costs, such as the covering and construction materials, greenhouse heating comprises the major operational expenses (Başak & Sevilgen, 2016).

Heating provides many other benefits besides its positive influence on productivity, earliness and quality. It is much easier to control high humidity, which is the primary cause of plant

diseases, in heated greenhouses than in unheated ones (Baytorun & Zaimoğlu, 2016).
In order to improve the energy efficiency of the greenhouse, it is important to predict its energy consumption (Shen et al., 2018).
The thermal energy requirement of a greenhouse depends on many factors as the solar radiation, the inside and outside air temperature, the wind speed, the soil temperature, the greenhouse area, the geometry and orientation, the thermal proprieties of covering materials, the air ventilation and loss, and so on (Anifantis et al., 2016).
A number of studies have been carried out on greenhouse cultivation and heating so far. A design of a greenhouse using renewable energy for its optimal operation for chilly plants over the year is presented in (Fahmy et al., 2016). The effect of a greenhouse heating system by a tank fillet rocks placed on the ground of the greenhouse is studied in (Gourdo et al., 2018). During the day these rocks store the heat coming from the air of the greenhouse and release it into the air inside the greenhouse overnight.
Some vegetables and flowers for greenhouse cultivation have been investigated according to the optimal growth temperatures - such as strawberry, chrysanthemum, rose and eggplant (Yang et al., 2012.2); tomatoes (Pevicharova et al., 2013; Shamshiri et al., 2018); salad (Kostadinov et al., 2019); pepper (González-Briones et al., 2018); peppers, tomatoes, cucumber, lettuce, poinsettias, carnations and geraniums (Bošnjakovi et al., 2013).
The application of classical and generalized predictive control to greenhouse heating is examined Ramírez-Arias et al., 2005) in order to analyze and compare the energy savings.
The purpose of this paper is to determine the amount of energy required for heating a greenhouse based on energy efficiency normative documents.

MATERIALS AND METHODS

The study object of this work is a greenhouse, located in town of Plovdiv, Bulgaria at 42°9′ north latitude and 24°45′ east longitude.
The experimental greenhouse is an even-span single-layered glass (4 mm thick) as shown in Figure 1. The roof slope is 26.5°. The greenhouse is dedicate for growing various types of vegetables and flowers.

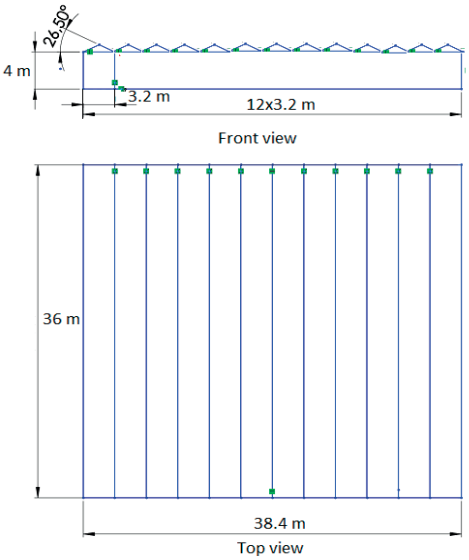

Figure 1. General view of greenhouse

Dimensions of the greenhouse structure are 36 m for width, 38.4 m for length and 4.0 and 4.7 m for height at the side walls and ridge, respectively. The greenhouse is equipped with retractable thermal screening systems for the both side walls and a plane at the height of 3.5 m. The air volume of the greenhouse is approximated to be 6010.5 m^3 and is reduced to 4200 m^3 at night time by spreading the screens. The specification of the experimental greenhouse is present in Table 1.

Table 1. The greenhouse specification

Item	Description
Orientation	Nord-South
Floor area	1382.4 m^2
Roof area	1507.42 m^2
Wall area	621.91 m^2
Shape	Multi-span roof
Wall and roof material	Single glass 4 mm

The heat balance of the studied greenhouse is presented in Figure 2. According to the first principle of thermodynamics, the energy gained by the greenhouse is balanced by the energy loss by it.

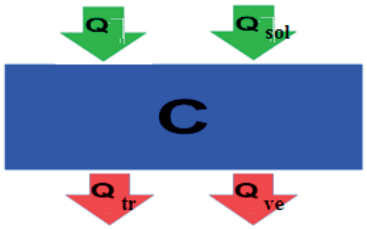

Figure 2. Greenhouse heat balance model
Q - Thermal energy required for greenhouse heating, Qsol - Heat gain from solar radiation, Qtr - Heat loss from heat transfer, Qve - Heat loss from ventilation, C - Space of the glasshouse

The heat loss is composed mainly of two components – transmission heat loss through the roof and walls and infiltration (ventilation) heat loss. The heat loss from perspiration and respiration of plants are neglected, since they are relatively small compared to those by transmission and infiltration. The heat gains are mainly due to solar radiation. The air change method is the general method for infiltration heat loss calculation. A common assumption is that ventilation loses are calculate for 20 air changes per day (Ikonomopoulos & Tsilingiridis, 2016).
For the purpose of this study meteorological data (solar radiation, ambient air temperature) for 3 years period before this year are used. The average indoor night temperature and minimal outside temperature are considered to be 16^0C and -15^0C, respectively and the air exchange is 1 h^{-1}.

RESULTS AND DISCUSSION

The total heat losses Q_{ht} from the greenhouse are defined as the sum:

$$Q_{ht} = Q_{tr} + Q_{ve}, \text{ kWh} \quad (1)$$

where:

- Q_{tr} - heat loss from heat transfer, kWh;
- Q_{ve} - heat loss from ventilation, kWh.

During the heating period heat loss from heat transfer through the greenhouse envelope Q_{tr} depends on the thermal properties of these elements. The exterior walls of the greenhouse are made of glass with a thickness 0.004 m. The area of the external walls is 621.91 m^2, and their coefficient of heat transfer is 6.66 W/(m^2K) - as a single-pane glass with metal frame (Kaloyanov, 2006).
The roof of the greenhouse is a warm roof without an air layer. The roof is multi-span and is made of glass with a thickness 0.004 m. The area of the roof is 1507.42 m^2. The heat transfer coefficient of the roof is 6.66 W/m^2K.
The floor is the land on which plants are grown. The floor area is 1382.4 m^2, and its perimeter is 148.8 m. The heat transfer coefficient from the heated area to the outside air is determined according to (Regulation № 7, 2004). The spatial characteristic of the floor B' is determined by equation 2:

$$B' = A/(0.5*P) = 18.58 \text{ m} \quad (2)$$

where:

- A - the floor area (m^2);
- P - the perimeter of the floor (m).

Equivalent floor thickness d_t is determined by the equation 3:

$$d_t = w + \lambda*(R_{si} + R_f + R_{se}) = 0.57 \text{ m} \quad (3)$$

where:

- w - the thickness of the overhead part of the vertical walls above the level of the terrain (m);
- λ - the coefficient of thermal conductivity of the Earth. Assume that λ = 2 W/(mK);
- R_{si} - heat transfer resistance from the inner surface, R_{si} = 0.17 m^2K/W;
- R_f – heat conductivity coefficient of the floor, m^2K/W;
- R_{se} - heat transfer resistance from the outer surface, R_{se} = 0.04 m^2K/W.

If d_t < B' the heat transfer coefficient through the floor is evaluating according to the equation 4:

$$U = [(2\lambda)/(\pi B'+d_t)] \ln (\lambda B'/d_t+1) = 0.315 \text{ W/}(m^2.K) \quad (4)$$

The coefficient of heat transmission through heat transfer H_{tr} is determined by the equation (5):

$$H_{tr} = H_D + H_g + H_U + H_A \quad (5)$$

where:

- H_D - the coefficient heat transmission by heat transfer through the enclosing elements, bordering the outside air (W/K);
- H_g - coefficient heat transmission by heat transfer through the Earth in the stationary regime (W/K);
- H_U - coefficient heat transmission by heat transfer through the elements bordering on non-heated or non-cooled areas (W/K);

- H_A - coefficient heat transmission by heat transfer through the elements, bordering clinging buildings (W/K).

The coefficient heat transmission by heat transfer through the enclosing structures bordering the outside air H_D is given by the equation 6:

$$H_D = \Sigma_i(U_iA_i) + \Sigma_k(l_k\psi_k) + \Sigma_j\chi_j, \quad (6)$$

where:

- i, j, k - numbers of elements, of linear thermal bridges and of point thermal bridges;
- U_i - coefficient of heat transfer of the i^{-th} enclosing element, bordering the outside air ($W/(m^2K)$);
- A_i - the surface area of the i^{-th} enclosing element (m^2);
- l_k - the length of the k^{-th} linear thermal bridge (m);
- ψ_k - linear coefficient of heat transfer of the k^{-th} linear thermal bridge (W/(mK));
- χ_j - coefficient of heat transfer in j^{-th} point thermal bridge (W/K).

Because the walls and roof of the greenhouse are made of the same material - single glass with metal frames the coefficient of heat transfer by heat transfer through the walls and roof H_D is determined by an equation 7. The impact of thermal bridges has been taken into account when calculating the heat transfer coefficient through the walls. For this reason, second and third member of the equation will be ignored.

$$H_D = U_WA_W = 6.66*2129.34 = 14181.4 \text{ W/K} \quad (7)$$

The coefficient of heat transfer through the floor (Earth) H_g is calculated by equation 8.

$$H_g = U.A_f = 0.315*1382.4 = 435.34 \text{ W/K} \quad (8)$$

Therefore, the coefficient of heat transfer through the heat transfer calculated in equation 9 is:

$$H_{tr} = H_D + H_g = 14616.72 \text{ W/K} \quad (9)$$

The heat loss from heat transfer Q_{tr} are calculated for the duration of the heating period for each month by equation 10 and are shown in Table 2:

$$Q_{tr} = 1/1000*[(H_{tr} + \Phi_g)*(\theta_{i,H} - \theta_e)]*t \quad (10)$$

where:

- H_{tr} - coefficient of heat transfer in the surrounding area elements when temperature difference is 1 K (W/K);
- Φg - heat flow through the Earth at temperature difference 1 K, caused by the thermal inertia of the Earth (W/K);
- $\theta_{i,H}$, - temperature in the greenhouse in the heating period (^{0}C). Middle volume temperature of the greenhouse air is 16^0C;
- θ_e - the average monthly value of the ambient temperature (^{0}C);
- t - month's duration (h).

Table 2. Heat loss by heat transmission

Month	Days	$\theta_{i,H}$ ^{0}C	θ_e, ^{0}C	$\theta_{i,H}$ -θ_e, K	Htr, W/K	Qtr, kWh
1	31	16	-15	31	14,616.72	337,119.94
2	28	16	-15	31	14,616.72	304,495.43
3	31	16	-15	31	14,616.72	337,119.94
4	6	16	-15	31	14,616.72	65,249.02
10	8	16	-15	31	14,616.72	86,998.69
11	30	16	-15	31	14,616.72	326,245.10
12	31	16	-15	31	14,616.72	337,119.94
Total						1,794,348.06

Heat losses from ventilation for the heating period are determined by the equation 11 and are presented in Table 3:

$$Q_{ve} = [H_{ve}*(\theta_{i,H} - \theta e)*t]/1000 \quad (11)$$

where:

- H_{ve} is coefficient of heat transfer with the ventilation air, calculated by equation 12:

$$H_{ve} = (\rho c)_a*n*V = 0.34*1*6010.5 = 2043.56 \text{ W/K} \quad (12)$$

where:

- $(\rho c)_a$ = 0.34 $Wh/(m^3.K)$ is specific volume heat capacity of the air;
- n - average air exchange, h^{-1}, n = 1 h^{-1};
- V - net heated volume, m^3, V = 6010.5 m^3.

Total heat losses Q_{ht} from the greenhouse calculated by equation (1) is 2045215.37 kWh.

They have to be reduced by heat gains from solar radiation through transparent enclosures.

The total heat gains from solar radiation for each month of the heating period are calculated by the equation 13:

$$Q_{sol} = (\Phi_{sol,k}*t)/1000, \text{ kWh} \quad (13)$$

Table 3. Heat loss by ventilation

Month	Days	$\theta_{i,H}$, ^{0}C	θe, ^{0}C	$\theta_{i,H} - \theta e$, K	H_{ve}, W/K	Q_{ve}, kWh
1	31	16	-15	31	2,043.56	47,132.65
2	28	16	-15	31	2,043.56	42,571.42
3	31	16	-15	31	2,043.56	47,132.65
4	6	16	-15	31	2,043.56	9,122.45
10	8	16	-15	31	2,043.56	12,163.26
11	30	16	-15	31	2,043.56	45,612.24
12	31	16	-15	31	2,043.56	47,132.65
Total						250,867.31

Heat flow $\Phi_{sol,k}$, of solar radiation through the transparent greenhouse enclosure element k is given by the equation 14:

$$\Phi_{sol,k} = F_{sh,ob,k} * A_{sol,k} * I_{sol,k}, W \quad (14)$$

where:

- $F_{sh,ob,k}$ - the shading of the host solar energy for external obgekts, $F_{sh,ob,k} = 1$ as there is no shading from external objects;
- $A_{sol,k}$ - effective area of the host solar energy surface (m);
- $I_{sol,k}$ - middle daily intensity of sunshine on the host surface (W/m^2).

The effective receiving surface of a transparent envelope (walls and roof) A_{sol} is determined by the formula 15 and the values obtained are shown in Table 4:

$$A_{sol} = F_{sh,gl} * g_{gl} * (1-F_F) * A_{w,p} \quad (15)$$

where:

- $F_{sh,gl}$ - the shading factor (from moving shadows);
- g_{gl} - the total throughput of the transparent part of the element;
- F_F - the frame factor of the element k (the part occupying the frame);
- $A_{w,p}$ - the total area of element κ (m^2).

When the Sun's rays do not fall perpendicular to the surface, the value of g_{gl} is determined by the equation 16:

$$g_{gl} = F_W * g_{gl,n} = 0.9*0.85 = 0.765 \quad (16)$$

where:

- F_W is the correction factor for no perpendicular radiation. $F_W = 0.90$;
- $g_{gl,n}$ - the actual ratio of total solar transmittance at normal radiation, account from (Regulation No 7, 2004).

Table 4. Effective host surface of transparent enclosing elements

$A_{w,p}$	$1-F_F$	$F_{sh,gl}$	$g_{gl,n}$	Fw	A_{sol}
2,129.34	0.9	1	0.85	0.9	1,466.05

The values of heat gains from solar radiation through transparent enclosures Q_{sol}, calculated according to equations 13 and 14 are presented in Table 5.

Table 5. Heat gain by solar radiation

Month	Days,	$A_{sol,k}$, m^2	$I_{sol,k}$, kW/m^2	Coefficient, 24/1000	$Q_{H,gn}$, kWh
1	31	1,466.05	67.76	0.024	73,908.62
2	28	1,466.05	91.03	0.024	89,681.44
3	31	1,466.05	118.40	0.024	129,143.76
4	6	1,466.05	147.40	0.024	31,117.79
10	8	1,466.05	102.10	0.024	28,739.27
11	30	1,466.05	67.90	0.024	71,672.25
12	31	1,466.05	54.20	0.024	59,118.17
Total					483,381.31

Energy required for heating the greenhouse for the winter period is calculated by equation 17:

$$Q_A = Q_{ht} - \eta_{gn} * Q_{sol}, kWh \quad (17)$$

where:

- Q_{ht} - total heat loss (kWh),
- Q_{sol} - heat gains from solar radiation (presented in Table 5) (kWh),
- η_{gn} - dimensionless factor of utilization of heat gains.

The factor of utilization of heat gains depends mainly on the "heat gain/heat loss" ratio χ for the greenhouse: $\chi = Q_{sol}/Q_{ht} = 0.24$.

The dimensionless factor of utilization of heat gains is defined by the equation 18:

$$\eta_{gn} = (1-\chi^{\wedge a})/(1-\chi^{\wedge(a+1)}) = 0.81 \text{ when } \chi>0 \quad (18)$$

where: a is a numerical parameter that is determined by the equation 19:

$$a = a_o + \tau/\tau_o = 1 \quad (19)$$

where:

- $a_o = 1$;
- $\tau_o = 15$;
- τ is the time constant, which is determined by the equation 20:

$$\tau = Cm/(Htr+H_{ve}) = 42246.14/2045215.37 = 0.021 \text{ h} \quad (20)$$

where:

- Cm - effective heat capacity of the heated area, Wh/K. Its value depends on the massiveness of the building and

Cm=30.56*A_f=30.56*1382.4=42246.14 Wh/K.
The required energy for heating the greenhouse Q_A=2045215.4–0.81*483381.3=1654045.85 kWh. It is necessary to turn the energy in power through its division by the number of heating days in the year (they are 165) and for a period of 24 hours per day. Therefore, the peak required power for the studied greenhouse is 417.7 kW.

CONCLUSIONS

A methodology for defining the required energy for heating a greenhouse and providing the necessary parameters for plants growing has been developed. The calculations are made on the basis of the European and national energy efficiency legislation so that the energy consumption and the respective CO_2 emissions are minimized. The methodology coud be used for greenhouses designin with different parameters than those specified in the publication.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

STUDY THE QUALITY OF DIFFERENT TYPES OF PELLETS BY THEIR SPECIFIC CALORIFIC VALUE

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Abstract

The pellets are environmentally friendly bio fuels and have a lot of advantages over conventional firewood or biomass for heating. The European EN 14961-2 standard defining the requirements for pellets has been in force since 2010. Many pellet manufacturers certify their production according to the German standard DIN 51731 or according to the Austrian standard ÖNORM M 7135. All pellet labels state that they are manufactured according to EN 14961-2 standard. But does the inscription on the pellet packaging correspond to reality because the regulation does not require providing data about the specific calorific value on the pellet label. The calorific value of the pellets is one of the most important parameters from the customer's perspective. The aim of this paper is to define the quality of various types of wood and agro pellets as well as of one type of biomass, produced from rose stems by directly measuring of their combustion characteristics and to compare them. The measurements were made under laboratory conditions using a KL-11 calorimeter.

Key words*: biomass, calorific value, calorimeter, pellets.*

INTRODUCTION

A global warming becomes too serious problem recently. Because of the need for urgent actions to combat climate change, the European Council supports the goal of achieving the climate-neutral EU by 2050, in line with the Paris Agreement. However, achieving climate neutrality will require overcoming serious challenges and considerable investments. The European Council recognizes the need to ensure energy security and respects the right of Member States to choose the most appropriate energy technologies (European Council meeting, 2019).

In this regard the renewable energy production from waste is a promising technology, because the large quantities of waste biomass are generated every day from the agriculture and processing industry. The use of biomass for the production of heat may contribute positively to reduce environmental pollution and to cope with environmental problems. This could be a solution for the utilization of this types of waste and contribute to the generation of energy from alternative technologies in countries whose economy is based on agriculture and could encourage economic development (Manrique et al., 2019).

The most important characteristic of biomass used for energy production is its calorific value. Many scientists have examined energetic characteristics of different types of residues - such as biomass fuels (Acar & Ayanoglu, 2012), cashew shell, coconut pith, rice husk and combinations of them (Nakkeeran et al., 2019), winter wheat, maize, sunflower by-products, sweet sorghum and some bio-energy by-products (Jóvér et al., 2018), cardboard, paper, plastics, sewage treatment plants, charcoal (Bouabid et al., 2013), empty cones of pine, spruce, larch as well as husks and stems of silver fir (Aniszewska & Gendek, 2014) and lingo-celluloses materials (Demirbas & Demirbas, 2004).

The measurement of gross calorific values in a bomb calorimeter is especially important for the solid bio-fuels since their chemical and physical composition is usually quite different (Toscano & Pedretti, 2009).

The pellets are environmentally friendly bio fuels and have a lot of advantages over conventional firewood or biomass for heating. The heat of combustion of one kilogram of

high-quality pellets is usually from 4.6 to 5.1 kWh.

Pellets are a product that is formed by dry compression of biomass under mechanical pressure (Figure 1) and are intended to fuel heating installations with automation systems for the combustion process. The pellets are produced from waste wood biomass from coniferous and deciduous trees. Biomass for pellets production could also be obtained from residues of agricultural products, such as straw, sunflower stems, cakes and peels, peanut peels, etc. (Mitkov et al., 2016). Today, around 8-10 million tonnes of pellets are produced worldwide. They are produced without the addition of binders (Hiegel et al., 2009; Mladenov), but they may also contain binders that reduce their friability or increase their calorific value and lower their initial ignition temperature. The only requirement for pellets is that they comply with the European standards for calorific value, ash content and environmental friendliness, explained below.

The European standard EN 14961-2 for pellets has been in force since 2010. It sets out uniform rules for all pellets sold and burned in Europe. This includes the length and diameter of the pellet, ash remaining after combustion, moisture content etc. With the adoption of a uniform EU pellet standard EN 14961-2 in 2010, an EN plus certificate for pellets used in domestic boilers and an EN-B certificate for commercial pellets used industrial boilers were introduced. There are two classes of qualities A1 and A2 in the EN plus certificate. Class A1 introduced strict limits on the ash content in the pellets while in class A2 ash content is up to 1.5%. The EN-B certificate for commercial pellets has significantly reduced restrictions.

Figure 1. General view of fire pellets

The introduction of a uniform quality standard for domestic and commercial pellets will allow a clear accounting of pellet consumption and quality (Hiegel et al., 2009; Mladenov).

The main difference between standards and certificates is that standards are not controlled. Certificates are compulsory for the whole chain from production to consumption (Hiegel et al., 2009; Mladenov). As you can see the use of standards alone is not enough. Certification and control of the products and of the entire supply chain is desirable. Existing national and international certification systems contributed to ensuring the quality of produced pellets and to win the trust of consumers. However, they all have certain disadvantages. There are no certificates covering the entire supply chain within one system (Hiegel et al., 2009).

In this regard, a large range of pellets are available on the market. All labels state that the pellets are manufactured according to EN 14961-2 standard or that they are EN plus certified. However, in many cases the pellets offered on the Bulgarian market are not even labelled and it is difficult for the end user to make the right choice. The price range is also wide. And despite the labels, the consumers eventually feel the difference in the quality of the pellets as a larger or smaller consumption of pellets for heating. As a result, it is difficult to predict the cost of heating, as well as the harmful emissions that will be released during the pellets combustion.

This article focuses on the experimental determination of the quality of seven different types of pellets marketed in Bulgaria and one type of biomass, produced from rose stems by determining their specific calorific value and ash content.

MATERIALS AND METHODS

Seven types of pellets and one type of biomass, produced from rose stems are investigated using a standardized methodology (Official Methods of Analysis of AOAC International) (Atanasov et al., 2010; Horwitz & Latimer, 2007), involving the determination of dry matter (by drying the samples at 105^0C) and the ash content (by burning the samples at 480-550^0C). The study presents the most

widespread types of pellets on the market in Bulgaria.

The composition of the studied types of pellets is shown in Table 1. One type of pellet (No 2) is produced from foreign manufacturer. Four of pellet types are made from wood and the rest types are made from agricultural waste. The bulk density of all samples is within 650 kg/m^3 and is indicated on the pellet packaging.

Table 1. Baseline data for the pellets tested

No	Type of pellets	Material description	Diameter, mm
1	Wood pellets	Coniferous wood without bark	6
2	Wood pellets	A mixture of 60% deciduous, 40% coniferous wood	6
3	Agropellets	Sunflower seed husks	6
4	Wood pellets	Coniferous wood with bark	6
5	Wood pellets	Coniferous wood mixture	6
6	Agropellets	Sunflower husks of seeds and stalks	6
7	Agropellets	Peanut flakes	6
8	Agropellets	Sticks of roses	6

Determining of combustion characteristics of pellets is done according to the calorimetric method by complete combustion of a sample in an oxygen environment by means of the KL 11 Mikado calorimeter (Figure 2). Pellets and biomass are grinded with the use of mill for particles below 1 mm and fragmented material is dried in a laboratory drier for 24 hours at temperature 105^{0}C until the dry mass obtained. Research is based on complete combustion of one-gram samples in oxygen atmosphere, under pressure of 3 MPa and determination of the increase in water temperature in the calorimetric vessel. Combustion takes place in a calorimeter bomb. A temperature of 17-20^{0}C is set in the vessel 5 of the calorimeter.

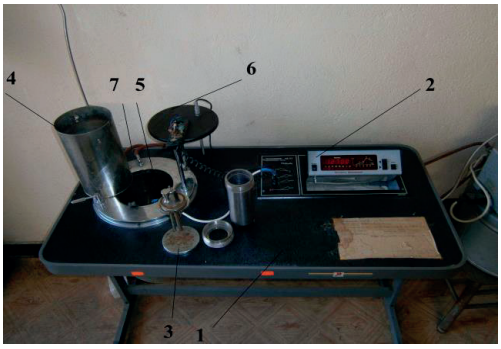

Figure 2. View of the KL-11 Mikado calorimeter:
1 working table; 2-meter; 3-fuel system; 4-outer casing;
5-vessel; 6-cover; 7-cooling part

Two kilograms of distilled water is placed in the calorimetric vessel at a temperature lower than that in the casing. The inner walls of the bomb are poured by 10 ml of distilled water to dissolve the nitrogen and sulphur oxides. Figure 3 shows the equipment for operating with the calorimeter. The mass of 100 mm of kanthal resisting wire 5 and of 1 gram of ground pellets are measured (to an accuracy of 0.0001 g).

Figure 3. Equipment for the KL-11 calorimeter:
1-block press; 2-container of the calorimeter; 3-power electrodes; 4-block of combustible material;
5- kanthal resisting wire; 6-crucible

The ground pellets are pressed with the block press 1 shown in Figure 3 around the kanthal wire 5. The block 4 is inserted into the calorimeter and the two ends of the kanthal

wire are clamped to the electrodes 3 of the ignition system. The container 2 is closed tightly and oxygen is supplied through the valve to a pressure of 3 MPa. Thus, prepared system is placed into the calorimeter and the automatic mode is started. The cycle duration is 10-30 minutes and is controlled by a microprocessor. At the end of the experiment, the specific heat value is read directly from the display in Joules (Atanasov et al., 2010). The container is removed from the calorimeter and opened, and then unburned kanthal wire residues are removed from the crucible 6. Their mass is subtracted from the original mass of the kanthal wire. The rest of the mass is burned. This mass is multiplied by 6688 J/g (specific heat of the kanthal wire) and the value obtained is subtracted from the energy determined by the sample and the burnt kanthal wire (Atanasov et al., 2010).

All results obtained for the ash content and calorific value of the pellets are recalculated and commented referring to absolutely dry matter (105^0C).

During the tests, absolutely dry matter is initially extracted at 105^0C. The experiments are carried out under gradual heating to 580^0C (Horwitz & Latimer, 2007). Experiments are performed on the natural samples, and the values obtained are related to absolutely dry matter.

For the accuracy of the results obtained, the experiments are performed with double repetition. Data are processed and arithmetic mean values are displayed.

RESULTS AND DISCUSSION

The results of the experiment after the necessary mathematical processing are given in Table 2. Analysing the results of the experiments, it is noticed that pellets produced from agro residues have higher ash content than those from wood. Ash in natural samples is normally to have lower value than that of absolutely dry matter because of the humidity contained therein. It is noted that the ash varies within 0.22% for pellets made from a mixture of coniferous and deciduous wood. The amount of ash is greatest (within 6.4% relative to absolutely dry matter) in the pellets produced from sunflower shells and stems. In the pellet calorific value examination, the native samples have lower calorific values than the samples compared to the absolutely dry mater, because of their moisture content. It is observed that the humidity of the pellets is within 9-10% for all pellet types. However, the pellets obtained from peanut shells give the highest calorific value due to the fact that they contain traces of fat in the shell. The calorific value of these pellets is 20029.65 J/g. Coniferous pellets with bark have a lowest calorific value - 17376.8 J/g, probably because of the higher percentage of bark in pellets. Pellets produced from agricultural residues have almost identical Calorific value as pellets produced from wood. The average calorific value of pellets from agricultural residues is 18943.96 J/g and that of wood pellets is 18528.33 J/g.

Table 2. Experimental results

No	Absolutely dry matter (ADM), %	Ash		Energy	
		Native, %	In absolutely dry matter, %	Native, J/g	In absolutely dry matter, J/g
1	90.2142	0.32772420747	0.36327335699	17364.168621701	19247.5
2	91.6745	0.20072359617	0.2189525059	17167.478121402	18726.55
3	90.7726	2.20612280834	2.43038454235	17007.241550388	18736.1
4	91.3815	0.21466206986	0.23490763996	15879.168728522	17376.8
5	91.3015	0.24453024453	0.26781672343	17131.765847348	18763.2
6	90.5151	5.79240713181	6.39938482359	17202.475394421	19005.1
7	90.1198	3.20785597381	3.55954459331	18050.689199118	20029.65
8	90.4737	2.46188527021	2.72110564101	16289.773325268	18005.00

Table 3 summarizes the caloric values of the pellets in units according to current European standards.
The energy content from a unit [J/g] is converted to units [MJ/kg] and [kWh/kg]. The values in [kW/kg] are based on the absolute dry matter.
Obviously, only peanut shell pellets meet the DINplus and ÖNORM M7135 standards. These standards require the caloric value of the pellets to be more than 18 MJ/kg at an ash content of 0.5%.

Table 3. Calorific value and cost of studied types of pellets

No	Calorific value, MJ/kg		Power at ADM, kWh/kg
	Nativ	Absolutely dry matter (ADM)	
1	17.36	19.25	5.35
2	17.12	18.73	5.21
3	17.00	18.74	5.21
4	15.88	17.38	4.83
5	17.13	18.76	5.22
6	17.20	19.00	5.28
7	18.05	20.00	5.57
8	16.30	18.01	5.00

Analysing the ash content, an increase in this indicator is observed for pellets obtained from agricultural residues. All types of pellets, except those made from coniferous wood with bark and roses stems, cover EN 14961-2 standard and EN plus certification. Standard EN 14961-2 provides that the caloric values of the pellets should be greater than 16.5 MJ/kg (or than 4.6 kWh/kg) at an ash content of 0.5% for ENplus A1 certificate. It is clear that with the exception of pellets made from coniferous wood with bark and roses sticks, all other pellets cover this certificate in terms of calorie content. As regards the ash content, the certificate is covered only by wood pellets. To reduce this ash content, facilities that burn pellets from residues of agricultural production should be switched to a higher working temperature. The pellets made from rose stems cover the ENplus B certificate in terms of calorie content but do not cover it in terms of ash.

In terms of price (Table 4), pellets produced from agricultural residues are about 25 to 100% lower than those produced from wood. Due to their good caloric content, the consumption of these pellets will be the same as that of wood pellets, but with an increase in ash when they are burned. This is probably due to the density of these residues compared to the density of the wood.

Table 4. Cost of the studied types of pellets per unit mass and calorific value

No	Price, €/kg	Cost, €/MJ
1	0.24	0.0125
2	0.26	0.0139
3	0.13	0.0069
4	0.19	0.0109
5	0.18	0.0096
6	0.13	0.0068
7	0.13	0.0065
8	0.04	0.0022

The lowest cost (in €/MJ) has the biomass produced from rose stems, followed by the cost of pellets produced from peanut shells. Pellets made from a mixture of coniferous and deciduous wood have the highest cost.

CONCLUSIONS

The energy content of pellets on the market is strongly influenced by their storage method and hence by their moisture content. There must be a requirement for traders to protect the pellets from the direct contact with atmospheric moisture during their storage so that their moisture content does not exceed 10-12%.
The pellets produced from agricultural residues cover the ENplus A1 certificate except those produced from rose stems. The calorific value of pellets produced from rose stems is within the certificate required ranges but their ash content don't cover the certificate required ranges.
Almost all types of pellets produced from agricultural waste could successfully replace the wood pellets for heating in domestic and industrial installations with a certain

combustion system adjustment. Their main advantage is their significantly lower prices.
Pellets made from coniferous wood with bark do not cover any ENplus certification, and those made from rose stems cover the ENplus B standard and are suitable for burning in industrial combustion facilities.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

PHYTOREMEDIATION POTENTIAL OF *MISCANTHUS* X *GIGANTEUS* IN SOIL CONTAMINATED WITH HEAVY METALS

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Abstract

There has been carried out a comparative research, which allow us to evaluate the efficacy of Miscanthus x giganteus for phytoremediation of contaminated soils. The effects of organic soil amendments (compost and vermicompost) on uptake of heavy metals in Miscanthus x giganteus were studied. Experiments have been implemented in controlled conditions. The soil used in this experiment was sampled from the vicinity of the area contaminated by the Non-Ferrous-Metal Works (MFMW) near Plovdiv, Bulgaria. The soils were amended or not with 5, 10, 15 or 30% of compost and 5, 10, 15 or 30% of vermicompost. Heavy metal contents in roots, rhizomes, stems, and leaves of Miscanthus x giganteus were analysed. The quantitative measurements were carried out with inductively-coupled plasma (ICP). The application of soil amendments favoured plant growth and development. Compost and vermicompost application led to effective immobilization of Pb, Zn, and Cd mobile forms in soil. A correlation was found between the quantity of the mobile forms and the uptake of Pb, Zn, and Cd by the Miscanthus x giganteus. Compost and vermicompost treatments were effective organic amendments and reduced heavy metals in leaves of Miscanthus x giganteus, but the effect differed among them. Also, there was a dose effect for amendments. The 30% compost and 15% vermicompost treatments led to the maximal reduction of heavy metals in Miscanthus x giganteus biomass. The depots for accumulation followed the order: roots > rhizomes > leaves > stems. The high concentration of heavy metals in the roots and rhizomes and the low translocation factor indicated the possibility of Miscanthus x giganteus to be used in phytostabilization. Miscanthus x giganteus harvested from heavy metals contaminated soil may be used for energy production.

Key words*: heavy metals, Miscanthus x giganteus, organic amendments, phytoremediation, polluted soils.*

INTRODUCTION

Phytoremediation is an emerging technology, which should be considered for remediation of contaminated sites because of its cost effectiveness, aesthetic advantages and long-term applicability (Chaney et al., 1993; Marques et al., 2008). This technology can be defined as the efficient use of plants to remove, detoxify or immobilize environmental contaminants in soils, waters or sediments through the natural, biological, chemical or physical activities and processes of the plants (Ciura et al., 2005; Lone et al., 2008). It is best applied at the sites with shallow contamination of organic, nutrient or metal pollutants (Yang et al., 2005).

The use of crop plants for phytoremediation of contaminated soils has the advantages of their high biomass production and adaptive capacity to variable environments (Fässler et al., 2010; Komarek et al., 2007). However, to succeed they must be tolerant to the contaminants and be capable of accumulating significant concentrations of heavy metals in their tissues. Additionally, crops could make the long time-periods for decontamination more acceptable, economically and environmentally. If the contaminated biomass may be further processed for added value products (not only concentrated on deposits of hazardous wastes), then such fact represents an improvement of economic efficiency of phytoremediation technology. Industrial plants, i.e. energy crops or crops for bio-diesel production, are therefore the prime candidates as plants for phytoremediation.

The use of biofuel crops for phytoremediation of heavy metal contaminated soils is of increasing interest (Pidlisnyuk et al., 2014). The main reason for this is the increase in demand for biomass as alternative energy sources, as well as the possibility of remediation of contaminated soils. Energy

crops include fast-growing varieties of trees and annual and perennial grasses. Among perennial grasses, *Miscanthus* x *giganteus* is considered the most promising biofuel plant. *Miscanthus* x *giganteus* is a sterile hybrid between *M. sinensis* and *M. sacchariflorus*, propagated vegetatively through its rhizomes. It is also called "elephant grass". The species has been distributed in Europe since the early 1980s.

The cultivation of *Miscanthus* x *giganteus* in Bulgaria began 5-6 years ago with the development of technology for the reproduction and cultivation of a perennial grass energy crop similar to reeds. It has rapid growth, low mineral content and high biomass yield. It reaches a height of more than 3.5 meters in one season and the annual dry weight yield can reach 25 tons per hectare. Preliminary studies have shown that *Miscanthus* x *giganteus* can be used for phytoremediation of contaminated land after the Chernobyl disaster in Ukraine and contaminated soils from mining in Slovakia. The use of *Miscanthus* x *giganteus* biomass for energy production seems promising in terms of the costs for phytoremediation and can find real application in practice compared to the use of expensive conventional methods. Studies have shown that the utilization of biomass obtained as a source of energy is feasible and can make the phytoremediation process profitable (Dornburg et al., 2005).

On the other hand, growing *Miscanthus* x *giganteus* on contaminated soils creates a potential risk of heavy metal pollution in the environment. The studies of Pogrzeba et al. (2011) show that the cultivation of *Miscanthus* x *giganteus* on contaminated soils leads to increased levels of heavy metals in the above-ground part of the plant. Contaminated biomass has to be treated as a hazardous material and its incineration has to be done in facilities equipped with filters for capture of metal oxides. That is why soil preparation before planting is a crucial step in the cultivation of *Miscanthus* x *giganteus*. It is necessary to propose measures to reduce the bioavailability of metals in the soil and very slow removal of metals from the soil associated with this perennial crop.

Growth and development of plants on soils contaminated with heavy metals depends on many factors, and above all on the concentration of these metals in the soil, the physicochemical properties of the soil, such as pH, organic matter content, as well as plant tolerance (Kabata-Pendias, 2001). Decrease in the amount of bioavailable (accessible) forms of heavy metals in the soil after the use of soil ameliorants can lead to a decrease in heavy metal content in biomass. According to Placek et al. (2017) the addition of inorganic fertilizers and/or lime leads to an increase of the biomass produced from *Miscanthus* x *giganteus* in contaminated soils but does not affect the uptake of the metals from the plant, whereas organic amendments are able to modify heavy metals bioavailability (Angelova et al., 2017). Addition of organic matter amendments, such as compost, and vermicompost in soil leads to immobilization of heavy metals and soil amelioration of contaminated soils (Angelova et al., 2013; Clemente et al., 2005).

Organic amendments are able to improve soil physical, chemical and biological properties by:

i. raising the pH,
ii. increasing the organic matter content,
iii. adding essential nutrients for plant growth,
iv. increasing the water holding capacity,
v. modifying heavy metals bioavailability (Angelova et al., 2013; Walker et al., 2003; 2004).

The aim of this experiment was to compare the effect of the selected organic additives on accumulation of heavy metals by the *Miscanthus* x *giganteus*, as well as to evaluate the possibilities to use the plant for phytoremediation of heavy metal contaminated soils.

MATERIALS AND METHODS

The soil used in this experiment was sampled from the vicinity of the area contaminated by the Non-Ferrous-Metal Works (NFMW) near Plovdiv, Bulgaria. Characteristics of soils and organic amendments are shown in Table 1. The soil used in this experiment was slightly alkalic, with moderate content of organic matter and essential nutrients (N, P and K). The pseudo-total content of Zn, Pb and Cd is

extremely high (2540.8 mg/kg Zn, 2429.3 mg/kg Pb and 51.5 mg/kg Cd, respectively) and exceed the maximum permissible concentrations (320 mg/kg Zn, 100 mg/kg Pb and 2.0 mg/kg Cd).

The pot experiment was conducted on soil with organic amendments (compost at 5, 10, 15 or 30% and vermicompost at 5.0%, 10.0%, 15% and 30% addition rates (calculated on soil dry weight basis). Soils were passed through a 2 cm sieve. Amendments were added and thoroughly mixed by hand. The pots were filled with 3 kg soil. All treatments were performed in triplicate. Three control pots were also set up without amendment. Pots were watered and stored in a greenhouse, where they were left to settle a minimum of 6 weeks at room temperature before planting the *Miscanthus* x *giganteus*.

Table 1. Characterization of the soil and the organic amendments used in the experiment

Parameter	Soil	Compost	Vermicompost
pH	7.6	6.9	7.5
EC, dS/m	0.2	0.2	2.2
Organic matter, %	3.99	72.10	38.58
N Kjeldal, %	0.24	2.22	1.57
C/N	9.41	32.43	24.59
Pseudo-total P, mg/kg	731	12654	10211
Pseudo-total K, mg/kg	4674.7	6082	10495
Pseudo-total Pb, mg/kg	2429.3	12.0	32.3
DTPA – extractable Pb, mg/kg	849.1		
Pseudo-total Zn, mg/kg	2540.8	170.8	270.3
DTPA – extractable Zn, mg/kg	236.8		
Pseudo-total Cd, mg/kg	51.5	0.19	0.69
DTPA - extractable Cd, mg/kg	36.8		

The *Miscanthus* x *giganteus* plants were grown in a climate chamber with regular watering and random rotation of the position of the pots. Rhizomes were sown in each pot. After 180 days, all plants were harvested.

The plants were gathered and the contents of Pb, Zn and Cd in their different parts – roots, rhizomes, stems, and leaves, were analysed separately. The contents of heavy metals in the plant material were determined.

To determine the effect of the organic amendments, soil samples were collected 1 month after addition of organic amendments. A soil subsample was air-dried, passed through a 2 mm sieve and characterized for soil pH (H_2O) in deionised water suspension of 1: 5 (w/v); total nitrogen by the Kjeldahl method (N Kjeldahl); total oxidizable organic carbon according to Tube digestion method (with titration) (Sparks, 1996).

The pseudo-total and DTPA-extractable concentration of heavy metals in the soils, after four weeks' equilibration were determined. Pseudo-total content of metals in soils was determined in accordance with ISO 11466.

The available (mobile) heavy metals contents were extracted by a solution of DTPA (ISO 14870).

The plant samples were treated by the method of microwave mineralization. To determine the heavy metal content in the plant and soil samples, inductively coupled emission spectrometer (Jobin Yvon Horiba "ULTIMA 2", France) was used.

RESULTS AND DISCUSSIONS

Accumulation of heavy metals in vegetative organs of Miscanthus x giganteus without amendments (control)

To clarify the issues of absorption, accumulation and distribution of heavy metals in vegetative organs of *Miscanthus* x *giganteus* samples of rhizomes, roots, stems, and leaves were analysed.

Table 2 presents the results obtained for the content of heavy metals in the vegetative organs of the study crop.

Considerably higher amounts were established in the roots of *Miscanthus* x *giganteus* compared to the above- ground parts of *Miscanthus* x *giganteus*. This is consistent with the results obtained by Fernando and Oliveira (2004), who found that metals accumulate primarily in the underground parts of *Miscanthus* x *giganteus* rather than in the above-ground parts. The content of Pb in the roots of *Miscanthus* x *giganteus* without amendments reached to 529.8 mg/kg, Zn -

365.8 mg/kg and Cd - 30.8 mg/kg, whereas in the rhizomes of *Miscanthus* x *giganteus* without amendments Pb reached to 119.5 mg/kg, Zn - 106.5 mg/kg and Cd - 5.94 mg/kg. Our results indicate that a considerable part of the heavy metals are accumulated in the roots and rhizomes, which is consistent with the results of other authors (Fernando and Oliveira, 2004). This is explained by the fact that during the penetration of heavy metals in the plasma there is inactivation and disposal of significant quantities of them, as a result of the formation of slightly mobile compounds with the organic substance.

Table 2. Content of heavy metals (mg/kg) in vegetative organs of *Miscanthus* x *giganteus* (without amendments, control)

Element	Roots x±sd	Rhizomes x±sd	Stems x±sd	Leaves x±sd
Pb	529.8±2.5	119.5±1.5	44.3±0.8	261.3±1.5
Cd	30.7±2.1	5.9±0.3	13.0±0.9	27.3±1,2
Zn	365.8±5.3	106.5±2.1	132.0±2.0	281.4±2.8

x - average value (mg/kg) from 5 repetitions; sd - mean standard deviation

The heavy metals contents in the stems and leaves of the *Miscanthus* x *giganteus* were considerably lower compared to those in the root system, which showed that their movement through the conductive system was strongly restricted. The content of Pb in the stems of *Miscanthus* x *giganteus* without amendments reached to 44.3 mg/kg, Zn - 132.0 mg/kg, and Cd - 13.0 mg/kg. The content of Pb in the leaves of *Miscanthus* x *giganteus* without amendments reached to 261.3 mg/kg, Zn - 281.4 mg/kg, and Cd - 27.3 mg/kg.

The results we obtained shown that the content of Pb in the above-ground parts of *Miscanthus* x *giganteus* is high despite the low level of bioavailable forms of Pb in the soil.

The studies of Pogrzeba et al. (2011; 2013) shown that the absorption of metals strongly depends on the level of accessible forms. In the cultivation of *Miscanthus* x *giganteus*, 2 mg/kg Pb, 0.3 mg/kg Cd and 25 mg/kg Zn are accumulated on clean soils, while at cultivation on contaminated soils - up to 200 mg/kg Pb, 5 mg/kg Cd and 700 mg/kg Zn. Barbu et al. (2009; 2010) found that there is a correlation between the Pb content of the above-ground parts of *Miscanthus* x *giganteus* and the Pb content in the soil.

Barbu et al. (2009; 2010) found that the amount of accumulated metals in leaves and stems of *Miscanthus* x *giganteus* when grown on contaminated soil (680 mg/kg Pb and 13 mg/kg Cd) is very low. Similar results were obtained by Nsanganwimana et al. (2015) who found that, despite the high content of Pb in the soil, plants accumulate small amounts of this element in their above-ground mass, which may be due to the accumulation of Pb in the roots of the plant.

The Translocation Factor (TF) provides information on the ability of plants to digest heavy metals through the roots and to move them to the above-ground mass (leaves).

The results obtained shown that, with respect to Pb, the translocation factor for plants without the importation of additives reaches up to 0.47, for Cd up to 1.1 and for Zn up to 0.88.

The effectiveness of phytoremediation is also determined by the bioconcentration factor (BCF), (McGrath and Zhao, 2003). BCF root is a ratio of the content of heavy metals in plant roots to soil content (BCFroots = [Metal] roots/[Available metal] soils).

The results obtained shown that this ratio reaches up to 0.72 for Pb, up to 0.94 for Cd and up to 1.37 for Zn.

BCF shoot is defined as the ratio of the metal concentration in the above-ground mass of the plant and in the soil (BCFshoots = [Metal] shoots/[Available metal] soils) and is a measure of the plant's ability to digest and move the metals to the above-ground mass, which can be easily harvested. In hyperaccumulators case, the enrichment factor is higher than 1 and in some cases it may reach 50-100 (McGrath and Zhao, 2003).

The results obtained shown that, with respect to Pb, the bioconcentration factor for plants without the importation of additives reaches up to 0.34, for Cd up to 1.03, and for Zn up to 1.20. The results obtained shown that BCF is higher for Zn and Cd than for Pb. Higher values for Zn and Cd are probably a consequence of the greater ability of these elements to accumulate in the above-ground mass than in the roots, which is consistent with the results of Korzeniowska et al. (2011) and Yoon et al. (2006).

According to McGrath and Zhao (2003), the BCF value for the above-ground parts of the

accumulator plants should be higher than that of the plant roots and should exceed 1. The results of the study show that *Miscanthus* x *giganteus* cannot be classified as an accumulator type, although the BCF for Cd reaches up 1.03, and up to 1.2 for Zn. Our results are in accordance with Pogrzeba et al. (2011) and Krzyzak et al. (2017) according to whom the *Miscanthus* x *giganteus* accumulates moderate amount of heavy metals in the leaves and has a relatively lower potential for phytoextraction.

Figures 1, 2 and 3 presents the results obtained for impact on organic amendments on the content of heavy metals in the vegetative organs of the *Miscanthus* x *giganteus*.

The results obtained by us shows that the absorption of the elements by the *Miscanthus* x *giganteus* is influenced by the organic amendments imported to the soil (type and quantity).

The addition of compost and vermicompost significantly affect the absorption of heavy metals (Pb, Zn and Cd) of the tested plants, and depends to a considerable extent by their quantity.

The addition of compost results in a decrease in Pb, Zn and Cd content in the roots of *Miscanthus* x *giganteus*, as this decrease is more pronounced when 30% of compost is imported. The content of Pb in the roots decreases to 396.2 mg/kg, Cd to 13.4 mg/kg and Zn to 289.9 (Figures 1, 2 and 3). The addition of compost leads to a decrease in Pb content in the stems and leaves of the *Miscanthus* x *giganteus*, as this decrease is more pronounced when 30% of compost is imported. Similar is the trend of decreasing the amount of Zn and Cd in the leaves of *Miscanthus* x *giganteus* where the Zn content decreases from 281.8 mg/kg to 201.8 mg/kg and Cd from 27.4 mg/kg to 3.5 mg/kg in the leaves.

On the other hand, the addition of compost leads to an increase in the content of Pb, Cd and Zn in the rhizomes of the *Miscanthus* x *giganteus*. Pb content in rhizomes increases from 119.5 mg/kg in the control to 382 mg/kg, Cd from 5.9 mg/kg to 11.4 mg/kg, and Zn from 106.5 mg/kg to 379.9 mg/kg.

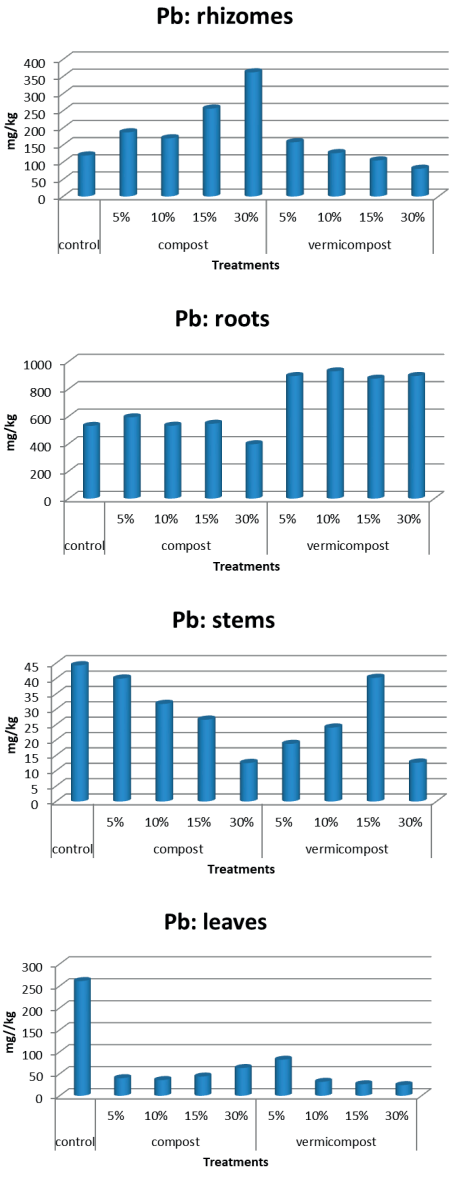
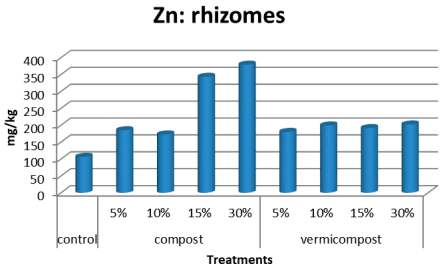
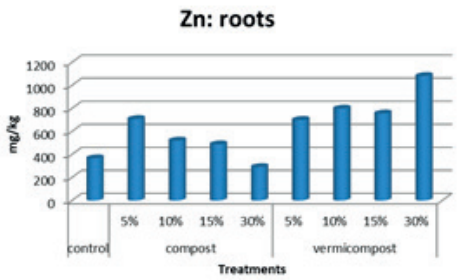
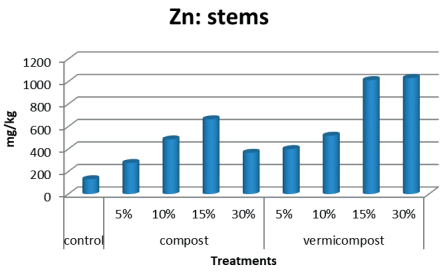


Figure 1. Effect of different organic amendments (compost and vermicompost) applications to accumulation of Pb in the vegetative parts of *Miscanthus* x *giganteus*







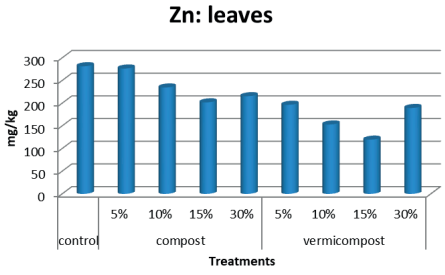
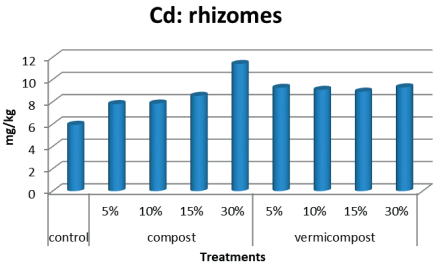
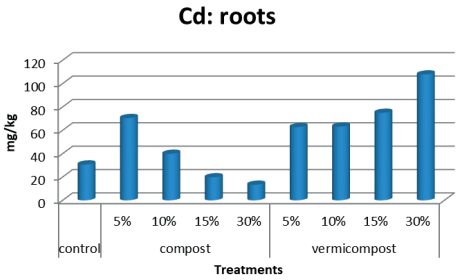
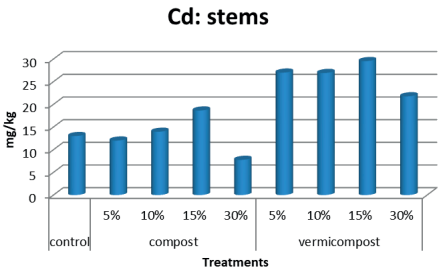


Figure 2. Effect of different organic amendments (compost and vermicompost) applications to accumulation of Zn in the vegetative parts of *Miscanthus* x *giganteus*







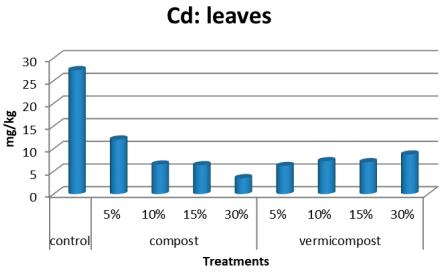


Figure 3. Effect of different organic amendments (compost and vermicompost) applications to accumulation of Cd in the vegetative parts of *Miscanthus* x *giganteus*

The addition of a vermicompost leads to a decrease in the Pb content and an increase in Cd and Zn content in the rhizomes of the *Miscanthus* x *giganteus.* Pb content in rhizomes decreases from 119.5 mg/kg in the control to 80.8 mg/kg, while Cd content increases from 5.9 mg/kg to 11.4 mg/kg and Zn from 106.5 mg/kg to 202.3 mg/kg. The addition of a vermicompost leads to a decrease in the Pb, Cd and Zn content in the leaves of the *Miscanthus* x *giganteus*. Pb content decreased from 261.3 mg/kg to 24.2 mg/kg, Zn from 281.4 mg/kg to 119.5 mg/kg, and Cd from 27.3 mg/kg to 7.0 mg/kg (Figures 1, 2 and 3). On the other hand, the addition of a vermicompost leads to an increase in Pb, Cd and Zn content in the roots and stems of the *Miscanthus* x *giganteus*, this increase being more pronounced with the importation of 30% vermicompost in the roots and 15% vermicompost in the stems.

The results obtained can be explained by the amount of mobile forms of heavy metals. The addition of compost and vermicompost to the soil leads to a decrease in the mobile forms of Pb, Zn and Cd (data are not shown), resulting in a significantly lower content of these elements in the leaves of the plants.

The addition of compost and vermicompost results in a decrease in the translocation factor for Pb and Cd, which indicates the lower ability of the plants to bioaccumulate these elements compared to the control (Figure 4). In the addition of 15% and 30% of compost, TF values for Zn increased from 0.87 to 1.04, while in the use of 15% vermicompost - to 1.2. In the variants mentioned, the TF values indicate that a significantly greater amount of Zn moves to the leaves compared to other variants.

The distribution of heavy metals in the *Miscanthus* x *giganteus* organs has a selective character, it is specific for the individual elements. The main part of Pb accumulates in the underground parts of *the Miscanthus* x *giganteus* (roots and rhizomes) - 68%. In terms of Cd, the content in the above-ground part of the Miscanthus x giganteus is slightly higher than in the underground part (52% in the above-ground part and 48% in the underground part), while in the Zn the opposite trend is observed (47% in the above-ground part and 53% in the underground part).

The distribution of Pb in plants organs for all options with the addition of compost follows the same correlation observed in the control. The highest content of Pb was found in the roots, followed by the rhizomes, leaves and stems (Figure 4).

Figure 4. Effect of organic amendments on Translocation factor and distribution of heavy metals in vegetative organs of *Miscanthus* x *giganteus*

These results correspond to the results of Fernando and Oliveira (2004) who found that in the aboveground parts of the plants the accumulation of heavy metals is less than that in the roots.

Similar results were obtained for the influence of vermicompost on the accumulation of heavy metals from *Miscanthus* x *giganteus*. There is a correlation between the amount of amendments and their content in the leaves, as with the increase of the amount of compost and vermicompost the content of heavy metals in the leaves is decreasing.

According to Pidlisnyuk et al. (2014) and Kocon et al. (2012) *Miscanthus* x *giganteus* can be grown on contaminated soils which are not contaminated with a high concentration of metals. However, the results we obtained clearly shows that *Miscanthus* x *giganteus* is a crop tolerant to heavy metals and can be grown on highly contaminated soils (2544.8 mg/kg of Zn, 2429.3 mg/kg of Pb and 51.5 mg/kg of Cd). The high concentration of heavy metals in the roots and the low translocation factor indicates the possibility of *Miscanthus* x *giganteus* to be used in phyto stabilization. Our results confirm that *Miscanthus* x *giganteus* has phytostabilization potential. The addition of compost and vermicompost further reduces the ability of Miscanthus x giganteus to transfer the heavy metals in the leaves, allowing its use as a safe energy crop.

CONCLUSIONS

Based on the results obtained the following conclusions can be made:

1. The *Miscanthus* x *giganteus* is a plant tolerant to heavy metals and which can be grown in heavy metal polluted soils (2540.8 mg/kg Zn, 2429.3 mg/kg Pb and 51.5 mg/kg Cd) and can be successfully used in the phytoremediation of heavy metal polluted soils.

2. The distribution of the heavy metals in the organs of the *Miscanthus* x *giganteus* has a selective character. *Miscanthus* x *giganteus* decreases in the following order: roots > leaves > rhizomes > stems.

3. The high concentration of heavy metals in the roots and the low translocation factor indicates the possibility of *Miscanthus* x *giganteus* to be used in phytostabilization.

4. Compost and vermicompost treatments were effective organic amendments and reduced heavy metals in leaves of *Miscanthus* x *giganteus*, but the effect differed among them.

5. The 30% compost and 15% vermicompost treatments led to the maximal reduction of heavy metals in the *Miscanthus* x *giganteus* leaves, allowing its use as a safe energy crop.

ACKNOWLEDGEMENTS

The financial support by the Bulgarian National Science Fund Project DFNI H04/9 is greatly appreciated.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

METHOD FOR DETERMINING THE FUEL COST OF AGRICULTURAL MACHINES THROUGH GPS SIGNAL

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Abstract

In operating a machine-tractor park on a modern farm, the most significant expense is that of fuel. Modern agriculture, as a way of doing business, is unthinkable without the use of modern machinery. In many cases even funny. In the technical specification of power machines, only the specific fuel consumption is specified. This is because the manufacturer of these machines is unable to know the specific operating characteristics of the machines he produces. In practice, there are different options for determining fuel consumption, but for the most part, these options are incorrect, unacceptable or inapplicable. The article deals with the variant of the application of GPS signal from a satellite to determining the speed of the machine and the time for crawling the specific field. In this way, its known formulas determine its slipping. After determining the machine's slipping, the fuel consumption can be determined accurately enough with the introduction of a corrective slipping factor.

Key words*: fuel, fuel economy, GPS, slipping, tractors.*

INTRODUCTION

A major element in the operating costs of vehicles is fuel. Its importance is increasing with the depletion of oil reserves worldwide and the continuing trend of rising fuel prices. At this stage, the methods for analyzing the fuel economy of wheeled vehicles are developed (Lilov et al., 2015; Totev et al., 2010; Ivanov et al., 2012).

According to Regulation 167/2013 of the European Parliament, the definition of "tractor" means any engine or wheeled or tracked agricultural or forestry vehicle equipped with at least two axles and a maximum design speed of at least 6 km/h, the principal function of which is related to its towing power and which is specially designed to tow, push, transport and propel certain removable equipment designed to carry out agricultural or forestry work, or to tow trailers or towed implements used in rural land and forestry; it may be adapted to carry loads when working in agriculture or forestry and/or may be equipped with one or more passenger seats (Regulation (EU) No 167/2013).

The ability to predict fuel consumption for tractors is very useful for budgeting and management. Using these equations, farmers can estimate and compare fuel consumption for different operating and loading conditions (Grisso et al., 2014; Grisso et al., 2004).

On the other hand, reducing the fuel consumption of transport vehicles reveals one of the possibilities of reducing air pollution from them. Fuel consumption is influenced by a number of design and operational factors.

The main operational factors that affect fuel consumption are (Evtimov et al., 2015):

- the type and condition of the road;
- the mass of the transport machine;
- speed of movement;
- ambient temperature;
- the speed of acceleration;
- vehicle operating time.

The use of an identifiable model for calculating tractor fuel consumption during soil cultivation for different types of soil cultivation significantly increases fuel efficiency and economy.

This leads to lower operating costs and increases agricultural productivity and ultimately leads to increased profitability in crop production (Nkakini et al., 2019).

This article introduces an innovative methodology for experimentally determining the fuel consumption of agricultural tractors. The methodology takes advantage of industry 4.0 and satellite navigation and information systems.

MATERIALS AND METHODS

Each element of the methodology has links to the other elements. The multigraph of the relationship between the various elements of the methodology is shown in Figure 1.

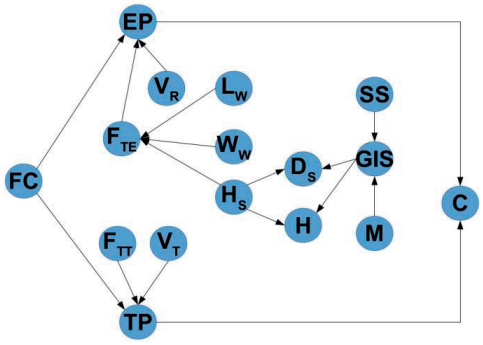

Figure 1. Multigraph of interconnections between the elements of the methodology for determining the fuel consumption of a tractor

According to Figure 1, the fuel economy (FC) of a tractor is determined by its fuel consumption over a certain operating time. It can be determined by some dependence (Equation 1) (Dimitrov, 1997; Dimitrov et al., 1980; Lilov et al., 2015):

$G_e = (g_T.P_T)/\rho$, l/h ..... (1)

where:

- g_T - the specific draft fuel consumption, g/kWh;
- ρ = 0.832 - density of the diesel fuel at temperature 20°C, kg/l;
- P_T - useful tractor traction power, kW.

The specific fuel consumption for each engine is a known value and is taken from the tractor's prospectus materials or documentation. This is because the operating conditions of the tractor are variable and depend on many factors (Evtimov et al., 2015). The most important element of the formula is the useful tractive power of the tractor is determined by Equation 2.1. (Dimitrov, 1997; Dimitrov et al., 1980):

$P_T = F_T.v$ ..... (2.1)

where:

- F_T - the tractor's pulling power, N;
- v_T - tractor speed, km/h.

For machines reporting hourly performance, the following formula can be used to determine the tractor's pulling power. With a known tractor hourly capacity, the traction power is determined according to Equation 2.2 (Dimitrov et al., 1980):

$P_T = (R.W)/(0.36\ \eta_{TT}.\tau)$, kW ..... (2.2)

where:

- R - the specific pulling resistance per unit width of the machine, N/m. The coefficient is different for different machines. For a plow with a working width of 0.5-3 m, the resistance is 10.0-2.4.10^4 N/m.
- W - hourly tractor performance in ha/h. It is reported directly from the readings of the tractor dashboard;
- η_{TT} - traction efficiency for operating mode. It can be read from the tractor's traction characteristic or selected. The value varies from: 4K4 with same wheels - 0.68; 4K4 with different wheels - 0.65 and 4K2 - 0.64;
- τ - ratio of working time;

With some hourly productivity, the determination of the tractive force is not necessary. However, a calculation can be made to compare the values of theoretical traction power. The speed of the tractor can be used in the calculations, which is determined by the tractor's hourly productivity (Equation 2.3) (Dimitrov et al., 1980):

$v_T = W/(0.36\ B)$, km/h ..... (2.3)

where:

- B - the machine working width, m. It is measured directly.

There are two approaches to determining the tractor's pulling power. One is theoretical and the other is experimental. It is necessary to make a comparison between the two types of approaches in order to compare the difference between them and to select a correction factor for fuel consumption.

The theoretical traction determination (FTT) is based on the known dependencies and speed characteristics of the engine. The approach is a little more general and probably leads to some differences with the actual fuel consumption of the machine. It is necessary to take into account the speed of rotation of the crankshaft during operation.

According to the methodology, the theoretical tractor traction force (FTT) is determined by the tractor traction balance Equation 3 (Dimitrov, 1997; Dimitrov et al., 1980; Lilov et al., 2015):

$F_{TT} = (M_E.i_T.\eta_T)/r_K – f.G$, N ..... (3)
where:

- M_E is the moment of the tractor engine, Nm;
- i_T - the transmission number. The total transmission number of the i_T transmission is a known value for each machine and is usually chosen depending on the nature of the agricultural work carried out, mainly in the operating range of the gears;
- r_K - radius of the tractor wheel;
- η_T - mechanical transmission efficiency. The mechanical transmission efficiency is also known and shows how much of the engine energy is lost to cover the transmission resistances. It varies from 0.88 to 0.9;
- f - traction resistance coefficient of the tractor. It is selected tabularly depending on the soil properties. For example, for stubble the drag coefficient is 0.12 for a wheeled tractor (Ivanov et al., 2006);
- G - traction coupling weight.

Tractor towing weight is obtained as the product of tractor mass and ground acceleration (Equation 4) (Lilov et al., 2015; Staneva et al., 2016):
$G = m.g$, N ..... (4)
where:

- m - the mass of the tractor, kg;
- g - acceleration due to gravity: g = 9.81 m/s^2.

The wheel radius is a size that is significantly difficult to determine because of the specific nature of the wheel contact with the road and the size of the contact spot. With sufficient accuracy for the gears, the wheel radius can be determined from Equation 5 (Dimitrov et al., 1980; Lilov et al., 2015):
$r_K = 1.035 (0.5 D-\xi B)$, m ..... (5)
where:

- B is the outer diameter of the tire, m;
- H - tire profile height, m.

Data on the outer diameter of the tire and the height of the tire profile are known values for each tire. They can also be measured directly.
Of interest is the tire deformation factor. It is determined experimentally or taken from a priori information (Ivanov et al., 2006). Convenient for calculation is a value of 0.14-0.2.
Wheel radius values are determined based on the tractor's 8-12 km/h operating speed.
Determining the tractor speed is more accurate using the Formula in 2.3, but it can also determine the dependence (Equation 6) by taking into account the crankshaft speed of the engine (Lilov et al., 2015; Dimitrov, 2011):
$v_T = (\omega/i_T).r_K$, km/h ..... (6)
where:
ω - the angular velocity of the crankshaft of the engine.
The angular velocity of the crankshaft of the engine is divided according to Equation 7:
$\Omega = (\pi.n)/30$, rad/s ..... (7)
where n is the crankshaft rotation frequency recorded by the engine speed control, min^{-1}.
In a number of cases, however, the speed determined by Formula 6 is not real at work. This is because it does not account for the machine slipping into the soil. In this case, the engine consumes more fuel to do the job. In order to determine the travel speed of the tractor while running, it is necessary to take the slip value from the slip curve $\delta = f(F^T)$ for the determined tractive power.
After determining the slip, the speed of the tractor must be adjusted in Equation 2.1 according to Equation 8 (Dimitrov, 1997):
$V = v_T.(1-\delta)$ ..... (8)
Of course, considerable knowledge of the tractor's theory and calculation, as well as a rich mathematical apparatus, is required to obtain the fuel consumption of the method thus outlined. In addition, a new load capacity calculation is required for any change in operating conditions. This leads to the creation of a huge database of calculations and complicates the process of determining fuel consumption, because after each determination of towing capacity it is necessary to calculate the hourly consumption and all the hourly fuel costs need to be added to the receipt of the total fuel consumption over a given period.
In order to determine the traction power experimentally (EP), it is necessary to capture different indicators from different sources. The determined traction power in this approach is more realistically determined. The traction power itself is determined by Equation 2.1. As has already been explained, the machine's traction power and the speed of the machine during processing are included. In the

experimental determination of traction power is taken from modern global sources of information.

The GNSS Global Navigation Satellite System can be used to determine the speed of the tractor. It is a combination of all existing navigation systems - GPS, GLONASS, WAAS, EGNOS, MSAS. WAAS, EGNOS and MSAS are in addition to the system as they are satellites that are geostationary orbit and provide corrections with much lower accuracy. The simultaneous use of GPS and GLONASS signals significantly increases the number of satellites observed, which in practice increases the ability to obtain more accurate results in real time and in adverse conditions (forest and mountain terrain, heavily urbanized areas, etc.). When the number of satellites observed is large, there is always sufficient data to resolve ambiguities in location. Currently, GPS and GLONASS contain 32 and 24 satellites respectively, with the tendency to increase in number (https://www.geonet.bg/home.html).

The actual speed of the machine is reported directly from the user interface (Figure 2) of the navigation system for the specific operation (https://agriculture.trimble.com/products/).

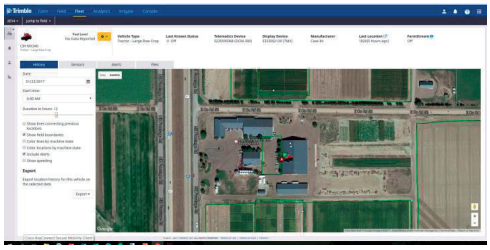

Figure 2. User interface of navigation system

The system connects to GLONASS and determines the position and speed of the tractor through a device mounted on it.

The system is compatible with tractor models equipped with such special devices or more up-to-date tractors (Figure 3).

Figure 3. General type of navigation system

In principle, any tractor can be equipped with a navigation system, but there are also cases where this is impossible for structural reasons or is economically disadvantageous. Then a mobile device of the type (Figure 4) is appropriate.

Figure 4. Mobile navigation system in general

The (F_{TE}) is less different in determining the tractor traction force. The traction resistance of a particular machine is determined, for example, the determination of the traction resistance of a plow of Equation 9 (Ivanov, 1962; Demirev et al., 2012):

$$F_{TE} = f_M G_M + H_S.a.b.n + \varepsilon.a.b.v^2 \quad \text{..... (9)}$$

where:

- f_M - the drag coefficient of the plow. It can be expressed as the coefficient of soil friction on the metal;
- G_M - weight of the working machine. It can be determined by Equation 4 using the values for the working machine;
- H_S - soil layer hardness, N/m^2;
- A - depth of treatment, m. The processing depth is set at the setting of the agricultural machine for operation and does not change until the machine tractor unit is disconnected;
- n - number of working bodies of the machine;
- ε - the coefficient of speed resistance, $N.s^2/m^4$. It depends on the form of the plow work surface and the soil properties (Ivanov, 1962). For the current plow the recommended value is $\varepsilon = 4000\ N.s^2/m^4$.

The hardness of the soil layer is actually the coefficient of specific soil resistance to deformation. Prior to Industry 4.0, it was experimentally determined by a number of soil samples. This is history and can be determined with sufficient accuracy by dependence

(Equation 10) (Shishkov et al., 1973; Nguen et al., 1990):

$H_S = e^S$ …… (10)

where:

- S is the computational value of the exponent.

The exponent is calculated by dependence (Equation 11) (Shishkov et al., 1973; Nguen et al., 1990):

$S = -9.32+0.194W_a+15.92\rho W_a -2.717\rho^2$ … (11)

where:

- Wa is the absolute soil moisture, %;
- ρ - soil density, kg/dm^3.

As already stated, soil density (DS) and soil moisture (H) is a complex process associated with constant field trawling and soil sampling.

This development proposes an innovative approach to determine soil moisture and density by obtaining satellite data (SS).

To determine the moisture value, it is convenient to use the Santinel-2 L1C, Santinel-2 L2A satellites to obtain the moisture index for the specific operating field and the set work time, as shown in the example in Figure 5 (https: //eos.com/sentinel-2/).

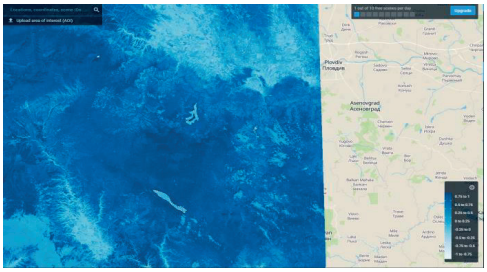

Figure 5. Moisture signal for satellite "Santinel-2 L1C"

After receiving a specific value of the moisture index, it is necessary to enter that value into the Global Information System (GIS).

An appropriate such system is ArcGIS (Figure 6) (Dallev et al., 2014).

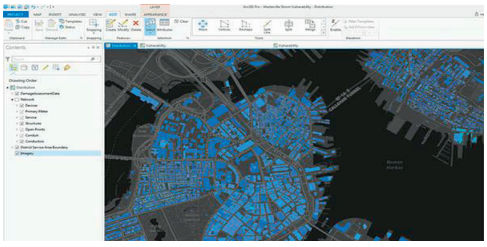

Figure 6. ArcGIS product overview

In the information system, the value of the humidity index after conversion with the help of a correction factor extracts the absolute moisture value Wa for the soil of the working field through the card that is selected.

Depending on which card is selected in the system, the type of soil and its density ρ are plotted. Soil maps are pre-programmed into the program and can be retrieved at any time with the desired information.

Direct measurement (M) is used to determine the correction factor for determining the absolute soil moisture. The direct measurement is performed with the help of a special hydrometer mounted on the agricultural machine, which measures the humidity at certain points in the field. In addition to the humidity, the apparatus allows to obtain other information on the content of certain substances in the soil. They can serve as a basis for creating a special map for the composition of the cultivated soil and the need to add substances to it. The measured humidity value can be used directly to determine (Formula 11) when the weather is cloudy and the satellite signal is inadequate. Based on the values of these points and using a GIS algorithm, a correction coefficient is constructed. The correction factor is different for different soil types. It connects modern satellite technology with conventional humidity detection technologies.

The last element of the methodology is the comparison (C) of the two models. At this stage, the values of the traction power determined by the two approaches are compared. This is necessary to evaluate the adequacy of the model. The obtained values of traction power determine the hourly fuel consumption and the pressure approach. The values are compared to the actual fuel consumed by the tractor as measured by the fuel flowmeter fitted to the combustion system.

To confirm the results, the fuel consumption, using a flowmeter, of an experimental tractor with a working plow attached was measured. Fuel consumption was determined using both approaches. Fuel consumption was determined using both approaches. The results show that the innovative fuel consumption method using satellite systems is closer to the actual fuel consumption of the machine. The method is

suitable for use by farmers without the need for a fuel consumption monitoring system.

CONCLUSIONS

An innovative methodology has been developed to determine the fuel consumption of tractors by determining its towing capacity.
The developed methodology uses satellite systems to determine tractor speed and soil moisture.
The methodology developed has been tested and shows the adequacy of the model.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

HEAVY METAL ACCUMULATION AND CHEMICAL COMPOSITION OF ESSENTIAL OILS OF WORMWOOD (*ARTEMISIA ABSINTHIUM* L.) CULTIVATED ON HEAVY METAL CONTAMINATED SOILS

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Abstract

Comparative research has been conducted to allow us to determine the content of heavy metals and chemical composition of wormwood oils, as well as to identify the possibility of wormwood growth on soils contaminated by heavy metals. The experimental plots were situated at different distances of 0.5 km, and 15 km, respectively, from the source of pollution the Non-Ferrous-Metal Works (MFMW) near Plovdiv, Bulgaria. On reaching flowering stage the wormwood plants were gathered. The content of heavy metals in leaves and flowering tips of wormwood were determined by ICP. The essential oils of the wormwood were obtained by steam distillation in laboratory conditions which were analysed for heavy metals and chemical composition was determined. Wormwood is a plant which is tolerant to heavy metals and can be grown on contaminated soils. Heavy metals do not affect the development of wormwood and the quality and quantity of oil obtained from it. Thirty-two components were identified in the oils. The main compounds of essential oi were as follows: β-Myrcene (2.24-28.20%), Sabinene (24.54-26.53%), Terpinene-4-ol (2.17-8.28%), beta-Linalool (2.24-6.27%), iso-Longifolol (4.40-5.59%), (E)-β-Caryophyllene (1.97-5.45%), Phytol (4.33-5.27%), γ-Terpinene (0.91-3.92%), Cembrene (1.24-2.72%), p-Cymene (0.11-2.50%), α-Terpinene (0.30-2.06%), Caryophyllene oxide (1.82-2.02%), β-Elemene (1.00-2.21%), α-14-hydroxy-Humulene (1.46-1.78%), α-Pinene (0.58-1.18%), (E)-9-epi-Caryophyllene (0.94-1.07%), Lavandulol (0.62-1.11%), cis-Sabinene hydrate (0.17-1.04%). The compounds in the essential oil that decreased as a result of heavy metals pollution are β-Myrcene, Sabinene, beta-Linalool, (E)-β-Caryophyllene, Cembrene, β-Elemene, Lavandulol, and cis-Sabinene hydrate, while the Terpinene-4-ol, Phytol, γ-Terpinene, p-Cymene, α-Terpinene, α-Pinene, and (E)-9-epi-Caryophyllene significantly increased. The essential oil of wormwood can be a valuable product for the farmers from polluted regions.

Key words*: contaminated soils, essential oil composition, heavy metals, wormwood.*

INTRODUCTION

Artemisia absinthium L. is a perennial shrub of the genus *Artemisia* and occurs as a weed in North Africa, Asia, Europe and New Zealand (Wang, 2004). The plant is known with different names such as wormwood (in English), grand absinthe (in French) and wermut (in German) (Wright, 2002). Common wormwood (*Artemisia absinthium*) is a perennial silver grey herbaceous plant, covered with a multitude of hairs with a pleasant aroma and a bitter taste. The stem is 40-120 cm high, branched at the top and woody at the base. Leaves on both sides are covered with silvery silk hairs. The flowers are tubular, yellow, without petioles, placed on a hairy torus. Wormwood blooms from July to September (Goud and Swamy, 2015).

Common wormwood has been known to humans as a spice and healing plant since ancient times. These properties are due to the essential oils, tannins, resins, flavonoids, fatty acids, vitamins (C, B6), minerals (K, Ca, P, Fe, Na) contained in common wormwood (Ahmad et al., 2010; Miron et al., 2014; Rachieru et al., 2017). Common wormwood contains 0.1-1.5% of oil (Orav et al., 2006; Basta et al., 2007; Msaada et al., 2015). The main components of oil are oxygen derivatives of bicyclic terpenes - the alcohol thiol and the ketone thujone, which are considered to be the characteristic ingredients for the wormwood oil (Juteau et al., 2003). The etheric oil also contains compounds such as monocyclic terpene phellandrene, bicyclic sesquiterpene cadinene and azulene sesquiterpene chamazulenogen, which is oxidized in the air to chamazulene. It has been proven that the bitter substances contained in the plant (absinthin) stimulate muscles of digestive organs, increase secretion of digestive juices and improve digestion (Miron et al.,

2014). The ingredients contained in the essential oil (thujone, thiol, etc.) excite the central nervous system and have a beneficial effect on neurological diseases (Lachenmeier et al., 2010). Chamazulene has an anti-inflammatory effect and the ability to remove spasms of the smooth muscle organs (stomach, bronchi, etc.). Common wormwood is used to treat gastritis and other inflammations of the stomach, liver and bile diseases (Ahmed et al., 2014).

Wormwood is an important ingredient of the absinthe liquor, and is also used for flavouring in some other alcoholic beverages and wines, such as vermouth (Judzentiene et al., 2009). Thujone levels in foodstuffs and beverages are limited by the EU (Council Directive 88/388/EEC), with the maximum levels (α- and β-thujones) 0.5 mg/kg.

Many studies have been done on the composition of *A. absinthium* oil (Chiavla et al., 1983; Tucker et al., 1993; Wright, 2003). Significant differences in the composition of wormwood oil were found. Thujones (*cis* and *trans*) were the principal components of wormwood oils from Argentina, Estonia, Greece, Italy, Spain, Ukraine, France, Iran, Serbia and Montenegro, USA, Poland, Croatia and Russia (Blagojevic et al., 2006; Chiavla et al., 1983; Khalilov et al., 2001; Lawrence, 2003; 2006; Morteza-Semnani and Akbarzadeh, 2006; Orav et al., 2006; Rezaeinodehi and Khangholi, 2008; Sacco and Chialva, 1988; Wright, 2003). *cis*-chrysanthenol (69.0%) is predominant in the oil from central France (Carnat et al., 1992), *cis*-epoxyocimene (49.7%) and *cis*-chrysanthenyl acetate (36.7%) in the oils from southern French Alps (Juteau et al., 2003), *cis*-epoxyocimene (76.3%) or *cis*-epoxyocimene (39.9%)/*cis*-chrysanthenyl acetate (33.4%) predominate in Spanish oils (Arino et al., 1999a, 1999b). Oils from Estonia, Russia and Italy also contain high levels of epoxyocimenes (59.7% in Estonia oil, 22.1% in Russian oil, 23.1-56.6% in Italian oil) (Chiavla et al., 1983; Orav et al., 2006). Monoterpene hydrocarbons (β-pinene - 34.0%, p-cymene - 14.6%, α-phelandrene - 25.5%, β-myrcene - 8.9% and sabinene - 14.4%) predominate in Iranian oils (Rahimizadeh et al., 2001; Sefidkon et al., 2003). High amounts of sabinene and β-myrcene are characteristic of oils from Estonia, Hungary, Scotland and Moldova (Orav et al., 2006). Oils from Estonia, France, Belgium, Russia, Armenia, Latvia, Italy and France are rich in sabinyl acetate (Chiavla et al., 1983; Lawrence, 2003; 2006; Orav et al., 2006; Wright, 2003). Turkish oils contain chamazulene (17.8%), nuciferyl butyrate (8.2%) and propionate (5.1%) (Kordali et al., 2005). Cuban oil contains bornyl acetate (23.0%) (Pino et al., 1997). Oils from Spain and Italy contain significant amounts of 1,8-cineole (18.0%), carvone (18.5%), thymol (10.8%) and carvacrol (9.7%), while *trans* verbenol is predominant in oils from Latvia and Lithuania (9.2% and 11.7%, respectively) (Orav et al., 2006). Greek oil contains caryophyllene oxide (25.3%), p-cymene (16.8%) 1,8-cineole (8.9%) and (Z)-lanceol acetate (7.3%) (Basta et al., 2007), whereas US oil contains 33.1% *trans*-thujone and 32.8% *cis*-sabinyl acetate (Tucker et al., 1993).

It has been found that the medicinal plants can accumulate larger amounts of heavy metals such as Cd, As, Pb and Hg compared to other plants (Kabata Pendias and Pendias, 2011). It is known that plants of the *Artemisia* family can accumulate metals from soils (Alirzayeva et al. 2006). The plants of the *Artemisia* family are also widespread in Bulgaria and have a large biomass production capacity. However, there are no studies on the possibilities of heavy metals accumulation in *Artemisia absinthium* L. when grown on contaminated soils, as well as the composition of wormwood oil in Bulgaria.

Insufficient is also the information available on the potential of wormwood for accumulation of heavy metals and its potential use for phytoremediation. There are no comprehensive studies on the relationship between the total content of heavy metals in soil, their uptake by the wormwood leaves and flowering tips and quality of oil.

The purpose of this work is to conduct a comparative study, which allows us to determine the quantities and deposits for accumulation of Pb, Zn, and Cd in the leaves and flowering tips of wormwood, the quality of wormwood oil, as well as the possibilities to use the wormwood for phytoremediation of heavy metal contaminated soils.

MATERIALS AND METHODS

The experiment was performed on an agricultural field contaminated by Zn, Pb, and Cd, situated at different distances (0.5 and 15.0 km) from the source of pollution, the NFMW near Plovdiv, Bulgaria.

Characteristics of soils are shown in Table 1. The soils were slightly neutral to alkalic with moderate content of organic matter and essential nutrients (N, P and K) (data are not shown). The pseudo-total content of Zn, Pb and Cd is high and exceeds the maximum permissible concentrations (MPC) in soil 1 (S1) (Table 1).

Table 1. Content of Pb, Zn and Cd in soils sampled from NFMW

Distance	pH	Pb x ± sd	Zn x ± sd	Cd x ± sd
Soil 1 (S1) 0.5 km	7.4	2509.1±6.5	2423.9±6.3	64.3±0.2
Soil 2 (S2) 15 km	7.5	49.4±0.2	172.7±2.1	1.0±0.1

x- average value (mg/kg) from 5 repetitions; sd - mean standard deviation
MPC (pH 6.0-7.4) - Pb -100 mg/kg, Cd-2.0 mg.kg, Zn-320 mg/kg
MPC (pH > 7.4) - Pb -100 mg/kg, Cd - 3.0 mg/kg, Zn -400 mg/kg

The study included wormwood grown on areas located at different distances (0.5 km and 1 km) from the source of contamination NFMW Plovdiv. Wormwood is grown according to conventional technology. Five plants of each area were used for the analysis. Upon reaching the stage of flowering, wormwood was harvested and the content of Pb, Zn and Cd in leaves and flowering tips was determined. The essential oil of the wormwood was obtained in laboratory conditions by steam distillation for 3 h using a Clevenger-type apparatus in accordance with European Pharmacopoeia method.

Pseudo-total content of metals in soils was determined in accordance with ISO 11466. The available (mobile) heavy metals contents were extracted in accordance with ISO 14870 by a solution of DTPA. The contents of heavy metals (Pb, Zn and Cd) in the plant material (leaves and flowering tips) and in the essential oil of sage were determined by the method of the microwave mineralization. The quantitative measures were carried out by ICP method (Jobin Yvon Emission - JY 38 S, France). Digestion and analytical efficiency of ICP was validated using a standard reference material of apple leaves (SRM 1515, National Institute of Standards and Technology, NIST). The chemical composition of the oils in hexane (1:1000) were analysed on Agilent 7890A Gas Chromatography system equipped with FID detector and Agilent 5975C mass spectrometer.

RESULTS AND DISCUSSIONS

Soils

The results presented in Tables 1 and 2 show that in the soil samples S1 (taken from the area situated at the distance of 0.5 km from NFMW), the reported values for Pb were exceeding MPC approved for Bulgaria and reached to 2509.1 mg/kg. In the area located at a distance of 15 km, the contents of Pb significantly reduce to 49.4 mg/kg. Similar results were obtained for Cd and Zn.

The results for the mobile forms of the metals extracted by DTPA show that the mobile forms of Cd in the contaminated soils are the most significant portion of its total content and reached to 57.2%, followed by Pb with 33.8 % and Zn with 9.8%.

In the soil located at a distance of 15 km from NFMW the mobile forms of Cd are the most significant part of its.

Table 2. DTPA-extractable Pb, Zn and Cd (mg/kg) in soils sampled from NFMW

Soils	Pb		Cd		Zn	
	mg/kg	%*	mg/kg	%	mg/kg	%
S1	849.1	33.8	36.8	57.2	236.8	9.8
S2	21.5	43.5	0.7	70	38.9	22.5

*DTPA -extractable/total content

Content of Heavy Metals in Wormwood

A significant accumulation of Pb is found in the leaves of the wormwood. The content of this element reaches up to 4414.9 mg/kg in leaves of the wormwood grown at a distance of 0.5 km from NFMW. Probably a portion of the accumulated heavy metals in the above-ground mass of the wormwood is also due to aerosol pollution, which can be explained by the anatomical and morphological characteristics of the crop. The greater accumulation of Pb in the above-ground mass is probably due to that the leaves and stems of the plant are covered

with fine silky hairs which favours the attachment of the aerosols and their accumulation therein. The content of Cd in the leaves of the wormwood grown at a distance of 0.5 km from NFMW reaches up to 225 mg/kg, respectively, values considered to be toxic to plants. According to Kabata Pendias and Pendias (2011), 5.0 mg/kg is considered to be a toxic value for the plants. Our results show the ability of the wormwood to accumulate Cd in the above-ground mass.

Table 3. Content of Pb, Cd and Zn (mg/kg) in leaves, flowering tips and essential oil of wormwood

Element	Distance km	Leaves x ± sd	Flowering tips x ± sd	Oils x ± sd
Pb	0.5 km	4414.9± 10.8	1223.3± 6.8	0.11+ 0.01
Pb	15 km	7.2±0.8	4.0±0.5	0.02± 0.01
Cd	0.5 km	225.1±3.5	163.9± 2.4	Nd
Cd	15 km	0.7±0.05	0.3±0.05	Nd
Zn	0.5 km	2461.8± 9.7	871.6± 6.9	0.44± 0.05
Zn	15 km	114.0±3.4	67.7±1.0	0.14± 0.02

x- average value (mg/kg) from 5 repetitions; sd - mean standard deviation, Nd- non detected

The content of Zn in the leaves of the wormwood grown at a distance of 0.5 km from NFMW reaches up to 2461.8 mg/kg, as these values are also higher than the critical values for plants: 100-400 mg/kg.

The content of heavy metals in the leaves of the wormwood grown at 15 km from NFMW reaches up to 7.2 mg/kg Pb, 0.7 mg/kg Cd and 114.0 mg/kg Zn.

The results obtained show that significant quantities of heavy metals are accumulated in the above ground part of wormwood, with their values significantly exceeding the widely accepted critical toxic levels (Marschner, 1995; Lobnik, 2004), but none of the symptoms of heavy metal toxicity have been detected. This shows that common wormwood has high tolerance to heavy metals. The results are in line with the findings of Alirzayeva et al. (2006), that in the *Artemisia* species studied, larger amounts of Zn are accumulated in their above ground parts. Zn concentrations vary from 600 to 900 mg/kg in the above ground mass, and from 100 to 330 mg/kg in the roots. The results we obtained are much higher than the results of Badea (2015) and Fischer et al. (2017) (5.37-14.42 mg/kg Pb, 0.118-0.434 mg/kg Cd and 0.005-0.012 mg/kg Zn) as well as the results of Chizola (2012) and Steff et al. (2009) (0-0.5 mg/kg Cd, 0-2.25 mg/kg Pb, and 41.3- 41.9 mg/kg Zn).

According to Rachieru et al. (2017), *Artemisia absinthium* L. has the ability to accumulate heavy metals mainly in the above ground parts (stems and leaves), when grown on a landfill. According to the authors, the high values of heavy metals in the above ground parts cannot be explained only by their absorption by the soil, but are also due to the adsorption of heavy metal aerosols from the air. Similar results were found by Imelouane et al. (2011), according to whom significant amounts of Pb and Cd in wormwood leaves are due to road traffic (Pb - 1036.1 mg/kg, Cd - 20.6 mg/kg, Zn - 798.1 mg/kg)

The heavy metal content in the flowering tips is considerably lower in comparison to the above-ground mass of the plants. The contents of Pb, Zn and Cd in the flowering tips of the wormwood grown at a distance of 0.5 km from NFMW reaches up to 1223.3 mg/kg, 871.6 mg/kg and 163.0 mg/kg, respectively. With increasing the distance from NFMW, a clear trend is seen towards reducing the content of heavy metals in the flowering tips of the studied crop. Significantly lower is the content of heavy metals in the flowering tips of the wormwood grown at 15 km from NFMW. The content of Pb in the flowering tips reaches up to 4.0 mg/kg, Zn - up to 67.7 mg/kg and Cd - up to 0.3 mg/kg. Probably a portion of the accumulated heavy metals in the flowering tips of the wormwood is due to the aerosol pollution (Table 4).

The heavy metal content in the essential oil from wormwood was also determined. The results obtained show that the majority of the heavy metals contained in the flowering tips of the wormwood do not pass into the oil during the distillation, therefore their content in the oil are much lower. Pb content in the essential oil of wormwood reaches up to 0.11 mg kg, Zn up to 0.44 mg/kg, while the content of Cd is below the limits of the quantitative measurement of the method used. Significantly lower are the results in the essential oil of wormwood grown at a distance of 15 km from NFMW - 0.02

mg/kg Pb and 0.14 mg/kg Zn. The results obtained shows that the content of heavy metals in the essential oils is much lower compared to the leaves and flowering tips of the wormwood, and the amounts of Pb, Zn and Cd in the oil of wormwood are lower than the accepted maximum values and meet the requirements of an environmentally friendly product (0.1 mg/kg Pb, 0.05 mg/kg Cd). The results are confirming the ones established by Angelova et al. (2015), which found that the heavy metal content in the essential oil is very low and is not affected by the level of soil contamination with heavy metals. Essential oils contain only traces of heavy metals in distilled oils because these metals have too heavy and large molecules to be volatilized enough and to be concentrated by the distillation process.

Essential oil content and composition

Oil content of wormwood from different European countries was reported as 0.1-1.1% (Orav et al., 2006). Evaluating our results of oil content measurements, it can be established that our results are in accordance with those of previous reports and corresponded to the European Pharmacopoeia standard (not less than 0.2%).

The results of the chromatographic analysis of essential oils obtained by processing the leaves of wormwood grown at a different distance from NFMW-Plovdiv are presented in Table 4.

Figure 1 shows the chromatograms from the GC MS analysis of wormwood oil.

The results show that wormwood oil is a complex mixture of monoterpenes, monoterpenoids, sesquiterpenes, and 32 compounds (Table 4) were identified that represent 97.51-97.95% of total oil content.

The main compounds of essential oils were as follows: β-myrcene (26.24-28.20%), sabinene (24.54-26.53%), terpinene-4-ol (2.17-8.28%), beta-linalool (2.24-6.27%), iso-longifolol (4.40-5.59%), (E)-β-caryophyllene (1.97-5.45%), phytol (4.33-5.27%), γ-terpinene (0.91-3.92%), cembrene (1.24-2.72%), p-cymene (0.11-2.50%), *α*-terpinene (0.30-2.06%), caryophyllene oxide (1.82-2.02%), β-elemene (1.00-2.21%), *α*-14-hydroxy-humulene (1.46-1.78%), *α*-pinene (0.58-1.18%), (E)-9-epi-caryophyllene (0.94-1.07%), lavandulol (0.62-1.11%), *cis*-sabinene hydrate

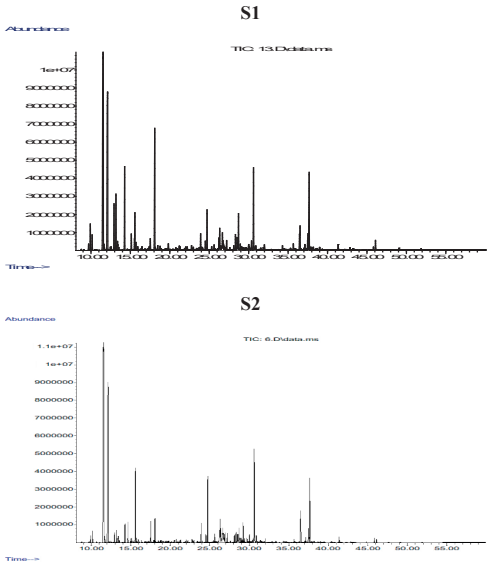

Figure 1. Chromatograms of the essential oil from the wormwood (*Artemisia absinthium* L.) grown in the region of NFMW-Plovdiv

(0.17-1.04%). There are significant compositions differences for most components between oils obtained from areas located at different distances from NFMW-Plovdiv, which have varying degrees of pollution.

The results obtained show that monoterpenic hydrocarbons (sabinene, β-myrcene, cambrene, p-cimene, α-terpinene, α-pinene) are predominant in oil, but significant differences in their content are observed in oils from contaminated and uncontaminated area.

The content of sabinene ranges from 24.54% in the contaminated soil (S1) to 26.53% in the uncontaminated area (S2); β-myrcene from 26.24% (S1) to 28.21% (S2), cambrene from 1.24% (S1) to 2.72% (S2); α-terpinene from 0.299% (S2) to 2.06% (S1); p-cimene from 0.11% (S2) to 2.5 (S1); and α-pinene from 0.58% (S2) to 1.18% (S1).

Higher levels of monoterpenic hydrocarbons α-terpinene, α-pinene, camphene, and p-cimene are observed in the oils from the contaminated area

Table 4. Composition of wormwood oil (%) obtained by processing fresh leaves and flowering tips of wormwood grown in the region of NFMW

№	Composition	RI	S1 (0.5 km)	S2 (15.0 km)
	Oil content, %			
	Compound		% of TIC	
1	α-Pinene	939	0.58	1.18
2	Camphene	953	0.33	0.73
3	Sabinene	969	26.53	24.54
4	β-Pinene	979	0.57	0.26
5	β-Myrcene	991	28.20	26.24
6	α-Terpinene	1014	0.30	2.06
7	p-Cymene	1026	0.11	2.5
8	Eucalyptol	1031	0.58	0.22
9	γ-Terpinene	1054	0.907	3.93
10	*cis*-Sabinene hydrate	1065	1.039	0.17
11	Terpinolene	1086	0.23	0.73
12	beta-Linalool	1097	6.27	2.24
13	n-Nonanal	1102	0.19	0.38
14	Lavandulol	1165	1.11	0.62
15	Terpinene-4-ol	1177	2.17	8.28
16	α-Terpineol	1189	0.31	0.16
17	*trans*-Piperitol	1207	0.42	0.15
18	p-Cumic aldehyde	1238	0.22	0.18
19	Geranial	1270	0.58	0.25
20	Perillaldehyde	1273	0.97	0.78
21	Lavandulyl acetate	1288	0.17	0.13
22	β-Elemene	1389	2.21	1.01
23	(E)-β-Caryophyllene	1419	5.45	1.97
24	α-Caryophyllene	1454	0.38	0.51
25	(E)-9-epi-Caryophyllene	1465	0.94	1.07
26	*trans*-Nerolidol	1567	0.43	1.04
27	Caryophyllene oxide	1581	1.82	2.02
28	α-14-hydroxy-Humulene	1700	1.46	1.78
29	Longifolol	1713	0.83	1.51
30	iso-Longifolol	1728	5.59	4.40
31	Cembrene	1937	2.72	1.24
32	Phytol	1942	4.33	5.23
	Total		97.95	97.51

RI - Relative Index; TIC - Total Ion Current compared to the oil from the uncontaminated area.

Significant amounts of oxygenated monoterpenes were also found in the oils: β-linalool, which ranges from 2.24% (S1) to 6.27% (S2); phytol - from 4.33% (S2) to 5.27 (S1); terpinene-4-ol - from 2.17 (S2) up to 8.28% (S1), perillaldehyde from 0.78 (S1) to 0.97% (S2). Higher levels of oxygenated monoterpenes terpinene-4-ol, phytol, and n-nonanal are observed in the oils from the contaminated area compared to the oil from the uncontaminated area.

The content of sesquiterpene hydrocarbons ((E)-B-caryophyllene, α-caryophyllene, (E)-9-epi-caryophyllene, α-14-hydroxy-humulene, longifolol and iso-longifolol, β-elemene) in the oils has been determined, their quantity being higher in oils from uncontaminated area (S2).

The oils also contain oxygenated sesquiterpenes (*trans*-nerolidol and caryophyllene oxide), their quantity being higher in oil from contaminated area (S1).

Chialva et al. (1983) describe six different chemotypes of European *A. absinthium*, three "pure" chemotypes: (a) (Z)-6,7-epoxyocimene (Italy), (b) sabinyl acetate (France), and (c) β-thujone (Italy), and three "mixed" chemotypes: (d) β-thujone/(Z)-6,7-epoxyocimene, (e) β-thujone/sabinyl acetate, and (f) (Z)-6,7-epoxyocimene/chrysanthenyl acetate/sabinyl acetate (Italy, Siberia and Romania). The content of sabinene and myrcene in these chemotypes was low (0.1-6.3%).

Orav et al. (2006) found three additional chemotypes of *A. absinthium*: (g) sabinene/myrcene (Estonia), (h) neryl butanoate (France) and (i) 1,8-cineole (Spain).

The results show that wormwood oil from contaminated and uncontaminated area belongs to sabinene and myrcene rich chemotype. Orav et al. (2006) found that monoterpenes predominate with high amounts of sabinene and β-myrcene (21.2% and 25.6%) in some of the oils from Estonia. Comparatively large contents of sabinene and β-myrcene (9.2-38.9%) were also found in the oils from wormwood growing in Hungary, Scotland and Moldova).

Judzentiene et al. (2004) found that monoterpenoids comprised a large part (55.7-80.2%) of wormwood oils, as well as oxygenated monoterpenes (47.1-66.7%) formed about a half of oil content. A high content of oxygenated sesquiterpenes (11.9-29.8%) characterized the samples from Italy, Latvia, Lithuania and Germany (Orav et al., 2006). Msaada et al. (2015) found that in oils

from Tunisia, monoterpene hydrocarbons (45.31-62.08%) predominated, with the main component chamazulene (39.93%).

The compounds in the studied essential oils that decreased as a result of heavy metals pollution are β-myrcene, sabinene, beta-linalool, (E)-β-caryophyllene, cembrene, β-elemene, lavandulol and cis-sabinene hydrate, while the terpinene-4-ol, phytol, γ-terpinene, p-cymene, α-terpinene, α-pinene, and (E)-9-epi-caryophyllene significantly increased.The observed differences in the profile of the essential oils of wormwood when grown on contaminated and uncontaminated soils may be related to soil contamination.

The chromatographic profile shows a complex mixture of components contained in wormwood oil. Figure 2 shows the classification of the identified compounds based on functional groups. The highest is the content of monoterpenic hydrocarbons (60.47-63.39%), followed by oxygenated monoterpenes (17.71-18.50%), sesquiterpene hydrocarbons (12.24-16.86%), oxygenated sesquiterpenes (2.21-3.06%) and non-terpene derivates (0.14-033%).

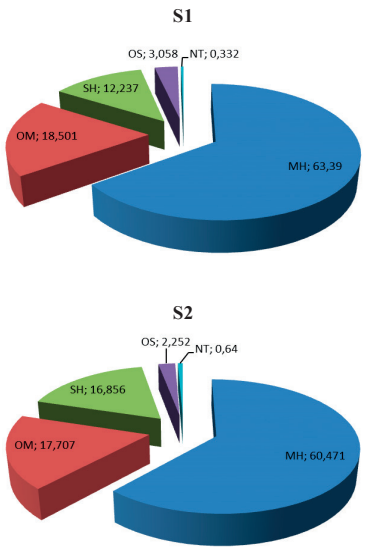

Figure 2. Classification of the identified compounds based on functional groups (OM - oxygenated monoterpenes; MH - monoterpenic hydrocarbons; OS - oxygenated sesquiterpenes;SH - sesquiterpene hydrocarbons; NT - and non-terpene derivates)

CONCLUSIONS

Based on the results obtained the following conclusions can be made:

1. *Artemisia absinthium* L. is a plant which is tolerant to heavy metals and can be grown on contaminated soils.
2. The amounts of Pb, Zn and Cd in the oil of wormwood grown on contaminated soil (Pb - 2509.1 mg/kg, Zn - 2423.9 mg.kg, Cd - 64.3 mg/kg) are lower than the accepted maximum values and meet the requirements of an environmentally friendly product.
3. Processing of the leaves and flowering tips to oil and the use of the wormwood oil will significantly reduce the cost of phytoremediation.
4. Wormwood oil from contaminated and uncontaminated area belongs to sabinene and myrcene rich chemotype.
5. The highest is the content of monoterpenic hydrocarbons in essential oils of wormwood (60.47-63.39%), followed by oxygenated monoterpenes (17.71-18.50%), sesquiterpene hydrocarbons (12.24-16.84%), oxygenated sesquiterpenes (2.21-3.06%), and non-terpene derivates (0.14-033%).
6. The compounds in the essential oil that decreased as a result of heavy metals pollution are β-Myrcene, Sabinene, beta-Linalool, (E)-β-Caryophyllene, Cembrene, β-Elemene, Lavandulol and *cis*-Sabinene hydrate, while the Terpinene-4-ol, Phytol, γ-Terpinene, p-Cymene, α-Terpinene, α-Pinene and (E)-9-epi-Caryophyllene significantly increased.
7. The essential oil of wormwood can be a valuable product for the farmers from the polluted areas.

ACKNOWLEDGEMENTS

The financial support by the Bulgarian National Science Fund Project DFNI H04/9 is greatly appreciated.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

IMPROVING OF TRANSPORT DIESEL ENGINES ENERGY EFFICIENCY AND ENVIRONMENTAL SAFETY BY FUMIGATION OF AIR CHARGE

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Abstract

The paper is devoted to the problem of improving of energetic efficiency and ecological safety of automotive diesel engines. To solve this problem, it is proposed to use the method of fumigation of air charge with different liquid activators (alcohol, biodiesel, gasoline, kerosene) in the diesel engine at the intake stroke. For the practical realization of such method, a concept of technical solution was formulated and a theoretical foundation was performed. An algorithm of device, performing automatic activator injection at different speed and load modes, was developed. The technical means (microprocessor unit, electromagnetic injectors and sensors) for single-point and multi-point injection of liquid activator into the intake manifold were designed, patented and researched. Depending on activator type and dose, fumigation of air charge with invented devices promotes to reduce exhaust smoke opacity by 10-50 percent and brake specific fuel consumption by 3-14 percent. Simultaneously, the brake power increases by 3-12 percent. These completed studies confirm the efficiency and practical applicability of fumigation of air charge on diesel-powered automotive machinery.

Key words*: diesel engine, ecological safety, fumigation of air charge, system, smoke opacity, transport.*

INTRODUCTION

Energetical efficiency and ecological safety of transport machinery powered by diesel engines, represents an actual and practically significant problem. One of the methods for solving such problem is the fumigation of air charge in the diesel engine at the intake stroke with liquid activators such as alcohol, gasoline, biodiesel, etc. (Imran et al., 2013; Ou et al., 2012).

The analysis of existent mechanical devices for fumigation of air charge was performed. It shows that these devices carburetor is the most used device for activator fumigation in diesel engine (Mariasiu et al., 2015), but it is not able to ensure the automatic regulating of required percentage (dose) of activator and fuel at the different diesel engine speed and load modes.

Improving the precision of activator dosage is possible with the help of electronic controlling over the electromagnetic injectors, placed on the diesel engine in the intake manifold (Stanglmaier, 2004).

MATERIALS AND METHODS

For the practical realization of this way, the single point and multi-point injection systems for hydrocarbon fumigation of air charge in the diesel engine were developed, manufactured and researched.

The quantity of activator supplied into the intake manifold usually amounts from 10 % to 20 % of standard motor fuel dose injected into the combustion chamber by the standard fuel system. This dose may be supplied at reduced cyclic feed of motor fuel (when fuel dose is partially replaced accordingly to activator dose) or at standard cyclic feed. In the first case, it leads to improving diesel engine parameters at all operating modes, in the second case - to boosting the diesel engine at short-term overload mode.

The single point injection system for fumigation of air charge supplies activator with electric pump (2) (Figure 1) to the electromagnetic injector (3) placed in the intake manifold (4)) of the diesel engine.

The functioning of injector is controlled by electronic control unit (ECU) 7 in according with signals from the engine crankshaft rotation speed sensor (5) and the high-pressure pump (HPP) rack motion sensor (6). When the control voltage supplied from ECU in the circuit of the electromagnetic injector is high (positive impulse), it injects the activator into the intake manifold. When the control voltage is low (zero impulse), the injection is stopped.

In depending on engine speed and load operational mode, the quantity of activator supply is changed by varying of control impulse (width of pulse is from 7 to 700 m/sec and pause is from 25 to 325 m/sec) in accordance with initial setting of adjustors (11) and (12) for certain percentage of diesel fuel and activator.

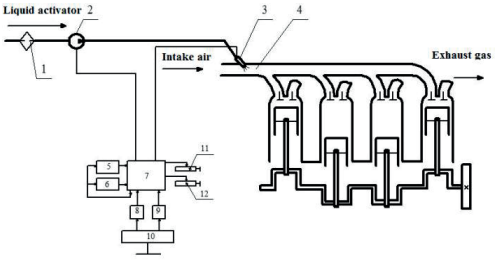

Figure 1. The single point injection system for fumigation of air charge with activator: 1 - filter; 2 - electric pump; 3 - electromagnetic injector; 4 - intake manifold of the diesel engine; 5, 6, 8, 9 - sensors of: crankshaft rotation speed, high pressure pump rack motion, temperature of coolant, onboard power voltage; 7 - electronic control unit; 10 - power source; 11, 12 - adjustors for initial settings of width and pause of impulse signal

The basic elements of the single point system for fumigation of air charge are shown in Figure 2.

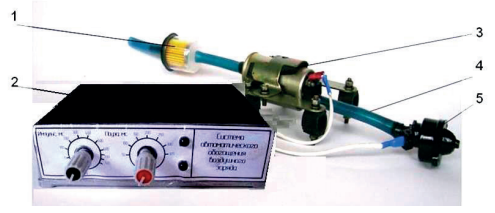

Figure 2. The basic elements of the single point system for fumigation of air charge: 1 - filter; 2 - electronic control unit; 3 - electric pump; 4 - connecting hoses; 5 - electromagnetic injector

A disadvantage of for single-point fumigation of air charge is some inequality of distribution of air and activator mixture, when it enters the cylinders of the diesel engine at the intake stroke. As a solution of this problem, the multi-point fumigation of air charge with activators may be used, when the number of electromagnetic injectors is equal to the number of engine cylinders. The injectors are placed in the engine inlet ports in close proximity to inlet valves of gas distribution mechanism (Figure 3).

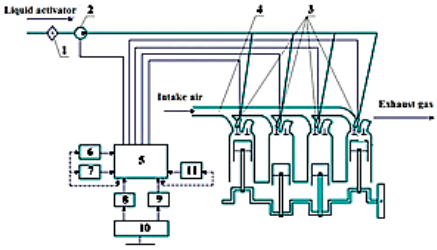

Figure 3. The multi-point injection system for fumigation of air charge with activator: 1 - filter; 2 - electric pump; 3 - electromagnetic injector; 4 - intake manifold of the diesel engine; 5 - ECU; 6, 7, 8, 9, 11 - sensors of: crankshaft rotation speed, high pressure pump rack motion, temperature of coolant, onboard power voltage and phase; 10 - power source

However, many diesel engines do not have separate branches of intake manifold for each cylinder, therefore the mounting of injectors requires the modification of the cylinder head. The most popular wheeled agricultural tractors in Russia is MTZ tractors powered with four-cylinder four-stroke D-243 diesel engine produced by the Minsk Motor Plant (Belarus). This engine has only two inlet ports in cylinder head per four cylinders. In their turn, such ports are connected with two branches of the intake manifold, and the fresh air charge arrives into a pair of neighbouring cylinders through them at the intake stroke.

For this reason, for the practical embodiment of multi-point injection of activator on diesel engines, fitted with such intake manifold, a two-point system for the fumigation of air charge is an effective technical solution.

The electromagnetic injectors (4) (Figure 4) are placed in the insertions (2) at the branches of the standard intake manifold (1). The upper flanges of the insertions (2) are connected with manifold's branches. The lower flanges of the insertions are connected with inlet ports of the cylinder head.

The input channels of the injectors (4) are placed at the outlet pipes of the rail (3), which is used as a pipeline for activator supply. A pressure governor (5) is placed at the dead end of the rail. It is intended for regulation of activator pressure and for bypassing of excess activator back to the tank.

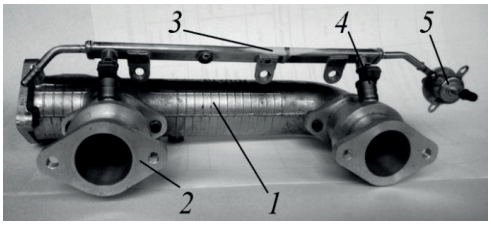

Figure 4. The intake manifold for two-point injection system for fumigation of air charge of the diesel engine: 1 - standard intake manifold; 2 - insertion; 3 - rail; 4 - electromagnetic injector; 5 - pressure governor

Two-point activator supply into the branches of the intake manifold is performed by two electromagnetic injectors: the 1st injector performs fumigation of air charge incoming into the 1st and 2nd cylinders; the 2nd injector - into the 3rd and 4th cylinders.

The order of operation of injectors is agreed to cylinders firing order (1-3-4-2). The quantity of activator supply should to correspond to the certain adjusted dose (10% or 20% of fuel consumption) at the different engine speed and load modes. Thus, for implementation of certain dose of activator supply, the primary objective is the development of operational algorithm of electromagnetic injectors and substantiation of parameters of control electrical impulses supplied on the injectors.

The firing order of cylinders is 1-3-4-2. The four-stroke four-cylinder diesel engine performs the intake stroke once per two rounds of the crankshaft in each cylinder. Thus, each electromagnetic injector, working for two cylinders, performs injection of activator once per every crankshaft revolution. So, the order of operation of electromagnetic injectors of two-point system for fumigation of air charge is 1-2-2-1.

As the electromagnetic injectors execute the injection of activator on cue of impulses formed by electronic control unit, so the datum point is the start of intake stroke in the 2nd cylinder.

In this case, the firing order of cylinders may be written as 2-1-3-4, so the order of operation of electromagnetic injectors will be 1-1-2-2. Thereby, the injectors perform pairwise cyclical injection of activator into the branches of the intake manifold.

A diagram of control impulses shown at Figure 5 is displaying the operational algorithm of the electromagnetic injectors of two-point system for fumigation of air charge.

It follows from the diagram, that each injector interchanges its angular phases between the moments of start of activator injection. These phases are 180 degrees and 540 degrees of crank angle (°CA).

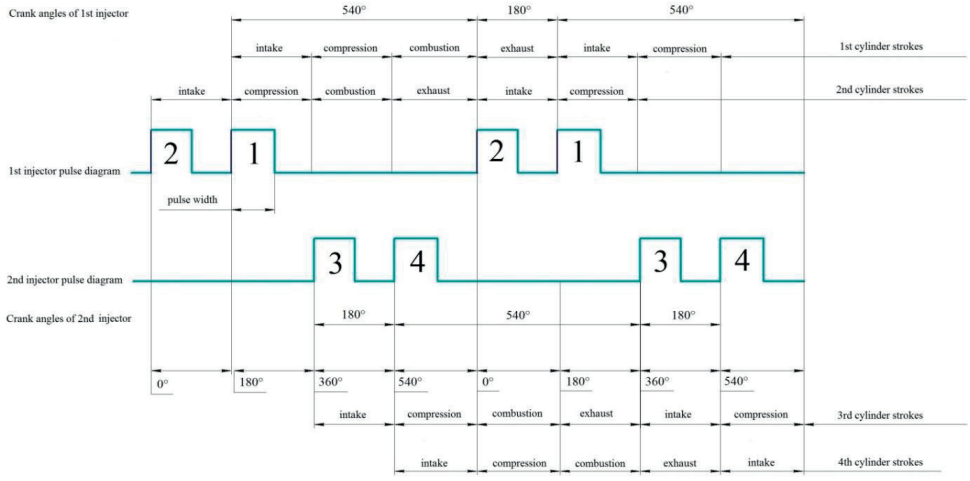

Figure 5. The control pulse diagram for multi-point fumigation of air charge on four-cylinder diesel engine with two electromagnetic injectors (1, 2, 3, 4 are the numbers of cylinders at the intake stroke)

For example, when a control impulse is supplied to the 1st injector, it injects a certain dose of activator into the 2nd cylinder at the start of intake stroke during a period *T* and angle φ. Then a pause between impulses ensues during φ = 180°CA («short-term» pause). Thereafter, the 1st injector injects activator into the 1st cylinder during the same period *T* and angle φ. After that, a pause between impulses follows during φ = 540°CA («long-term» pause) till the moment when the intake stroke in the 2nd cylinder will start again.

During the «long-term» pause in the 1st injector, the 2nd injector in the same order and with the same period *T*, injects activator into the 3rd cylinder, then into the 4th cylinder. Thereafter, «long-term» pause acts in the 2nd injector, the 1st injector turns on again, and the the duty cycle repeats. Thus, each injector interchange «long-term» pause and «short-term» pause between the control pulses.

It was theoretically determined, that to implement the multi-point fumigation of air charge, depending on the activator dose and the engine speed and load mode, the cyclic dose of activator amounts may be from 1 mg per cycle to 13 mg per cycle, while the activator injection duration is from 0.27 m/s to 3.5 m/s (Ryblov et al., 2018).

The design of two-point injection system for fumigation of diesel engine air charge is given at the Figure 6.

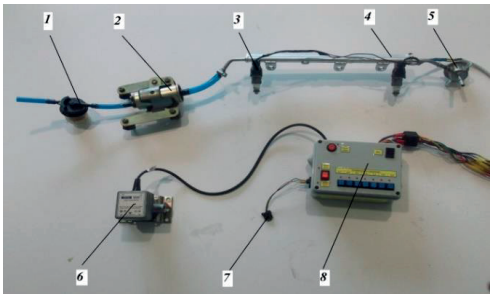

Figure 6. The design of two-point injection system for fumigation of air charge with liquid activator:
1 - filter; 2 - electric pump; 3 - electromagnetic injector; 4 - rail; 5 - pressure governor; 6 - fuel flow meter; 7 - phase and crankshaft rotation speed sensor; 8 - electronic control unit

The system contains filter (1), electric pump (2), two electromagnetic injectors (3) fixed in the outlet pipes in the rail (4), pressure governor (5), fuel flow meter (6), phase and crankshaft rotation speed sensor (7) and ECU (8).

The fuel flow meter (6) is used as an engine load mode sensor and serves to provide the required activator dose (10% or 20% of fuel consumption). It is placed low-pressure fuel pipeline of the standard fuel system of the diesel engine (between the coarse fuel filter and low-pressure feed pump). The phase sensor and crankshaft rotation speed sensor is united into one sensor designed on the base of Hall Sensor. The intake strokes in cylinders are determined by the angle of high-pressure fuel pump drive shaft.

The technical solutions used during the developing systems for single-point and multi-point fumigation of air charge are protected by 10 Patents of Russian Federation (No. 2392481, 2383757, 72018, 157301, 2518711, 176498, 2514544, 2515586, 177583, 2330173).

An experimental research of fumigation of air charge with liquid activators by the single point and multi-point injection systems were carried out on brake setup, including the four-cylinder four-stroke D-243 diesel engine, KS-56/4 dynamometer brake and measuring apparatus. The following activators were used: gasolines RON80, RON92 and RON95, aviation kerosene TS-1, summer diesel oil L-0.2-62, ethanol, methanol, rapeseed methyl ester (RME) and biodiesel blends: 50% RME + 50% diesel; 50% rapeseed oil + 50% diesel; 20% safflower oil + 80% diesel.

RESULTS AND DISCUSSIONS

The results of engine motor tests show that single-point fumigation of air charge with the dose 10% of gasoline RON80 or RON92 reduces exhaust smoke opacity by 4-6% (Figure 7). Simultaneously, the brake specific fuel consumption (BSFC) is less by 8-11%, when the brake power (BP) increases by 7-10% in comparison with the engine operation in standard specification without fumigation of air charge.

With the fumigation of air charge by the dose 10% of kerosene TS-1, smoke opacity reduces by 11%, BSFC decreases by 6%, BP increases by 5%.

With the 10% dose ethanol fumigation, smoke opacity reduces by 11%, BSFC decreases by 3%, BP increases by 3%.
More significant reduction of exhaust smoke opacity was observed with the 10% dose methanol fumigation (by 19%) and RME biodiesel (by 21%), but BSFC increases by 4-6%, when BP decreases by 3-4 %.

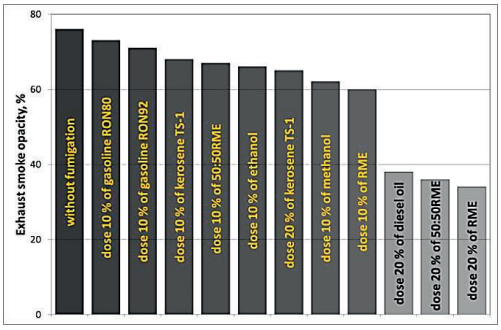

Figure 7. The exhaust smoke opacity of four-cylinder four-stroke D-243 diesel engine at the maximum torque at the engine speed 1400-1600 rpm

Fumigation of air charge with 20% dose of summer diesel oil L-0.2-62 leads to reducing smoke opacity by 22%, when shift of BP and BSFC is not significant.
The most significant reduction of exhaust smoke opacity was achieved with the 20% doses of RME and biodiesel blend 50% RME + 50% diesel: by 50% and by 45%, respectively. Simultaneously, BSFC increases by 5-6%, when BP decreases by 4-5%.
Two-point fumigation of air charge allows to improve diesel engine energetic parameters (BP and BSFC) by 3-4% in comparison with single-point fumigation. Simultaneously, the reducing of the exhaust smoke opacity is nearly the results obtained with single-point fumigation.
For example, Figure 8 shows the shift of engine exhaust smoke opacity with two-point fumigation of air charge by 10% doses of kerosene TS-1, ethanol, biodiesel blend 50% RME + 50% diesel, RME, as well as 20% doses of biodiesel blend and RME.
The most significant reduction of BSFC (by 14%) was achieved with the two-point fumigation of air charge by 10% dose of gasoline RON92, when brake power increased by 12%.

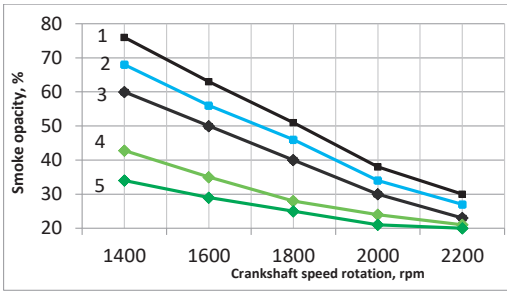

Figure 8. D-243 diesel engine exhaust smoke opacity with two-point fumigation of air charge:
1 - without fumigation; 2 - with fumigation by 10% dose of kerosene TS-1, ethanol or biodiesel blend;
3 - with fumigation by 10% dose of RME; 4 - with fumigation by 20 % dose of biodiesel blend; 5 - with fumigation by 20% dose of RME

CONCLUSIONS

As a result of study, the technical means for single-point and multi-point fumigation of air charge in the diesel engine were designed, patented and researched.
The results of diesel engine motor tests show that the best parameters are achieved with multi-point fumigation of air charge by activator dose 10% or 20%.
Fumigation of air charge in diesel engine allows to reduce exhaust smoke opacity by 10-50% and decrease brake specific fuel consumption by 3-14% when brake power may increase by 3-12%.
The performed study evidences the efficiency of activator fumigation in diesel engine. It promotes to improving of ecological and energetic parameters of diesel engines used on the transport machinery.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

EFFECTS OF SOIL POLLUTION WITH HEAVY METALS ON PLANT SEEDS OF *BRASSICA NAPUS, PISUM SATIVUM* AND *SECALE CEREALE*

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Abstract

In the paper we studied the effects of soil pollution with cadmium, chromium and zinc on the germination and roots elongation of rape (Brassica napus), peas (Pisum sativum) and rye (Secale cereale). The soil used in the experiments was an OECD reference soil. The soil was contaminated with solutions of $CdCl{\cdot}H_2O$, $K_2Cr_2O_7$ and $ZnSO_4{\cdot}7H_2O$ in concentrations from 200 mg/kg to 1200 mg/kg. At the maximum pollutant concentration in the respective soil, 1200 mg/kg, the lowest germination rate was obtained for pea seeds 34% (in the case of chrome soil pollution), for rye seeds 50% and 60%, respectively for seeds of rapeseed (in case of soil pollution with zinc). As far as elongation of the roots is concerned, zinc was the metal that most affected their growth. Thus, the root length decreased in the case of Pisum sativum from 44.08 mm (0 mg/kg) to 0.86 mm (at the concentration of 1200 mg/kg). Chromium was the only metal whose effect on rye seeds was the reverse, namely, to stimulate germination and to lengthen the roots with increasing soil concentration.

Key words*: effect, germination, root elongation.*

INTRODUCTION

Heavy metal pollution is a global problem, degrading the environment and being a serious threat to human health. The underlying causes are anthropic activities such as mining, irrigation with wastewater, applying sludge to wastewater and applying chemical fertilizers, as well as rapid industrialization (Zhang et al., 2019; Onyenmechi et al., 2020; Wuana and Okieimen, 2011; Antonkiewicz et al., 2018).

Thus, heavy metals can cause serious ecotoxicological problems because they are non-degradable and persistent in the environment (Rana, 2008; Cortés-Eslava et al., 2018).

In different plant species heavy metals can alter the membrane permeability, reduce enzyme activities, disturb mineral nutrition, damage the photosynthetic apparatus, and generate oxidative stress, therefore affecting the morphology, growth and photosynthetic processes of plants. Excess of heavy metals in cells induces molecular damage to plants mainly through the synthesis of reactive oxygen species such as superoxide radical, hydroxyl radical and hydrogen peroxide (Verma et al., 2003; Steliga et al., 2020).

Heavy metal contamination not only affects the functioning of the ecosystem, but also represents potential threats to human health, because these metals could be absorbed by humans through the food chain. Therefore, remediation of heavy metal-contaminated soil is important for improving the health of the ecosystem and humans (JunKang et al., 2020).

Physical and chemical methods of soil depollution involve high costs and can cause the damage of soil structure (Smolinska, 2015; Liu, 2019).

Phytoremediation is a cost-effective and environmentally friendly strategy for decontamination of soil contaminated with heavy metals, which involves the use of plants that have the ability to absorb metals from the soil and transfer them to its upper parts (Farrag et al., 2012; Salati et al., 2010; Turgut et al., 2004). Anyway, the efficiency of phytoremediation may be limited by low plant biomass, low rate of root translocation, and low bioavailability of metals in soils (Khan et al., 2000; Zaier et al., 2010). One method of

determining the metal concentration in the soil from which the plants are affected, both at germination and root lengthening is the use of Phytotoxkit toxicity tests.
These tests presents the following advantages: set-up is simple and rapid; little bench space and incubation space are required; transparent test plates allows direct observation of the germinated seeds without any manipulation; images of the test plates with the germinated seeds are easily stored and accessed using computers; rapid, automated root-length measurements are feasible using image-analysis techniques; multiple tests are carried out concurrently (Wadhia and Clive Thompson, 2007; Janssen et al., 2000).
The objective of this study is to determine the toxicity of cadmium, chromium and zinc on the germination and elongation of the roots of rapeseed (*Brassica napus*), peas (*Pisum sativum*) and rye (*Secale cereale*).

MATERIALS AND METHODS

The soil used in the performed Phytotoxkit toxicity tests was purchased by order from MicroBioTests Inc in Belgium. This is a reference soil (Figure 1) used especially in this type of tests and has the following composition, according to the distributor: air-dried quartz sand (85%), kaolin clay (10%), sphagnum peat (5%), calcium carbonate (to obtain an initial pH of 6.5-7.0).

Figure 1. The soil used in experiments

25 g of soil was introduced into the bottom of the Phytotoxkit plate. It was contaminated with solutions of $CdCl \cdot H_2O$, $K_2Cr_2O_7$ and $ZnSO_4 \cdot 7H_2O$ in concentrations from 200 mg/kg to 1200 mg/kg. Distilled water was used to saturate the soil of the control sample. The polluted soil was then covered with a filter paper on which 10 plant seeds were placed in the case of rape and rye and 6 seeds in the case of peas, at a distance of 1 cm one from another. The plant seeds were purchased from the Plant Genetic Resources Bank Suceava, Romania. Pictures of seeds used in experiments can be seen in Figures 2, 3 and 4.

Figure 2. Seeds of *Pisum sativum*

Figure 3. Seeds of *Secale cereale*

Figure 4. Seeds of *Brassica napus*

After closing the plates with the transparent lid, they were placed vertically in a support and incubated in the dark at a temperature of 25 ± 1ºC for 3 days. Each experimental variant was performed in 3 repetitions. At the end of the incubation period, photos of the germinal plants were taken for each Phytotoxkit plate.
The percentage of seed germination inhibition (Rg) and root elongation (RI) for each plant was calculated with Eq. 1 (Oleszczuk, 2008):

$$Rg/RI = \frac{A-B}{A} \cdot 100 \quad (1)$$

where:

- A is the seed germination or the average length of the roots in the control sample;
- B seed germination or average root length under the influence of the applied pollutant.

Root elongation was measured using the Image Tool 3.0 software.

RESULTS AND DISCUSSIONS

After the 3 days of incubation, we can first visualize the germinated seeds and the elongation of the studied plants roots. The figures below present the effect of the pollutant for each plant studied separately (Figures 5, 6, 7).

Figure 5. Seed germination and root lengthening of *Pisum sativum* under the influence of soil pollution with Cd from 0 mg/kg to 1200 mg/kg

Figure 6. Seed germination and root lengthening of *Brassica napus* roots under the influence of soil pollution with Zn from 0 mg/kg to 1200 mg/kg

It can be seen that the most affected by pollution soil with the studied metals in terms of germination, was pea.
The germination rate of the above mentioned three types of seeds, under the influence of the applied pollutant, was calculated and the obtained results are presented in Table 1.

Figure 7. Seed germination and elongation of *Secale cereale* roots under the influence of soil pollution with Cr from the concentration of 0 mg/kg to 1200 mg/kg

At the maximum pollutant concentration in the respective soil, 1200 mg/kg pea seeds had a germination rate of 68% in case of soil pollution with Cd, 34% in case of soil pollution with Cr and 35% in case of soil pollution with Zn.
The germination rate of rapeseed was 80% in case of soil pollution with Cr and 60% in case of soil pollution with Zn.
Germination was not affected in the case of soil contamination with Cd, the germination rate being 100%. In the case of rye seeds, the germination rate of the soil with Zn was 50% and the soil pollution with Cd of 80%.
The only metal that did not affect the germination of the rye seeds was chromium, its effect being inverse, to stimulate germination as the pollutant concentration in the soil increased.
As for the root's elongation, their length has depended on the metal concentration in the soil. The higher the concentration, the smaller the length of the roots was, except for the rye in the case of pollution of the soil with chromium, which stimulates the growth of the roots.
For each studied plant, it was determined the average of the roots length and the obtained results can be seen in the following figures (Figures 8-10).

Table 1. Germination rate of the studied plant seeds

Plant seeds	Pollutant	Pollutant concentration (mg/kg)						
		0	200	400	600	800	1000	1200
		Germination rate (%)						
Pea	Cd	100	100	100	100	100	100	68
	Cr	100	100	100	100	100	100	34
	Zn	100	100	86	86	86	86	35
Rape	Cd	100	100	100	100	100	100	100
	Cr	100	100	100	100	100	100	80
	Zn	100	100	100	100	90	80	60
Rye	Cd	100	100	90	90	90	90	80
	Cr	60	60	80	90	100	100	100
	Zn	100	100	100	100	100	90	50

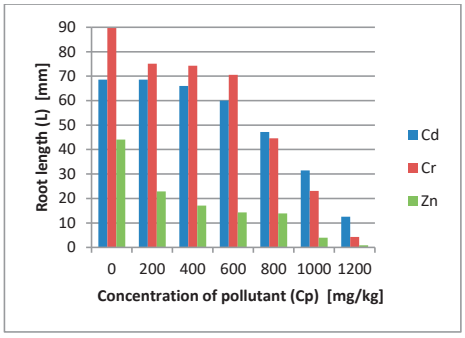

Figure 8. Elongation of pea roots

Zinc was the metal that most affected the elongation of the studied plants roots.

Thus, the root length decreased in the case of *Pisum sativum* from 44.08 mm (0 mg/kg) to 0.86 mm (conc. 1200 mg/kg), from 56.2 mm (0 mg/kg) to 9.72 mm (mg/kg) in the case of *Secale cereals* and from 69 mm (0 mg/kg) to 4.2 mm (1200 mg/kg) in the case of *Brassica napus.*

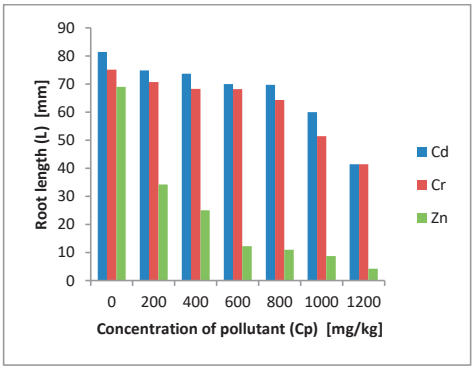

Figure 9. Elongation of rape roots

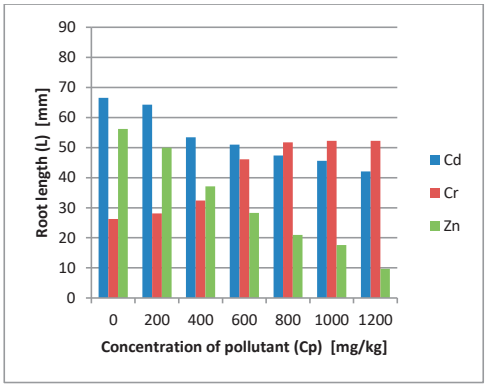

Figure 10. Elongation of rye roots

The correlation between the pollutant concentration and the inhibition of plant seeds under its influence can be seen in the figures below (Figures 11-13).

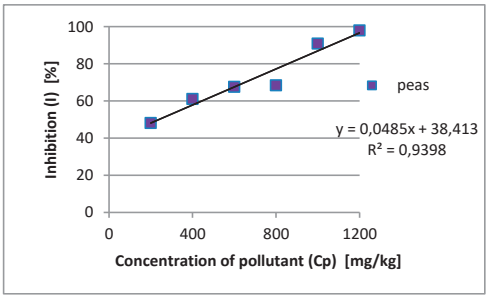

Figure 11. Correlation between the pollutant concentration (Cp) and inhibition (I) of pea seeds under the influence of soil pollution with Zn

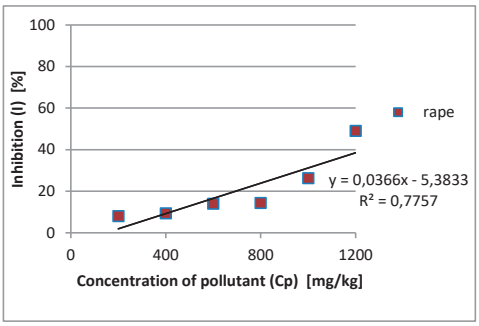

Figure 12. Correlation between the pollutant concentration (Cp) and inhibition (I) of rape seeds under the influence of soil pollution with Cd

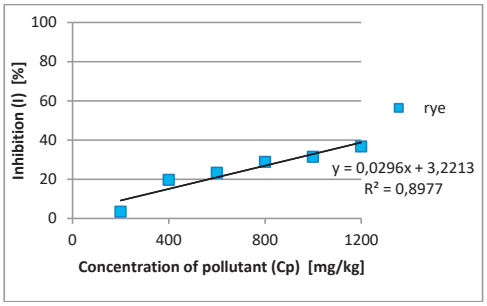

Figure 13. Correlation between the pollutant concentration (Cp) and inhibition (I) of rye seeds under the influence of soil pollution with Cd

CONCLUSIONS

The carried out and presented research in this paper led to the following conclusions:

- Seeds germination and root elongation decreased with increasing soil pollutant concentration except rye (in the case of chrome soil pollution).
- Chromium has positively contributed to both germination and elongation of rye roots.
- Zinc, on the other hand, affected the most studied plant seeds.
- At the maximum concentration of zinc in the soil, the root length decreased by 93.05% in the case of *Pisum sativum*, by 93.91% in the case of *Brassica napus* and by 82.70% in the case of *Secale cereale* compared to the control sample.
- Of the studied plants, the least affected plant by soil pollution with metals was *Secale cereale* both at germination level and at the root elongation stage.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

WASTE FROM THE THERMAL POWER PLANTS - SOME RECYCLING POSSIBILITIES THAT CONTRIBUTING TO ENVIRONMENTAL IMPACT MITIGATION

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Abstract

The problem of reuse, recycling and recovery of waste is our concern since at European level, is used, currently a huge amount of materials per year and per person and a significant amount of this materials become waste. The top priority is finding ways to reduce waste where possible, reuse what can be recovered, and recycle more and more amounts of waste. The paper aimed to present some possibilities of valorization of the ash and slag that results from coal (lignite) burning in the large boiler of this thermal power plant in order to achieve the mitigation of the environmental impact. These possibilities consist in experimental work there were achieve within the technological transfer project that is implemented by "Constantin Brancusi" University of Targu Jiu in partnership with industrial partner.

Key words*: bottom ash, fly ash, heavy metals, recycling, thermal power plant pollution.*

INTRODUCTION

The growth of industrial sector determined the growth of electricity demand in the last years. In the Stated Policies Scenario, global electricity demand grows at 2.1% per year to 2040, twice the rate of primary energy demand. In the Sustainable Development Scenario electricity plays an even larger role, reaching 31% of final energy consumption (Figure 1), (www.iea.org).

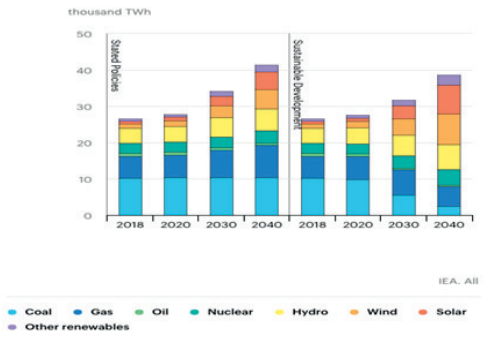

Figure 1. Electricity generation by fuel and scenario, 2018-2020

In this scenario, The Energy Strategy establishes that Romania will maintains the position of energy producer in the region and will played an active and important role in managing the situations stress at the regional level(http://energie.gov.ro/wpcontent/uploads/2019/02/NECP_EN_COM.pdf).

In 2016, a complex study of macroeconomic modeling, with simulation and comparison a numerous development scenario was realized.

To 2030, the results of this complex study, for the optimum scenario, looks an increase of energy production from nuclear sources from to 17.4 TWh in 2030, up to 23.2 TWh in 2035.

An increase up to 29 TWh will be recorded on total renewable sources, representing a share of 37.6% of total sources primary energy that will make up the energy mix in the year 2030 (http://energie.gov.ro/wpcontent/uploads/2019/02/NECP_EN_COM.pdf).

The energy produced by coal will be 15.8TWh and will representing a share of 20.6% (Figure 2) (http://energie.gov.ro/wpcontent/uploads/2019/02/NECP_EN_COM.pdf).

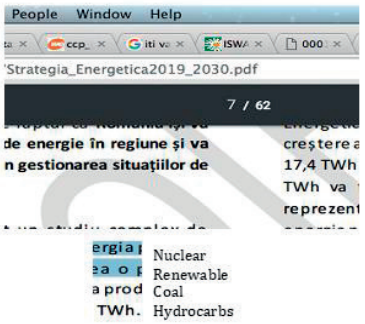

Figure 2. Evolution of energy production based on primary energy sources

In this situation the problem of coal combustion products or waste of energy production flow will still remain our concern in term of environmental factors.

The recovery, reuse and recycling are still very important and the circular economy is important too in this regard (Figure 3).

With the price of primary raw materials rising as supplies become scarcer and competition for them increases, European companies can become more competitive by cutting waste and its disposal costs, and using more recycled and recovered materials.

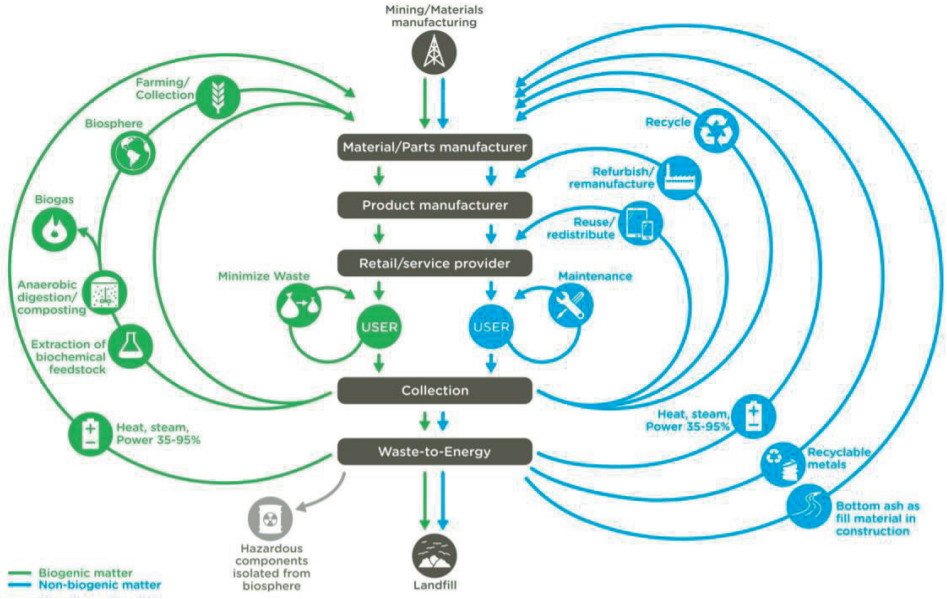

Figure 3. The circular economy concept (Ramboll K. K. et al., 2015)

Eco-innovation in industry saves money, opens up new growth opportunities and attracts customers. It is good not only for the environment but also for the economy and society (https://op.europa.eu/en/publication-detail//publication/07bba962-49c9-4992-a6a3-df826ced5ec2).

EU waste management policies aim to reduce the environmental and health impacts of waste and improve Europe's resource efficiency (https://ec.europa.eu/environment/waste/pdf/Waste%20brochure.pdf).

The long-term goal is to turn Europe into a recycling society, avoiding waste and using unavoidable waste as a resource wherever possible (https://ec.europa.eu/environment/waste/pdf/Waste%20brochure.pdf). The aim is to achieve much higher levels of recycling and to minimize the extraction of additional natural resources. Proper waste management is a key element in ensuring resource efficiency and the sustainable growth of European economies (https://ec.europa.eu/environment/waste/pdf/Waste%20brochure.pdf).

In the early days of the power generation industry, coal combustion products were considered to be a waste material

(https://www.weenergies.com/environmental/ccp_handbook.pdf).
The properties of these materials were not studied or evaluated seriously and nearly all of the coal combustion products were landfilled (https://www.weenergies.com/environmental/ccp_handbook.pdf).
In the course of time, the cementitious and pozzolanic properties of fly ash were recognized and studied by several individuals and institutions (https://www.weenergies.com/environmental/ccp_handbook.pdf).
The products were tested to understand their physical properties, chemical properties and suitability as a construction material (https://www.weenergies.com/environmental/ccp_handbook.pdf).
During the last few decades these "waste" materials have seen a transformation to the status of “by-products” and more recently “products” that are sought for construction and other applications (https://www.weenergies.com/environmental/ccp_handbook.pdf).
The main coal combustion products that are generated by thermal power plant from Oltenia region are:

- bottom ash, with a diameter from 0.25 mm to 1 mm and more, which is collected at the furnace bottom;
- fly ash (with a diameter < 0.25 mm), which is collected from flue gases through electrostatic precipitators (ESP), and from there it is mixed with water and sent to a pumping station or is collected in silo in order to delivery in cement industry;
- gypsum, that results by flue gas desulfurization through introduction of wet limestone into the flue gases.

While the bottom ash and fly ash results by coal combustion into the boiler, the gypsum is producing in order to apply the regulation to reduce sulfur dioxide emission (SO_2), as can be seen in Figure 4 (Ramboll K. K. et al., 2015).
Annual, by coal combustion are generated the huge amounts of ash and slag. The usually method of coal combustion products storage is landfill that affects the important surface of the land with immediately consequences of soil, water (surface water, ground water) and air quality.

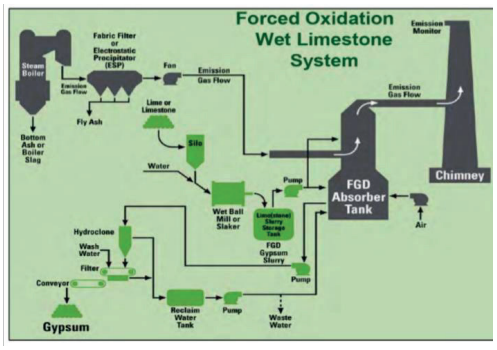

Figure 4. Coal combustion products generation (Ramboll K. K. et al., 2015)

The disposal cost of coal combustion products rose in last time due to significant changes in landfill design regulations in according with EU environmental policies. The utilization of coal combustion products in other industry as substitute of raw materials is solution to preserve existing licensed landfill capacity and thus reduces the demand for additional landfill sites.
Reusing of these coal combustion products can create many environmental, economic, and other benefits including:

- **Environmental benefits** such as reduced land surface for landfills, greenhouse gas emissions mitigation, because the replacement of natural raw material (like sand, limestone) with different kind of ashes leads to save the energy that is consumed in order to extract and processing of this natural raw material and reduced use of other natural raw materials.
- **Economic benefits** such as reduced costs associated with coal combustion products disposal, increased revenue from the sale of fly ash or gypsum, and savings from using coal ash in place of other, more costly materials.
- **Product benefits** such as improved strength, durability, and workability of different construction materials.

In term of pollution it is necessary to mention that ash and slag have a content of heavy metals and other substances that are known to be harmful to health. For example, the Thermal power plant Rovinari, that is the most important thermal power plant of Romania, generated in last three years the important

amount of ash and slag, that was disposal to landfill. Also, based on the ash sample, was realized an assessment of the heavy metal content as can be seen in Table 1.

Table 1. The heavy metal quantity generated annually in last three years

Annually amounts	**2017**	**2018**	**2019**
Energy generated [GW]	6.442	6.072	5.667
Ash and slag disposed [millions of tons]	1.830	1.784	1.772
Mercury [kg]	55.23	51.769	34.669
Cadmium [kg]	0.078	0.0735	0.068
Arsenic [kg]	0.623	0.584	0.544
Chromium [kg]	0.566	0.530	0.495
Lead [kg]	0.653	0.612	0.571
Nickel [kg]	0.619	0.572	0.533
Zinc [kg]	0.39	0.362	0.337

The use of coal combustion products in construction industry reduces the need for raw materials, manufactured aggregates and cement.

The replacement of raw materials as natural aggregates (bottom ash can replace sand, that is mineral aggregate) and cement (cement can be replace at least partially with fly ash) helps to conserve energy and reduce emissions associated with manufacturing and processing of these materials. It is important to keep in mind that Portland cement is replaced, at least partially with fly ash, and, also it is important to mention that the amount of emission in term of CO_2 and other emissions to the atmosphere from cement production are reduced by decreasing the need for limestone calcination as well as the energy consumption.

MATERIALS AND METHODS

The amounts and qualities of coal combustion products depends of quality of coal and burned and the yield of technological flow.

The bottom ash and fly ash characterization were achieved within the project *Use of waste from extractive, energy and metallurgical industries as sources of raw materials to manufacture of thermal insulation refractory products and building materials UCBECOTECH, financing contract no. 92/08.09.2016, MySMIS Cod 105628* (UCBECOTECH Project).

The aim of industrial researches within this project is to realize the transfer of university know how from the previously projects ("*New building materials by eco-sustainable recycling of industrial wastes*" - EcoWASTES, LIFE10ENVRO729 project, "*Assessment of possible recycling directions of heavy & rare metals recovered from combustion waste products* - RAREASH" project) to the industrial partner in order to achieve some king of building materials (bricks, mortar, concrete, pavers, bordures) with bottom ash addition.

Usually, in construction industry are used, as basic raw materials, clay, sand, cement.

In term of chemical composition between three types of raw materials that are used in composition of construction material it can find some aspect of similarity and the different too, as is presented in the Table 2.

These similarities make possible the replacing of natural raw materials with waste form energy industry.

Table 2. Chemical composition of raw materials and coal combustion products

Raw material	Basic oxide compounds (%, mass)					
	Sio_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O +K_2O
Clay from Rovinari	63-68	14-17	5-6	0.8-1.1	1.5-1.8	4-4.5
Quarzite sand	85-89	4-5	2-3	1.5-2.5	0.4-1	1.7-2.2
Bottom ash Rovinari	40-50	16-21	8-9	9-14	2-3	1.2-3
Fly ash	14-45	10-25	4-15	15-40	3-10	0-10

RESULTS AND DISCUSSIONS

One of industrial partners that is involved in industrial researches of *Use of waste from extractive, energy and metallurgical industries as sources of raw materials to manufacture of thermal insulation refractory products and building materials UCBECOTECH project, is SC MACOFIL SA,* one of the largest producers of bricks made from burnt clay in Romania.

Within the works that were realised on the technological flow of SC MACOFIL SA were tested many experimental compositional variants of bricks with bottom ash content of 10% - 60%. The results of laboratory tests that

were realized on the experimental bricks are present in Figures 6, 7, 8 and 9 (UCBECOTECH Project Technical Report, 2019).

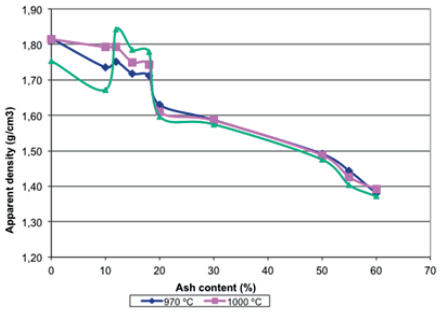

Figure 6. The variation of apparent density of processed mixture depending on the content

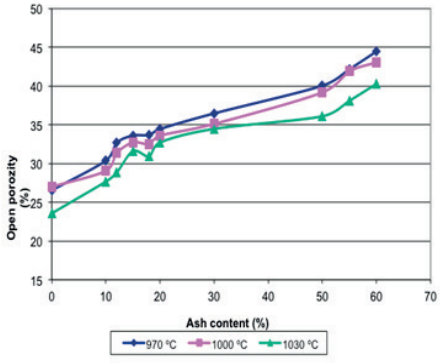

Figure 7. The variation of open porosity depending on the ash content

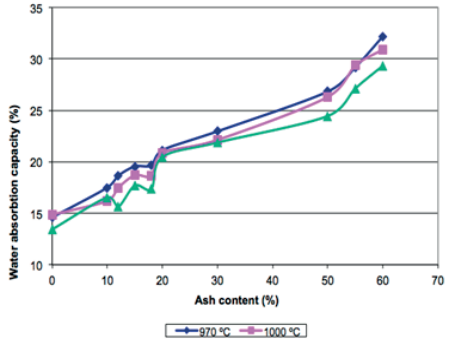

Figure 8. The variation of water absorption capacity depending on the ash content

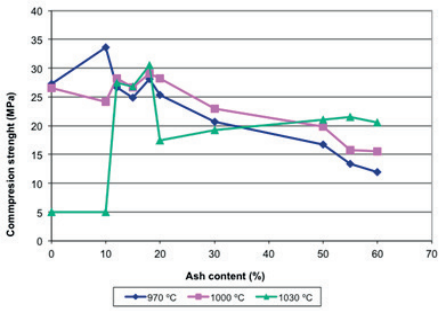

Figure 9. The variation of compression strength depending on the ash content

Following the variation of the physical parameters of the products according to the maximum temperature reached during the heat treatment, it is observed that in the case of burning at 1030ºC there are some areas of marked anomaly, especially in the compositional variants containing 10-20% ash of the power plant and more pronounced in the situation of the mechanical resistances, these being determined even by phenomena of deformation of the ceramic parts after combustion and cooling.

A first conclusion is that in the case of ash and clay mixtures, the temperature of 1030ºC represents too high a level of heat treatment, being recommended to carry out this process within a maximum of 970-1000ºC.

It is also found that the increase of the ash content in the procesed mixture determines a better stability of the products during the combustion, the argument being that of diminishing the negative effects after the combustion at 1030ºC.

In order to carry out the industrial works on the manufacturing flows of the construction bricks at MACOFIL SA, it was chosen to use 5%, 10% and 15% ash additions in the plastic mixture of extrusion molding, the results being very good.

CONCLUSIONS

The paper presented concrete solutions for the use of bottom ash in the construction materials industry, showing results of works carried out under industrial flow conditions.

Actually, the industrial research works were carried out jointly by the researchers from the university and the experts from the industrial partners SC MACOFIL SA.
The results of the performed works have responded positively to the expectations of the industrial partners, so that SC MACOFIL SA will take into consideration the introduction, in the current activity, the production of the different types of construction materials with a variable bottom ash content.
Thus, this industrial partner is an example of good practice, which will certainly be followed by other manufacturers of construction materials.
Ash and slag deposits cover large surface of land having the negative impact on the environmental because of different reasons, that where be expose above.
The recovery and reuse of power plant ashes represents an important way to reduce the impact against the environment caused by its landfill.

ACKNOWLEDGMENTS

This work was supported by a grant of the **Ministry of Research and Innovation - Intermediate body,** trough the project *Use of waste from extractive, energy and metallurgical industries as sources of raw materials to manufacture of thermal insulation refractory products and building materials UCBECOTECH, financing contract no. 92/08.09.2016, MySMIS Cod 105628*

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

FRAMING AND DESCRIBING COMMON BEECH STANDS FROM THE SOUTHERN CARPATIANS IN THE SMART FORESTS CATEGORY

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Abstract

The present paper intends for the first time to frame common beech from the Southern Carpathians in the smart forest's category, a new concept similar with Climate-Smart Agriculture. This framing is based on data from forest management plans characteristic to higher than 40-year-old common beech stands as well as by offering a grade for 16 of its characteristics. As such, it was observed that beech smart forests are located in the Southern Carpathians, especially in Fagaras Mountains as well as in Retezat, Valcan, Sureanu and Candrel. These forests have relatively high ages (80-130 years), are located on fields with large slopes and at altitudes between 510 and 1200 meters. The predominant soil is eutric-cambisol, while the site types is normal common beech with mull flora and the production subunit is Regular forest with common assortment. The framing of some forests from Romania's forest area in the smart forest category is important for their proper management, while knowing their site characteristics can lead to choosing optimum silvicultural solutions for using them at their maximum potential.

Key words*: beech, site, smart forests, soil, Southern Carpathians.*

INTRODUCTION

Common beech (*Fagus sylvatica* L.) occupies 2.115.613 ha in Romania, namely 30.5% of the national forest fund (http://roifn.ro/site/rezultate-ifn-2/), being one of the most widespread species in our country (Șofletea and Curtu, 2007). Even though it is one of the most resistant species, common beech is affected by some harmful biotic or abiotic factors (Chira et al., 2003; Mihal and Cicak, 2007; Roibu et al., 2011).

The concept of Climate-Smart Agriculture (CSA) was defined in 2010 at FAO Hague Conference on Agriculture, Food Security and Climate Change. It aims at sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing greenhouse gas emission. A similar concept is now being defined and implemented for forests, namely "smart forest" (http://climo.unimol.it/). In this way, discussions and studies are being developed concerning stand characteristics that can be framed in the "smart forests" concept (Blaga et al., 2019; Dincă et al., 2019).

This present articles intends to frame common beech stands from the Southern Carpathians in this new "smart forests" category based on numerous data present in forest management plans as well by analyzing their characteristics.

MATERIALS AND METHODS

Only pure common beech stands have been analyzed (100% composition). Stands up to the age of 40 were not taken into consideration. The data that have been used belong to forest management plans realized during 1980-2008 for state forests. As such, all forest districts from the Southern Carpathians were analyzed, studying 2547 sub parcels.

Each analyzed parameter has obtained a grade from 1 to 5, namely: 1 = very low; 2 = low; 3 = average; 4 = high; 5 = very high. In total, 16 parameters specific to the stands or station were taken into consideration (Table 1).

A total grade has resulted by adding all these values characteristic for each sub parcel. Based on this, common beech stands from the Southern Carpathians were distributed.

Table 1. Grade obtained based on the stand's characteristic

Nr crt	Characteristic	Grade				
		1	2	3	4	5
1	Lopping	0.1; 0.2	0.3; 0.4	0.5	0.7	0.6
2	Vitality	5	4	3	2	1
3	Average diameter (cm)*	8-20	22-28	30-36	38-44	46-98
4	Average H (m)*	8-17	18-20	21-23	24-26	26-37
5	Production class	5	4	3	2	1
6	Volume (m^3)*	24-176	177-227	228-285	286-328	329-638
7	Current growth (m^3/an/ha)*	0.3-2.1	2.2-3.9	4.0-5.9	6.0-7.6	7.7-12.5
8	Structure		1	2	3	4
9	Consistency	0.1-0.4	0.5-0.6	0.9	0.7	0.8
10	SUP	O; C	A; D	J, V	G, M	E, K
11	Functional group + Functional category	2.1C	1.4J; 1.5L; 2.1B	11A; 1.1B; 1.1C; 1.1G	1.2A; 1.2B; 1.2C; 1.2L	1.5A; 1.5I 1.5J
12	Litter	1	2	3	4	5
13	Flora	45; 68	36; 42; 46	32; 34; 44	43; 51	21; 31; 41
14	Soil type	3305, 4102	3107, 4101	1701, 2401, 3301,	2201	3101, 3102
15	Forest type	5151, 9821	1341, 4117, 4212	4114, 4115, 4131, 4142, 4151, 4161, 4221, 4241	4112, 4141 4331	4111, 4211
16	Station type	3120, 4120,	3321, 3331, 4210, 4311, 4321, 4331, 4410, 5231	3322, 3332, 4220, 4332, 4420, 5232, 5242	5142, 5233, 5243	3333, 4430

*For these characteristics, the entire value range was divided in 5 categories, 1 = the smallest (ex: average diameter between 4-20 cm), 5 = the highest (ex: current growth higher than 5-21 m^3/year/ha). Grades were given for each category. The category division was realized so that the analyzed biometric characteristics are respected. In addition, a balanced division was intended as number of values for each category.

The meaning of terms used in Table 1 is rendered below:

Vitality: 1 = very vigorous; 2 = vigorous; 3 = normal; 4 = weak; 5 = very weak.

Structure: 1 = even aged stand; 2 = relatively even aged stand; 3 = relatively uneven aged stand; 4 = uneven aged stand.

Production/protection subunits (SUP) (excerpt): A = Regular forest, normal assortments: wood for timber, constructions, celluloses; E = Reservations for the integral protection of nature according to the Environment Protection Law; G = Gardened forest; J = Quasi-gardened forest; K = Seed reservations; M = Forests under the extreme conservation regime; O = Fields that will be taken out of the forest fund.

Functional group (GF) and functional category (FCT) (excerpt): 1.1C = Forests from river slopes located in the mountain and hilly areas that supply existent accumulation lakes or whose management has been approved, situated at distances of 15 up to 30 km upstream from the accumulation limit, based on the lake's volume and its surface, alluvium transportation and basin torrentiality; 1.2A = Forests located on rock lands, screes, on fields with gully erosion, on fields with the slope higher than 35 degrees, or on flysch, sand or gravel with a slope higher than 30 degrees; 1.2C = Forest strips from around alpine holes, with widths of 100-300 m; 1.2L = Forests located on fields with lithological substratum, very vulnerable to erosion and landslides; 1.5L = Forests created in protection areas (buffer areas) from reservations; 2.1B = Forests destinated to mainly produce voluminous trees of superior quality for timber.

Litter: 1 = missing litter; 2 = narrow interrupted litter; 3 = narrow continuous litter; 4 = normal continuous litter; 5 = thick continuous litter.

Flora: *Mixture common beech and resinous forests and pure mountain common beech stands:* 31 = *Asperula-Dentaria*; 32 = *Rubus hirtus*; 34 = *Festuca altissima*; 35 = *Luzula-Calamagrostis*; *Hill forests with common beech participation:* 41 = *Asperula-Asarum*; 42 = *Carex pilosa*; 44 = *Festuca altissima*; 45 = *Luzula albida*; 46 = *Vaccinium-Luzula*.

Soil type: 1701 = specific rendzina; 2201 = specific preluvosol; 2401 = specific luvosol; 3101 = specific eutricambosol; 3102 = mollic eutricambosol; 3107 = lithic eutricambosol; 3301 = specific districambosol; 3305 = lithic districambosol; 4101 = specific prepodzol; 4102 = lithic prepodzol; 9101 = specific litosol.

Forest type (TP): 1341 = Mixture of resinous and common beech on skeleton soils; 4111 = Normal common beech with mull flora; 4112 = South common beech of high altitude with mull flora; 4114 = Mountain common beech on skeleton soils with mull flora; 4115 = Limit common beech with mull flora; 4131 = Mountain common beech with *Rubus hirtus*;

4141 = Common beech with *Festuca altissima*; 4151 = Mountain common beech with *Luzula luzuloides*; 4161 = Mountain common beech with *Vaccinium myrtillus*; 4211 = Hill common beech with mull flora; 4212 = Hill common beech on skeleton soils with mull flora; 4221 = Common beech with *Carex pilosa*; 4241 = Hill common beech with acidophil flora.

Station type (TS): 3311 = Mountain mixture Bi small edaphic luvosol with *Vaccinium* and other acidophilus; 3312 = Mountain mixture Bm(i) podzolic sub-average edaphic with moss and other acidophilus; 3321 = Mountain mixture Bi luvosol and preluvosol small edaphic with *Luzula* +- *Calamagrostis*; 3322 = Mountain mixture Bm(i) luvosol and preluvosol average edaphic with *Festuca*+-*Calamagrostis*; 3332 = Mountain mixture Bm eutricambosol average edaphic with *Asperula-Dentaria*; 3333 = Mountain mixture Bs eutricambosol high edaphic with *Asperula-Dentaria*; 4120 = Common beech mountain-pre-mountain Bi, rockland and excessive erosion; 4220 = Common beech mountain-pre-mountain Bm, average edaphic rendzinic; 4311 = Common beech mountain-pre-mountain Bi, small edaphic luvosol with *Vaccinium*; 4332 = Common beech mountain-pre-mountain Bm, average edaphic preluvosol and luvosol with *Festuca*; 4420 = Common beech mountain-pre-mountain Bm, average edaphic eutricambosol with *Asperula-Dentaria*; 4430 = Common beech mountain-pre-mountain Bs, high edaphic eutricambosol with *Asperula-Dentaria*; 5231 = Common beech hill Bi, small edaphic luvosol with *Vaccinium-Luzula*; 5232 = Common beech hill Bm, average edaphic luvosol with *Festuca*; 5233 = Common beech hill Bs, average edaphic luvosol stagnic with *Carex pilosa*; 5242 = Common beech hill Bm, average edaphic eutricambosol edafic with *Asperula-Asarum*.

RESULTS AND DISCUSSIONS

From the point of view of geographic distribution, the first 20 smart forest beech stands from the Southern Carpathian are located predominantly in Fagaras Mountains (12 stands from the first 20). Other mountains from this Carpathian chain in which valuable common beech stands are present are Retezat, Valcan, Sureanu and Candrel Mountains (Figure 1, Table 2).

The majority of common beech forests are located on the north tilt of the Southern Carpathians.

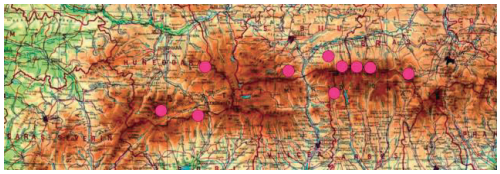

Figure 1. The distribution of the first 10 smart beech forests from the Southern Carpathians

Table 2. The characteristics of the first 20 smart beech stands from the Southern Carpathians

Nr crt	Forest District	Age (years)	SUP	Inclination (%)	Altitude (m)	Soil type	Site Type
1	Retezat	100	M	40	940	3102	4111
2	Arpas	90	A	9	510	2407	5212
3	Arpas	90	A	15	700	3101	4111
4	Sercaia	100	V	15	790	3101	4111
5	Şercaia	100	V	20	690	3101	4111
6	Arpas	110	M	14	680	3101	4111
7	Sercaia	130	M	25	560	3101	4111
8	Orastie	90	A	15	1160	3101	4211
9	Arpas	95	A	18	745	3101	4111
10	Sercaia	105	V	15	720	3101	4111
11	Vl. Sadului	110	M	36	900	3301	4111
12	Zarnesti	120	A	30	965	3101	4111
13	Lupeni	120	A	27	1200	3101	4111
14	Vidraru	80	A	27	1100	3101	4111
15	Voila	90	A	10	780	3301	2211
16	Arpas	90	A	23	695	3101	4111
17	Arpas	100	A	18	485	3101	4111
18	Voila	110	A	20	965	3101	4211
19	Arpas	110	A	24	810	3101	4111
20	Zarnesti	120	A	34	950	3101	4111

The smart beech stands from the Southern Carpathians have advanced ages (between 80 and 130 years), generally belong to the A production subunit (normal forest with common assortments: wood for timber, constructions, and celluloses). In addition, stands from the following categories are also present: M = Forests under a special conservation regime and V = Forests with recreation functions through hunting in which forest regeneration cuttings are allowed. The characteristic soil for these stands is 3101 = specific eutric cambisol. This type of soil that occupies 13% of the total surface of forests soils from Romania (Dinca et al., 2014) has

characteristics that vary with altitude (Sparchez et al., 2017). Furthermore, it is a soil characterized by a good supply with humus (Dinca et al., 2015; Filipov, 2005). The characteristic station type for these smart beech forests is 4111 = Normal common beech with mull flora. This type comprises all characteristics (edaphic, climatic and orographic) favorable to common beech (Tarziu et al., 2004).

Beech smart forests from the Southern Carpathians are spread out on fields with different inclinations, from 9% to 40%. The majority of stands are located on fields with a very high slope (Figure 2), which indicates the common beech's capacity to realize special stands even on difficult fields even though high slopes are characteristic to the mountain area with the highest peaks from the country.

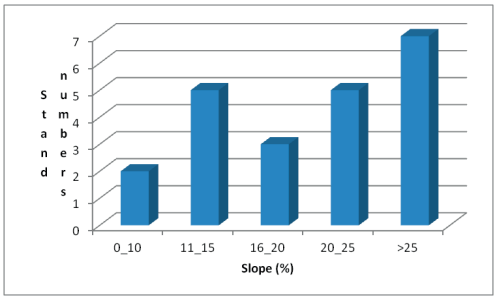

Figure 2. The distribution on slopes of the first 20 smart beech forests from the Southern Carpathians

In regard with the altitude, the common beech from the Southern Carpathians that can be situated in the smart forest category can be found at altitudes between 510 m and 1200 m, with a higher percentage at altitudes of 500-700 m (Figure 3).

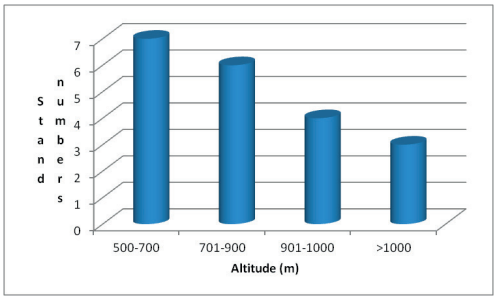

Figure 3. The distribution on altitudes of the first 20 smart beech forests from the Southern Carpathians

CONCLUSIONS

The majority of common beech smart forests from the Southern Carpathians are situated on the North tilt of Fagaras, Retezat, Valcan, Sureanu and Candrel Mountains. With ages between 80 and 130 years, these stands belong generally to the following production subunit: "Normal forest, common assortments: wood for timber, constructions, and celluloses". The stands are located especially on fields with high and very high slopes, at altitudes between 510 and 1200 meters, on eutric cambisols and on "Normal common beech stands with mull flora station types".

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

PARTICULARITIES OF THE ASSESSMENT OF LAND AND GROUNDWATER CONTAMINATION IN THE AREA OF PETROLEUM PRODUCT WAREHOUSES

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Abstract

The study presents the main investigation and assessment methods of quantifying the level of contamination of potentially contaminated and contaminated sites, the advantages and limitations dictated by the specificity of petroleum product storage and distribution sites (warehouses) and also by the type of information required for their optimal characterization. Case studies and real contaminated sites are used in this analysis to be more applicative and convincing for the scope of this assessment. The conclusions of this analysis allow establishing the mechanisms and particularities of soil and groundwater pollution on petrochemical industrial areas, as well as the petroleum product deposits in terms of geological and hydrogeological characteristics, pollution sources, and activities conducted on these platforms. The study is a preliminary stage for the assessment of the risk generated by the level of contamination with such products. This study will ensure a very useful and effective tool for establishing the protection and remedial measures for this type of soil and groundwater contamination.

Key words*: contaminated site, deposits, investigation methods, petroleum products.*

INTRODUCTION

The development of the oil industry in Romania over time was, to a small extent, associated with the environmental protection issues. The extraction, processing and transport of petroleum products have been conducted at a swift pace and without paying major attention to the environment. During the Second World War, many sites of this industry were bombing targets, thus causing pollution of the underground environment. These situations have led, over time, to a significant pollution, accumulated and extended, of the underground environment.

The administrative framework regarding the management of contaminated sites has identified 1393 potentially contaminated site sand contaminated sites (mainly specific to the mining industry, metallurgical industry, oil industry, and chemical industry).

A recent update of the registry, in 2017, listed 516 contaminated sites for the oil and gas industry. The limitation and/or elimination of the potential risks to the human health and to the environment can be achieved by reducing the impact on the environment, caused by soil and underground water contamination. To take these measures, an investigation is necessary, during the first stage, so as to widely and rigorously get familiarized with the site, assess the contamination, and decide the next steps to be taken.

The case study has the particularities of a storage and distribution site (warehouse) for petroleum products, a specific one, considering most of the geological and hydrogeological characteristics, the activity carried out, the general and particular components (Bica, 1998). The main scope of business is the supply, through railway and road transportation means, the storage in vertical and horizontal, over ground and underground tanks. To make sure the entire activity is carried out, the site included the main facilities: loading/unloading platform to ensure the transfer of products, storage tanks, pumping station, settling tank, separating tank, over ground and underground transmission lines, urban public networks, product storage premises, concrete platform, administrative buildings, green areas.

The potential causes of pollution during the activity carried out in warehouses have been split into three categories (Figure1):

- **technical causes:** leaks along the underground or over ground technological pipes through the joints and cracks of pipe sections, of armatures; deterioration of transmission lines over time, first because of the chemistry of circulated water; leaks of petroleum products from the storage tanks when filled or when in stand-by; leaks of petroleum products during the supply from the vehicle platform; joints in the tanker unloading railway platform area; malfunctions of the technological platforms that could cause leaks of petroleum products as a result of the failure to conduct revisions and repairs in due time or accurately; the lack of a potential leaks retaining system or its deterioration;
- **human causes:** handling of petroleum products, loading/unloading of petroleum products; emptying and cleaning of the tanks and of the petroleum product storage technological platforms; during the decommissioning or demolition of technological platforms and pipes;
- **natural causes:** the nature of the underground environment can favour the contamination and transport of pollutants because of the lithological composition and hydrological characteristics.

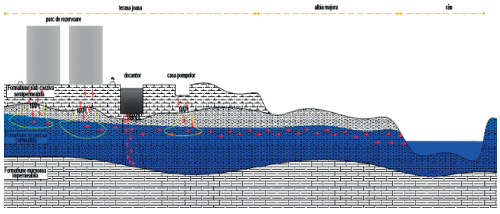

Figure 1. Petroleum product deposits-main causes of contamination of the underground environment

Usually, the lithology of deposits is characteristic to river plain areas (major bed), terraces, as well as to plain and plateau areas. The upper soil layer is slightly cohesive (clayey sand, silty sand, sandy silt), followed by a non-cohesive layer (sand, gravel).
The underground water level is high, allowing the quick infiltration and migration of the pollutant in the underground water flowing direction, even off the site limits. From the geomorphological point of view, the analysed site is located in a terrace area, close to its contact with a plain area (Figure 2). The land has a slight downgrade that descends from west to east (from the elevation of 100 maBS to 97.50 maBS), then follows an embankment approx. 7.0 m high, connecting to the plain area. In this area, the land slope is much gentler, from the elevation of 90 maBS to 89 maBS.

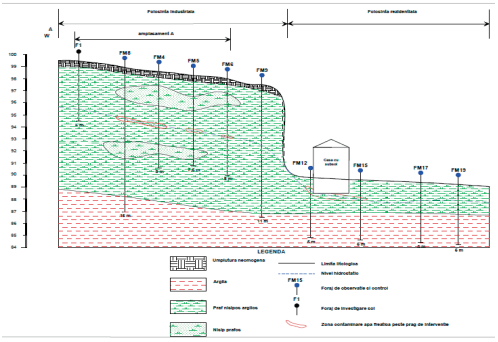

Figure 2. Lithological section

The terrace area consists, at the surface of the land, of an infilling layer approx. 0.50 m thickness, under which a semi-cohesive formation develops, mainly consisting of sandy silthat meet clayey sand lentils. This formation is quite thick, approx. 10 m. The bedrock formation develops under this layer, impermeable, consisting of marly clays. In the plain area, at the surface of the land, a vegetal soil layer develops, under which the semi-cohesive formation appears, mainly consisting of sandy silt approx. 2.50 m thickness. The bedrock formation develops under this layer, consisting of marly clay.
From the hydrogeological point of view, the presence of a free-flowing phreatic aquifer is noticed, surrounded by semi-cohesive formations. In the terrace area, the underground water level goes approx. 4.50 m deep, whereas in plain areas, approx. 1.60 m deep. The phreatic aquifer is supplied particularly from rainfall. During intense rainfall periods, springs are noticed at the bottom of the embankment of terrace a. The general flow direction of the phreatic aquifer is from west to east.

MATERIALS AND METHODS

The work method applied for this study includes a characterization of the polluted site,

the application of the investigation methodology, and the identification of the soil and underground water sampling points, the use of direct, preliminary and detailed, investigation methods by sampling undisturbed soil samples and analysing them in the laboratory (ANZECC, 1999; Fetter, 1993). The organic pollutants identified and analysed were: aliphatic hydrocarbons (TPH Total Petroleum Hydrocarbons), aromatic hydrocarbons BTEX (benzene, toluene, ethylbenzene, xylene), MTBE, heavy metals (copper, lead, sulphur). The negative impact is caused by the concentrations of pollutants that exceed the regulations of the legislation in force and may pose a risk to the site recipients.

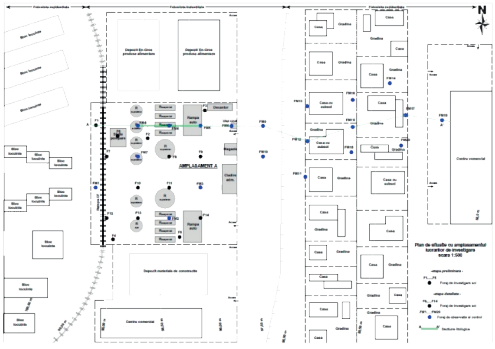

Figure 3. Master plan of the warehouse, with location of technological items

After analysing the available information, a preliminary soil and subsoil investigation plan was prepared, at site level, taking into account the potential sources of pollution and the clearly contaminated areas.

The judgment-based investigation method was used. The benefits of this investigation method, which is the most common method, are that it requires low costs and identifies the site contamination based on the available data. The main limitation of the method is given by the fact that the contamination cannot be validated and that it could allow errors to occur because of its structure (M.E., 2004). Five soil investigation drillings, each 5 m deep, were included.

The soil investigation drillings were located in the area of the potentially polluting and easily accessible constructions (Figure 3). These were located in the area of the railroad (F1, F4), in the area of the tanks located in the northern part of the site (F2), in the settling tank area and vehicle loading platform area (F3), as well as in the south tanks area, vehicle loading platform (F5).

Soil samples were taken from these drillings and one underground water sample from the F3 drilling, analysing the concentrations of TPH, BTEX, heavy metals (copper, iron, sulphur, lead). Direct investigation methods were used, soil investigation drillings were performed mechanically, in dry system. Soil samples were taken from depths of 0.30 m, 1.0 m and then every meter down to an approximate depth of 5.0 m, depending on the contamination identified organoleptically.

The existence of soil pollution, caused by the activity carried out on the site, known in the preliminary investigation stage, and knowing that the downstream underground water is contaminated because of the petroleum product irisations and smell, it was decided to do a detailed investigation both at site level and downstream, in the underground water flowing direction.

The fluctuation of the underground water level between rainy and droughty periods over the year has implications on the vertical migration of the pollutant, particularly of the NAPL type (non-aqueous phase liquids), refined, light petroleum products, that quickly infiltrate (Bica, 2014). The detailed investigation will aim at the vertical and horizontal detailing of the soil, subsoil, and underground water pollution in the entire potentially contaminated and contaminated area, its special delimitation, depending on the depth, nature and intensity of pollution, the connection between pollutants and the structure of the geological environment, the pollution migration and transport paths (Bica, 2014; Manescu, 2002) .

To get more details about the pollution of the soil and underground water, the soil drillings and, subsequently, the observation and control drillings (piezometers) were systematically placed approx. 25 m away from it, both inside and outside the site.

The systematic investigation model will reduce subjectivism, detecting contaminated areas, other than the previously known ones, and can validate the sites in terms of residual contamination (M.E., 2004).

The limitation of this method could be about the high costs and the large number of the investigation points (M.E., 2004). The soil investigation drillings were conducted mechanically with percussion, in dry system. The drilling method was chosen so as not to allow contamination between the various depth ranges and the soil samples taken be as representative as possible.

Drillings were located in the railroad area(FM1, F7, F12, F4), in the northern tanks area (FM8, F2, FM4, FM7, F8, F9), in the vehicle platform area (FM5), in the pumping station area (F3), in the scavenge oil storage area (FM6), in the central area (F10, F11, FM3), in the southern tanks area (F13, FM2), in the southern vehicle platform (F14), between the site and the residential area (FM9, FM10), in the residential area (FM11÷FM20).

Outside the site, the investigation works were conducted in the potentially polluted areas at the soil and underground water level, by also taking into account the characteristics of the pollutant type and the information available during the preliminary data analysis stage. At the same time, the accessibility of the staff and equipment, in view of conducting these works, was taken into account.

RESULTS AND DISCUSSIONS

After analysing the laboratory results and the isolines with TPH concentrations, it follows that the contamination of the soil, particularly at the level of the former facilities: pumping station, tanks and vehicle platform in the northern area of the site, settling tank, specifically the railroad and the scavenge oil storage area. Also, it is estimated that, in this area, the pollutant migrated vertically into the soil, down to the underground water level, contaminating it. The results of the laboratory tests, that took into account the provisions of Order 756/1997 on the assessment of environmental pollution, have shown a significant contamination of the soil with petroleum products intended for less sensitive use (Figure 4).

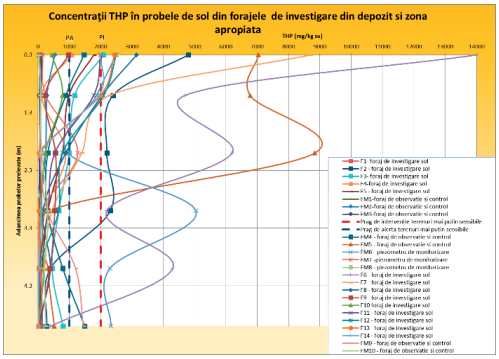

Figure 4. TPH concentrations in the soil samples of the investigation drillings on site and in the adjacent area

The results obtained after performing the investigation works and the laboratory tests were entered into the Surfer software, which modelled the distribution of the TPH contamination of the soil at various depths (above the intervention threshold, 2000 mg/kg, for less sensitive lands), highlighting the following aspects: - for the depth of 0.3 m, inside the site, the TPH contamination was encountered in the area of the former potentially polluting constructions: pumping station (F6), railroad (F7), tanks (F2, F8) and vehicle platform (F3, FM5) in the northern area of the site, in the scavenge oil storage area (FM6) and on a small area near a tank (F12, F13) in the southern part of the site; - for the depth of 1.0 m, the TPH contamination in the pumping station area (F6) and the vehicle platform (FM5) in the northern part of the site; - for the depth of 2.0 m, the TPH contamination in the pumping station area (F6), tanks (F2) and vehicle platform auto (FM5) in the northern part of the site; - for the depth of 3.0 m, the TPH contamination in the scavenge oil storage area (FM6); - for the depth of 4.0 m, the TPH contamination in the pumping station area (F6), tanks (FM8) in the northern part of the site and the scavenge oil storage area (FM6); - for the depth of 5.0 m, the TPH contamination in the scavenge oil storage area (FM6) (Figure 5).

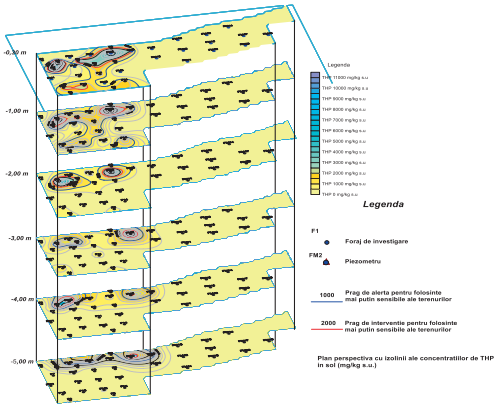

Figure 5. Isolines of contaminated area within the depth range 0.3 m ÷ 5.0 m

The results of the laboratory tests have shown a contamination of the underground water both in the site area and downstream of the site, in the residential area in the underground water flowing direction. The values of Total Petroleum Hydrocarbons in the underground water, above the intervention threshold limit, were identified in the observation and control drillings FM8 and FM4 (the tanks area in the north part of the site), FM5 (vehicle platform), FM6 (scavenge oil storage area) and FM12 in the residential area. The values of Total Petroleum Hydrocarbons in the underground water, between the intervention threshold and the alert threshold, were identified in most observation and control drillings, except for those located in the southern part of the site (FM1, FM2 and FM3), F3, as well as those in the residential area FM14 and FM19.

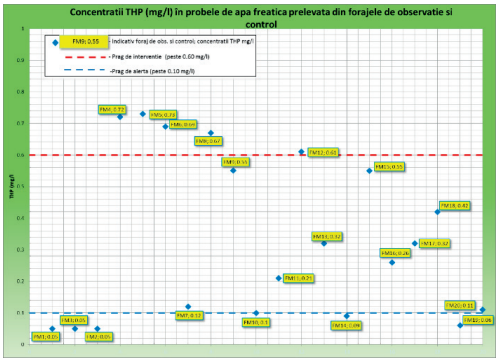

Figure 6. TPH concentrations in the underground water samples taken from observation and control drillings

After analysing the isolines, the TPH concentrations in the underground water show an infiltration of the pollutant from the northern area of the site and its migration in the underground water flowing direction, as well as an extension of the plume up to the residential area in the proximity of the site (Figures 6 and 7).

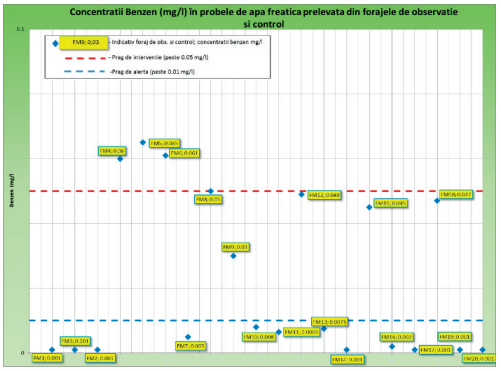

Figure 7. The benzene concentrations in the underground water samples taken from observation and control drillings

CONCLUSIONS

The pollution recorded over time on the petroleum product storage and distribution sites (warehouses) has had a negative impact on the environmental factors: soil, subsoil and underground water. As compared to pits and tank parks, warehouses cover the most extended pollution areas. Another particularity of these is their location inside human settlements, with the built-up area, with a potentially significant impact on the sensitive recipients (residential areas, hospitals, schools, etc). The specific geological characteristics are the plain areas, terraces, and plain and plateau areas, with predominantly slightly cohesive and non-cohesive lands. From the hydrogeological point of view, the underground water level is high, allowing a quick infiltration and migration of the pollutant in the underground water flowing direction. The contamination investigation methods for soil and underground water are mainly direct ones. As far as investigation drillings are concerned, which specific to the case study, they are used without drilling fluid (dry system), with protection tubing, so as to avoid (crossed) pollution

between layers and the deep pollution of the soil and underground water. In the case of piezometers, it is recommended that the underground water level permanently fluctuate in the filters section, so as to identify the existence of the free stage of the petroleum product and, potentially, to measure its thickness (NAPLs) and the tubing materials should be environmentally-friendly. The specificity of the site and the type of information taken into account to characterize the warehouses allowed the optimal choice of investigation models by judgment-based and systematic taking and collecting of samples. The pollution of the underground environment of the warehouse was favoured by the migration, transport and dispersion conditions of hydrocarbons. The specific contaminants for the soil environmental factor are TPH, benzene, and in the case of underground water, NAPL contamination was found at some distance from the site, in the residential area (subsoil of constructions) at approximately 10 m. The theoretical assessment of the contaminated areas at the level of the former technological items specific to the warehousing activity could be demonstrated using judgment-based and systematic sampling methods, as well as laboratory test results. The identified and validated *hot spot* areas were the pumping station, the storage tanks, vehicle loading platform, unloading railway platform, scavenge oil storage area. The contamination of the soil and of the underground water is a concern, aiming to improve the quantitative and qualitative risk assessment steps and the contamination of the former petroleum product storage and distribution sites, so that the remedial systems design parameters may be determined.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Technical University of Civil Engineering Bucharest, Department of Hydraulics and Environmental Protection and TUVAustria Romania.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

APPLICATION OF DROPLEG TECHNOLOGY FOR PIPER SPRAYING

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Abstract

Pepper, as a vegetable crop grown primarily for nutritional purposes, is valued for its taste and content of vitamins and minerals. It is consumed both raw and processed. Weeding of vegetable crops leads to a decrease in yields, a deterioration in the nutritional quality of production, a decrease in the efficiency of operation of agricultural machinery and to financial losses of the farmer. There is currently no suitable herbicide that is effective against weeds from secondary weeding and is selective for the crop. There is also no data on the implementation of Dropleg pepper technology. This article addresses issues related to the biometrics of the piper plant and the application of Dropleg herbicide application technology with two types of TeeJet 15003 and TeeJet 11003 nozzles located 0.15 m, 0.20 m and 0.25 m from the soil surface. The optimum height at which there is no risk of treating the pepper leaf mass of the TeeJet 15003 is proven to be 0.20 m and for the TeeJet 11003 it is 0.25 m with a transverse irregularity of less than 5%.

Key words*: biometrics, Dropleg technology, herbicide spraying, pepper.*

INTRODUCTION

Pepper is valued for the very high nutritional, dietary and taste qualities it possesses. They are determined by the content of sugars (glucose, fructose, sucrose), acids, mineral salts, vitamins and pectic substances. Vitamin C is ranked first among vegetables and even outnumbered 4-5 times by lemons. Practical studies and results show that weeds can cause a sharp decrease in vegetable yields of up to 70% and a deterioration in product quality (Velev B., 1984). In addition, weeds indirectly impair the mechanical cultivation and harvesting of these crops, reduce the productivity of the machines and impair the quality of their work. In peppers, secondary weeding with deciduous weeds is a major problem, as there is no suitable herbicide that is effective against weeds and at the same time is selective for the crop (Dospatliev L., 2012). Alternative spraying is possible with proper support of the spraying system parameters and selection of sprayers.

Such spraying is possible with the so-called Dropleg technology. The main difference from the conventional spraying method is that the Dropleg method allows spraying to be in the plant population rather than as usual from above. The idea is not new (Struck A., https://www.hofheld.de/kurz-erklaert-dropleg-system/). It was first applied in the 1950s in vegetable production. Today, technology is also applied to row and field crops (Hausmann J. et al., 2019; Heimbach U. et al., 2016).

The type and caliber of the nozzles for the Dropleg system can be selected according to the type of operation (Rüegg J., Total R., 2013). Deflector nozzles, for example, can be adjusted in such a way that fungicides and insecticides are sprayed on parts of plants that are difficult to spray, such as the lower leaves and shoots. The drop system can also be fitted with a wide-angle nozzle that points to the ground. This allows spraying of herbicides under the lowest layer of the leaves of the plants with minimal impact on the crop (eg maize, sugar beet, potatoes).

The authors (Kunz C. et al., 2015) observed the effect of herbicide sprays in sugar beet when applying various technical solutions. It has been found that the strip application of herbicides (Dropleg system) in combination with row spacing leads to a reduction in the amount of herbicide used by about 50 to 75%. Weed control efficiency with conventional herbicide treatments is 72%, with a combination of row spacing and band spraying up to 87% and 84% with precision plowing using RTK control.

The reason for the limited application of Dropleg so far is the large initial investment.

They are justified for farmers cultivating large areas. It becomes more interesting financially when the strengths of the technology are used in other crops - to combat weeds in sugar beet and corn. (https://www.iva.de/iva-magazin/forschung-technik/droplegs-applizieren-pflanzenschutzmittel-genauer).
Weed control is tolerable for these crops because the preparation does not fall on their leaves. Another added benefit of the Dropleg system is its low wind susceptibility. If the wind blows more than 5 m/s, conventional measures should be avoided as the drift is too large. Under these conditions, air movement is almost absent in the plant population. The time intervals for drug applications are increasing and machines may be better used.
The authors' research (Byass J., Lake J., 1977) shows that drift increases rapidly with both wind speed and barbell height. It is concluded that it is possible to establish a safe distance from the peaks downwards for the application of a herbicide, without prejudice to the plants grown.
There are three options for maintaining the set height permanently: by fixing the hydraulic system of the spreader system - a disadvantage in this variant is that the irregularities in the length of the working stroke have a strong influence on the actual height of the rod system; the second option is by mounting limiters (with sliders or wheels) to the boom. Restraints copy the terrain and maintain the set height of the unit; the third option is the use of laser tracking systems for the height of the bar. They are integrated in the modern sprayers and allow very precise maintenance of the set height. Unfortunately, these extras make the whole sprayer expensive.
When the height of the bar is changed by 0.10 m due to the sprayer wheel being hit in a pit, on a stone or in a track when working with a pesticide in a field with a lower stem than when adjusting, the norm in the area of overlapping of the torches increases with to 40%, while in other zones it decreases by about 30% (Redkozubov I., Rotenberg Yu., Raskatova T., 2012). This fact leads to a decrease in yield due to insufficient weed control in the underweight areas and possible overdose toxicity. The height of the bar has a particularly strong influence when working with low or minimum standards of preparation. In addition, increasing the height of the bar over 0.10 m increases twice the loss of detergent due to drift, which further increases in high winds.
The transition from the 80-90º spreaders to the 110-120º spreaders allows the chancel height to be reduced by about 0.25 m and to reduce the loss of drift.
Another huge benefit of using the Dropleg system is the protection of bees and other pollinators from the harmful effects of pesticides (https://www.iva.de/iva-magazin/forschung-technik/droplegs-applizieren-pflanzenschutzmittel-genauer; https: //beecare.bayer.com/; Heimbach U. et al., 2016). The agricultural industry is constantly looking for ways in which bees can be effectively protected as farmers take advantage of the results of their pollination. In addition, a healthy bee is a symbol of a healthy environment. As a result, Dropleg technology has returned to the focus of plant protection and conservationists. The pesticides are not sprayed on top of the flowers, but approximately 0.40 m below the broad rapeseed color belt (https://www.lechler.com/de-en/products/product-highlights/dropleg/).
Thanks to the technology used, they are applied in this area by treating the leaves and stems of the plant. As a result, there is virtually no measurable pesticide residue in the honey studied, even with the best analytical techniques.
To sum up, the use of the Dropleg system in the field of crop and vegetable protection has a number of positives. There is no evidence of pepper treatment in the literature reviewed. The purpose of this development is to specify the parameters of a Dropleg herbicide treatment system in pepper plantations.

MATERIALS AND METHODS

In order to achieve this objective, it is necessary to specify the biometric characteristics of the pepper plants, the performance of the spreaders used and the parameters of the spreader system for the treatment of the observed plants. In solving the tasks assigned, a dimensional characteristic of

the pepper plants is performed, observing the indicators determined according to the Figure 1.

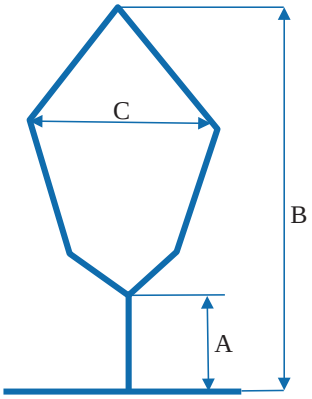

Figure 1. Schematic of a pepper plant:
A - height of the stem to the first branches, m;
B - total height of the plant, m;
C - maximum width of shrub, m

For this purpose, measurements of 100 randomly selected plants are made and the obtained results are statistically processed by determining the mean, variance and coefficient of variation for each of the indicators monitored (Mitkov A., Minkov D., 1989).

In the present work, observations are made with 2 spreaders, the first of which is the traditional LP TeeJet 11003 flat-jet spreader with a spreading angle of up to 110° - №3. The second is the TeeJet 15003 with 2 eccentric jets, with a spreading angle of 150° - also №3.

The following parameters are the width of the torch and the distribution of the working fluid along the width of the torch, depending on the height of the sprayer, at a pressure of 0.3 MPa.

The experiments are carried out at a stand in the Department of Mechanization at the Agricultural University - Plovdiv (Trifonov A., Petrov P., 2000). To determine the uniformity of the distribution of the working fluid, depending on the height, a series of experiments are performed, each in 3 repetitions. With the results of the bench tests of the working fluid distribution by width, histograms were constructed for the two dispensers in Excel media.

The distance between the individual boom spreaders is 0.50 m as standard. The work of the entire boom system is imitated. For this purpose, each histogram is shifted left and right by 0.50 m, and the newly received quantities are added together.

Once the size and shape of the torch have been determined for both spreaders, their height should be determined so that the leaves of the cultivated plants are not affected by spraying. For this purpose, the two figures (modeled-Figure 1) of the plants at the two-row band and the figures for the shape of the torch at the individual spreaders are superimposed on each other.

On the basis of the dimensional characteristics of the observed plants and the statistical characteristics of the distribution of the working fluid of the sprayers used, the height of the arrangement of the bar and the length of the extensions is determined so that spraying results in good work quality without affecting the leaf mass of the plants.

RESULTS AND DISCUSSIONS

Biometric indicators of the observed pepper plants (Table 1, Figure 1)

After observations were made regarding the dimensional characteristics of pepper plants, the data obtained were processed using the Statistica 7 software product and are presented in tables and graphs below.

Table 1. Biometric indicators

Descriptive Statistics				
Tracked metrics	Number of observations	Average value, cm	Dispersion	Coefficient of variation
A	100	22.90	2.23	9.74
B	100	65.50	7.28	11.11
C	100	34.60	4.50	13.01

The data shows that the average plant height is 0.655 m, with variation around this value being ± 0.0728 m. In this situation, the most developed plants are about 0.75 m high. In order not to injure the peaks and halt their development, the boom must be at least 0.30 m above them.

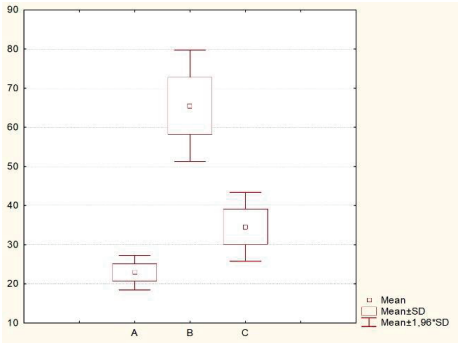

Figure 2. Graphic representation of the biometric indicators monitored

From what has been said here, it is necessary that the distance from the soil to the boom when under pepper treatment is approximately 1.00 m.

Torch width

This indicator is logically influenced by the height of the sprayer. The data from the bench tests for the two spreaders are shown in the Table 2.

Table 2. Torch width, m

Spreader height, m / Sprayer type	0.15	0.20	0.25
TeeJet 15003 (eccentric)	0.80	1.10	1.30
LP TeeJet 11003 (ordinary)	0.70	0.80	0.90

It is seen that as the height of the sprayer increases, the width of the torch or the area under cultivation increases.

The geometric representation of the torches of the two spreaders is shown in the Figure 3.

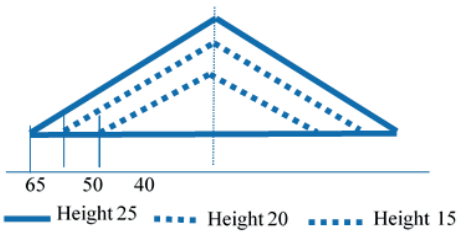

Figure 3. Torch size for TeeJet 15003 (eccentric)

The Figure 4 shows the torch of a conventional LP TeeJet 11003 slit sprayer.

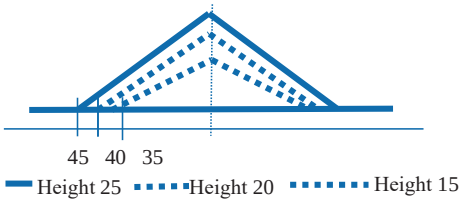

Figure 4. Torch size for LP TeeJet 11003

Height available for sprinklers

With a TeeJet 15003 sprayer, a height of 0.25 m is not appropriate because the jet passes very close to the sprayed plant and only a slight deviation from the ideal shape will cause damage to the cultivated crop. Therefore, a height of 0.20 m is more appropriate for this sprayer.

With the LP TeeJet 11003 sprayer at 0.25 m height there is no problem for the sprayed plants (Figure 5).

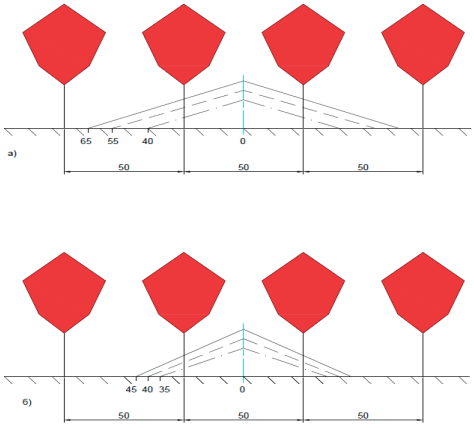

Figure 5 a, b. Arrangement of sprayer and sprayed plants

Even distribution of the working fluid

Under these conditions, the liquid distribution is as follows:

- For TeeJet 15003 sprayer

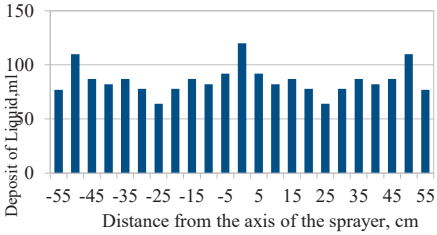

Figure 6. Transverse distribution of the fluid over the working width of the sprayer

The Figure 6 shows that there are no large peaks and drops in the distribution of the liquid. Only at the axis of the sprayer and 0.05 m there is a slightly larger amount of liquid, but this is logical since the largest spray occurs below the sprayer itself, and the next two adjacent sprayers are located at 0.50 m.
The observed statistical estimates have the following values: average value - 85.56; dispersion - 2.81; coefficient of variation - 3.29.
- For LP TeeJet 11003 sprayer
As can be seen from the Figure 7 there are no large peaks and drops in the distribution of the liquid. Only 0.05 and 0.45 m have a slightly larger amount of liquid.
The observed statistical estimates have the following values: - average - 93.26; dispersion - 3.34; coefficient of variation - 3.58.

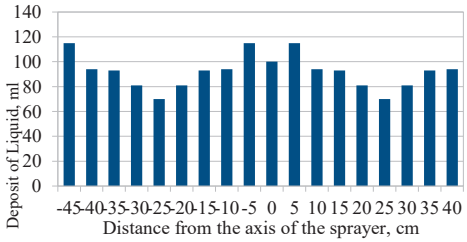

Figure 7. Transverse distribution of fluid over the working width of the sprayer

The results of monitoring the two spreaders give us reason to believe that there is a very good distribution of the working fluid across the width of the torch, which is a guarantee for good coverage of weeds with herbicides and their safe disposal.

CONCLUSIONS

The following conclusions and recommendations can be made on the basis of the experiments carried out, the processing of their results and analyzes:
The height of the pepper stem varies from 0.20 to 0.25 m and the total height of the plant varies from 0.55 to 0.75 m;
The width of the torch depends on the height of the spreader;
The optimum height at which there is no risk of treatment of the pepper leaf mass is 0.20 m for the Tee Jet 15003 and 0.25 m for the LP TeeJet 11003;
The transverse irregularity of both sprayers is below 5%, which is a guarantee for good herbicide coverage and weed control.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE BIOPRODUCTIVE POTENTIAL OF FAST-GROWING FOREST SPECIES ON DEGRADED LANDS

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Abstract

Afforestation represents a viable solution for the ecological reconstruction of degraded lands, creating medium and long-term premises for using and sustainably developing these lands. The usage of fast-growing woody species in the afforestation of degraded lands include many advantages. The present paper presents data regarding the actual state, biometrics and auxological characteristics, as well as the productive potential of stands from fast-growing species (locust, alders, poplars and willows) from different conditions of degraded lands. Locust (Robinia pseudacacia L.) is one of the fast-growing forest species utilised on degraded lands in Romania. In addition, the species has a recognized importance at a high international level both through its bioproductive potential as well as through its ecological plasticity. All the species that were analysed had a good behviour in relation with the environmental conditions of degraded lands, both from a growing perspective and a health state one. However, this situation is present up to the age of 25-30 years. After this age, stand dryness, thinning, and a decrease of tree growth and quality are affecting the stand's natural regeneration capacity and ecological diversity.

Key words*: bioproductive potential, degraded lands, fast-growing species.*

INTRODUCTION

In the context of climate changes that generate a worldwide increase of temperatures (Badea et al., 2013) with values estimated between 0.3 and 4.8ºC in this century (IPCC AR5, 2013), the United Nations Convention for Combating Drought (UNCCD) has proposed the concept of Land Degradation Neutrality (NDT). This concept intends to encourage measures for stopping land degradation, combined with measures for diminishing/reversing the already existent processes in order to prevent the negative effects generated by net losses for lands and productive soils.

According to recent estimations (ICPA, 2002), the surface of degraded agricultural lands from Romania ammounts to approximately 6.3 million hectares from which 2.5 million hecatres are strongly degraded. Previous or recent investigations (Untaru et al., 2013) have shownt that afforestation represents a medium and long-term viable solution for the ecological reconstruction of these lands, as it creates the premises for their usage and long-lasting management. With this purpose in mind, the National Strategy and Program of Actions for Combating Drought (2008) as well as the new Forest Code have identified and proposed for afforestation approximately 2 million hectares of nationally degraded lands.

In this context, the usage of fast-growing wood species for improving degraded lands presents numerous advantages among which the most important ones are: diminishing the effects of global warming through their high capacity of stocking atmospheric CO_2 (Dinca et al., 2015), fighting against desertification by stopping land degradation (Constandache et al., 2010) due to their soil fixing and improvement capacity (Nicolescu et al., 2018; Onet et al., 2019), supplying renewable energy as alternative for fosile fuels (Spirchez and Lunguleasa, 2016) and reducing the anthropic pressure on natural forest ecosystems.

The fast-growing species used in Romania on degraded lands with pedo-ameliorative purposes include poplars, locust, alders and willow. Amongst them, locust *(Robinia pseudoacacia* L.*)* is renowned at an

international level for its bioproductive potential (growth speed, wood quality, lack of harmful agents, an almost unlimited range of usages etc.) and ecologic plasticity. In Romania, locust occupies approximately 250.000 hectares (approximately 4% of the forests' surface) (Nicolescu et al., 2018), and is used in the afforestation of lands affected by different degradation processes (Constandache et al., 2006; Untaru et al., 2008; Enescu and Dănescu, 2013) or in creating protection forest belts (Constandache and Nistor, 2012; Constandache, 2006).

Even though fast-growing species were the subject of previous studies (Radu, 1972), there is a national need for updated data regarding the productivity of these species in different vegetation conditions and in the context of climatic changes.

The studies carried out in the present stage wanted to continue the research in order to know the state, structure and growth of forest cultures composed of fast-growing species (with a short production cicle) from degraded lands.

MATERIALS AND METHODS

The investigations were carried out on 32 long-term experimental surfaces (S), in representative stand and degraded lands situations. Locust, poplar, willow and alder forest cultures were investigated.

In addition, representative situations regarding the stand's characteristics were also analysed with a focus on: current state, biometric and auxologic characteristics, productive protential in different stational conditions;

Measurements and observations were carried out in forest cultures composed of fast-growinf species from improvement perimeters of degraded lands in which there are or were located (long-term) research surfaces. From a territorial point of view, the investigation were realized in the silvosteppe area (Agighiol - OS. Tulcea perimeter; Releu-Valceaua Negureni - OS Baneasa, Constanta; Hulubat - OS Epureni, Vaslui; Livada - O.S. Ramnicu Sarat; Lozovita - OS Hanu Conachi), oaks subarea (Murgeşti - OS Ramnicu Sarat perimeter; Valea Caselor - OS Vaslui, Buznea - OS Podu Iloaiei, Iasi perimeter), holm subarea (Caciu-BE Vidra perimeter), and common beech subarea (Rosoiu-Andreiasu - OS Focsani perimeter). The investigations were represented by collecting land data as well as operating and interpreting them. Their processing was done in an informatic system by using specific forestry statistical softwares.

RESULTS AND DISCUSSIONS

The investigations led to the identification of the main fast-growing species and categories of afforested degraded lands, namely:

-locust: clough lands, lands affected by surface erosion (with diversely eroded lands); mobile sands, puddled landslide lands without water excess and detachment ravines, ranging from the silvosteppe area up to the oaks subarea (and even the holm one);

-white and black alder - puddled landslide lands with an ensured humidity, clough lands (on the bottom of cloughs), alluvial lands;

-white and black poplar, white willow - puddled landslide lands and alluvial lands with water excess.

Land preparation works were realized before planting in order to ensure vegetation conditions, namely: landslides have undergone land modeling/leveling, the drainage of microdepressions with water excess etc. (Constandache et al., 2019; Dinca and Achim, 2019); strongly eroded lands (slopes) and cloughs from the silvosteppe area were managed/consolidated with simple terraces; clough bottoms were consolidated with grating or thresholds from local materials (Constandache et al., 2010).

The adopted afforestation compositions have included fast-growing forest species, differentiated based on the degradation form.

Locust cultures (*Robinia pseudacacia*) were realized on different categories of degraded lands, namely: on moderately to very strongly eroded lands, on clough lands (R) represented by clough ramps with molassic substratum formed of weakly consolidated sedimentary rocks (loess), on landslides with strongly fragmented soil mass (with light, deranged soils without water excess) and on the landslide dislocation ravine with surface rock.

The plantations included a number of seedlings between 5,000 and 10,000 per hectare,

depending on the degradation's form and intensity.

Locust is a thermophile fast-growing species, domesticated in our country during the last two centuries. The results were good in steppe and silvosteppe areas as well as in the inferior part of the forest area (oak and hol subareas), on degraded lands with light and loose soils. Satisfactory results were obtained on lands with a mellow rock substratum without a soil layer, especially on loess, sands and gravel with a lot of sand; the restrictive factors for the development of locusts are: the presence of calcium carbonates in the soil's first 100 cm, clay content, the soil's compaction degree, the lithological substratum (clay, shale, hard rocks, especially chalcky ones), superficial soils or early frosts. Locust is the most suitable species for lands eroded by water due to its fast growth rhythm (soil consolidation and coverage in 3-5 years). The species develops well on in depth erosion forms due to its exceptional biological particularities.

The investigations have shown that the locust stands show different biometric and auxologic characteristics in regard with the stational conditions (Murariu et al., 2018). In Romania, according to the domestic yield tables (Giurgiu and Draghiciu, 2004), the volume of the standing crop ranges between 81 and 365 m^3 ha^{-1}, depending on yield class.

In the case of young stands (aged 7-15), the consistency is high (0.8-1.0), while the number of trees is relatively high, of 4,000-5,000 samples per hectare (Figure 1).

The accumulated wood mass volume is correlated with the stand's age and stational conditions, being of: 32.5 m^3/ha, at 10 years and 80 m^3/ha, at 13 years on strongly eroded lands; 60 m^3/ha, at 10 years and 128 m^3/ha at 12 years on moderately eroded lands. The annual average growths in the case of pure stands are ranging between 3.225 m^3/year/ha at 10 years on strongly eroded lands and 9.652 m^3/year/ha at 11 years (first sprout generation) on moderately fragmented landslide lands (Table 1). The comparative analysis fo the locust's biometric characteristics at young ages (7-15 years) on different categories of degraded lands (Figure 2), emphasizes the effect of stational conditions on their growth. The largest diameters were obtained on moderately eroded and landslides , while the largest heights were on moderately eroded and clough lands. Weaker results (growts, number of trees/ha) were recorded in locust cultures from strongly eroded and clough lands (Table 1).

Figure 1. Locust aged 10-12 (sprout regeneration) on clough land (S3 - Murgesti)

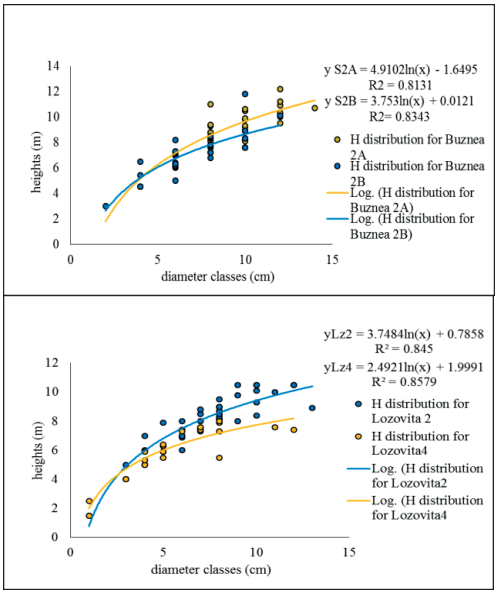

Figure 2. Distribution of heights on diameter species for the locust species in comparative situations on moderately to strongly eroded lands

Certain young locust stands originating from the natural regeneration of sprouts or suckers, have resulted after regeneration cuttings realized after the age of 30-35 years, an age when tree vitality is strongly weakened.

Table 1. Average growths (m^3/year/ha) for different fast-growing specices on degraded lands

Experimental plot	Phytoclimatic area-form of degradation	% species	Age	Mean growth (m^3/year/ha)
Livada S2/R	Ssd/R	20 locust	30*	2.103
		80 locust	64	4.415
Hulubat S6	SSd/E1	100 locust	10	6.727
Lobovita S2	Ss/E2	100 locust	10	5.987
Lobovita S4	Ss/E4	100 locust	10	3.255
Agighiol S2	Ss/E1	100 locust	13	6.646
Baneasa S4	Ss/E1	89 locust	10	9.366
		11 hardwood sp.	10	0.807
Murgesti S3	FD1/R	80 locust	12*	6.573
		20 ash		1.375
Murgesti S4	FD1/E2	92 locust	9*	5.218
		8 ash		0.461
Murgesti S5	FD1/A1	100 locust	11*	9.652
Murgesti S7	FD1/A1	100 white poplar	11*	15.61
Murgesti S13	FD1/A1	97 white poplar	43	10.188
		3 black poplar	43	0.105
Murgesti S14	FD1/A1	98 black poplar	43	4.383
		2 hardwood sp.	15	0.233
Vl. Caselor S1	FD1/A1	100 locust	15*	6.319
Vl. Caselor S2	FD1/R	100 locust	7*	6.731
Vl. Caselor S11	FD1/A1	83 white willow	40	4.740
		17 hardwood sp.	15	6.979
Buznea S2A	FD1/E1	100 locust	13	7.818
Buznea S2B	FD1/E2	100 locust	13	6.175
Caciu S1	FD3/A1+R	79 grey alder	38	2.702
		21 white willow		0.656
Caciu S2	FD3/A1+R	100 black alder	38	5.469
Rosoiu S5	FD3/ R	56 grey alder	45	2.224
		44 hardwood sp.		1.759
Rosoiu S6	FD3/ R	68 grey alder	45	2.566
		32 hardwood sp.		1.396

Legend: Ssd - hill forest steppe; Ss - forest steppe; FD1 - hill level with oaks and mixed harwood stands; FD3 - holm, common beech and holm-common beech hill level; R-ravines; Al - landslide; E 1…3 - moderately (1), strongly (2), very strongly (3) eroded lands; *second generation originating from sprouts.

The sprouts have reduced growths and are more inclined to damages in comparison with samples originating from suckers that are more vigorous and resistant to the action of harmful agents.

In the case of cultures with advanced ages (46-64 years), the consistency is reduced (0.5-0.7), while the number of trees per hectare is also diminished (729-1010 samples, including the naturally installed mixture species); locust is affected by drought in a percentage of 30-50% of the number of trees, while the annual average growths are of approximately 4.5 m^3/year/ha; the majority of locust samples present deformities (saber butts, twisted trunks, etc) or are inclined, a fact that compromises regeneration.

The distribution of the number of trees on diameter ccategories in the case of locusts older than 40 years emphasizes the fact that locust stands are relatively even-aged (Figure 3).

This situation as well as the fact that the stand's composition includes, besides the main species (locust), naturally regnerated species (American alder, elm, cherry tree) of different ages in small diameter categories (6-16 cm) determines high values for the variation coefficient (45.7%). This data emphasizes an increased stand variability and non-uniformity.

In the majority of situations, the average diameter and average height increase with aging. The growth tendency is differentiated based on the degradation form. Lower values are recorded for heights at an advanced age, a fact that is explained by the number of trees and the stand's thickness.

Forest poplar cultures were generally realized on landslide lands with a moderately to strongly fragmented soil mass, with a shifting mass, without water excecss (black poplar - S11 Murgesti) and on landslide lands with strongly fragmented soil mass, with derranged soils and without water excess: white poplar/black poplar (pure cultures or mxied with different species: white seabuckthorn or alder and willow).

White poplar was frequently used for the afforestation of torrential alluvial situations, especially downstream of transversal hydrotechnical works and in the alluvial cones of torrents. This specie prefers predominantly fine deposits, with accessible phreatic water from the silvosteppe area up to the common beech area. The investigations have

emphasized a good behaviour of white poplar on landslides with a fragmented soil mass, with soils mixed with rock and with a loamy to loamy-clay texture.

The average annual growths for poplars were of up to 15.6 m^3/year/ha at the age of 11 years old (sprout regeneration, first generation) and between 4.4 (black poplar) and 10.2 m^3/year/ha (white poplar) when exceeding 40 years old (Table 1). Black poplar has recorded weaker results in comparison with the white poplar.

The willow species used for the afforestation of degraded lands were white willow (*Salix alba* L.) and crack willow (*Salix fragilis* L.). Their results were good on deposits, especially on torrential alluvial ones, fine or coarse, mixed with fine material and accesible phreatic water, as well as on landslides with water excess.

After the age of 30-35, poplar and willow stands were affected by droughts (in a percentage of over 60%), a fact that has reduced their vitality, growth and consistency. The state of these stands indicates the effect of not realizing on time regeneration cuts, a fact that has led to a significant depreciation of their structure and a weakening of tree vitality and natural regeneration capacities. According to the approved technical regulations, the maximum age at which regeneration cuts must be done is of 33-35 years old.

The stand's structure degradation has allowed the regeneration of other species present nearby (locust, ash, sycamore, cherry and sometimes even holm or common beech) that ensure land coverage and protection functions.

Black alder (*Alnus glutinosa*) and **white alder** (*Alnus incana*) are species with a high adaptability to climate and soil conditions. However, they do not support drought and have requests regarding soil water and vegetate actively on humid soils from meadows (Blaga et al., 2019). Black alder had good results in capitalizing lands with ensured humidity (clough bottoms, plastic streams, landslides, alluvial deposits ş.a.) from low areas (plain, hill), while white alder has covered the same structures but on higher areas. Alders have recorded growths between 2.2-5.5 m^3/year/ha (Table 1) at ages of 38-45 years on clough lands and landslides from holm and common beech sub-areas (FD3).

In fast-growing forest cultures from the investigated improvement perimeters, the samples' dimensional variability is directly influenced by the stational conditions specific for each perimeter as well as by the species nature and their adaptability to present conditions.

In addition, expanded factors resulted from the plantation's characteristics also appear, especially from the plantation's scheme, distance or composition. Each sample's development space is many times strongly influenced by the development degree (especially horizontal) of nearby samples.

The comparative analysis of the real number of tree indicates a larger number of trees than the one from the tables in the case of 15 year old stands (locust, white poplar) originating from thick plantation schemes (1.5 x 1.0 m) with a large number of seedlings (6700/ha, S6 - Hulubat) or regenerated from sprouts and suckers. This aspects emphasizes the necessity of cultural operations (cleanings), especially in situations with more samples on the stump (resulted as cutting back after plantation).

CONCLUSIONS

From the current perspective of stand evolution on degraded lands, the following elements were highlighted:

-good results were recorded by forest cultures with locust and black poplar on landslides with reduced mobility, in stations with sandy-loamy up to loamy soils;

-pure locust cultures were realized on strongly up to very strongly fragmented landslides, in stations with regosols or erodisols with a sandy-loamy up to loamy texture; white poplar, alder and white willow cultures were realized in stations with ensures or excess soil humidity;

-relatively good results were obtained by locust cultures on clough lands, on landslide detachment surfaces and on strongly eroded lands with loamy-sandy up to loamy erodisols and a reduced content of calcium carbonates.

The majority of fast-growing forest cultures are presently pure stands; on degraded lands with more difficult conditions, forest cultures were realized from a reduced number of species (locust, alder) that had a good behaviour in regard with present conditions up to the age of

25-30. After this age, the stand became dry and thin, with a reduced quality, a fact that has affected its natural regeneration capacity.

Amongst the fast-growing species, locust was the most used one for the afforestation of degraded lands. The species capitalizes very well moderately up to strongly eroded lands with loamy or sandy soils and without or with a reduced content of carbonates, situated on slopes or ridges. The species has a good behaviour in pure cultures, realizing growths specific to average up to superior production classes. In these conditions, locust cultures have recorded annual average growths between 3.25 and 9.65 m^3/year/ha in report with stational conditions; the structural diversity degree is reduced, affecting the culture's stability and resistance towards abiotic factors (climatic stress).

White poplar was frequently used in the afforestation of strongly up to very fragmented landslides where it has generated annual average growths between 10.2 and 15.6 m^3/year/ha. Black poplar has recorded weaker results than the white poplar.

Alder (black and white) has realized growths between 2.2-5.5 m^3/year/ha, on different categories of degraded lands.

A good behaviour and growth can be observed for locust and white poplar, as well as a higher regeneration capacity and adaptability on degraded lands with different stational conditions in comparison with other species such as pines for example (Silvestru-Grigore et al., 2018; Vlad et al., 2019).

The age up to which the growths are active and stands can be led by these species is of 25-35 years for locst, 25-30 for willow, 30-35 for white and black poplar and 45-50 years for alder. Stands older than that were affected by drying, recording reduced values for growths, tree quality, regeneration capacity and protection functions.

Taking into account the significant number of degraded lands at a national level as well the nececssity of properly managing them on long-term, the usage of fast-growing species for ecological reconstruction works generates vital ecosystem services in areas with a deficit of forests.

In addition, they contribute to the diminishing of negative effects brought by climatic changes.

Choosing fast-growing species in the afforestation of degraded lands requires an optimum correlation between their biological characteristics and the stational conditions in order to avoid negative effects at the biotop level.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the Ministry of Research and Innovation, within the PN 16330305/2016 Project.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

AN INTEGRATED NATIONAL SYSTEM FOR ASSURING THE QUICK EVALUATION OF THE VULNERABILITY OF ALL INSTRUMENTED BUILDINGS AFTER AN EARTHQUAKE. RECENT DEVELOPMENTS

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Abstract

Within the National Network for Seismic Monitoring and Protection of Constructed Heritage from INCD URBAN-INCERC, studies are being conducted in the field of structural health monitoring having as object real buildings, seismically instrumented with modern equipment. The identification of equipment and connection types existing within the Network for Seismic Monitoring and Protection of Constructed Heritage, as well as the implementation of solution for seismic data transfer to the Data Centre, these aspects are followed. A multi-criteria selection is applied, which takes into account also the compatibility with equipment existing within the National Seismic Network for Constructions at URBAN-INCERC, to ensure their efficient use.
Some case studies are presented in the general way, focused on achieving the connections in distinct locations, by applying the own solutions for data communication (INCD URBAN-INCERC local system; The Cathedral of Saint Alexandru and Saint Nicholas of SULINA local system; The Arnota Monastery local system; Balta Alba Block of flats etc.)

Key words*: ambient/industrial vibrations, accelerations/velocities, damages.*

INTRODUCTION

Within the National Network for Seismic Monitoring and Protection of Constructed Heritage from INCD URBAN-INCERC, studies are being conducted in the field of structural health monitoring having as object real buildings, seismically instrumented with modern equipment (Figure 1).
The identification of equipment and connection types, as well as the implementation of new solutions for seismic data transfer to the Data Center, are issues to be solved in the development of the improved network.
There are several key parameters to consider when designing a physical data transmission system:

- the necessary information flow (the bandwidth of the channel for analogue links or the rate of data transfer with digital links);
- the desired reliability (the acceptable loading time of the connections, that is the maximum period of time per year when the signal-to-noise ratio is lower than necessary (analog connections) or the error rate of bits is higher than the allowed one (digital connections);
- the physical network and the protocol that will be used to establish a virtual seismic network (internet, WAN property networks (large space networks), public analog telephone network).

A multi-criteria selection is applied, which takes into account also the compatibility with equipment existing within the National Seismic Network for Constructions at URBAN-INCERC, to ensure their efficient use (Dragomir et al., 2012; 2017; 2019).

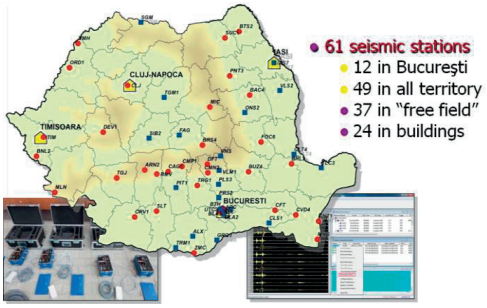

Figure 1. Seismically instrumented buildings by URBAN-INCERC

MATERIALS AND METHODS

Modern equipment of last generation exists, many buildings can be monitored from distance and data can be transmitted to users or to research institutes in the field through a system of transmitting in real time (wireless smart sensor networks, within a frequency range (0 ... 100 Hz); an Ethernet connection and optional Wi-Fi for fast data transfer; a mobile network available in the area from which the data is transmitted; a software; automatically applying different types of filters to recorded data etc.) After the acquisition of the signal, before calculation of any response spectrum, the baseline correction (to have a zero-mean signal and to remove any linear trend) and high-pass/low-pass filtering (to remove the high-frequency and low-frequency noise) are necessary.

Some case studies are presented in the general way, focused on achieving the connections in distinct locations, by applying the own solutions for data communication.

RESULTS AND DISCUSSIONS

INCD URBAN-INCERC. The local system for connection to the existing monitoring network: Connection via Lantronix Server/MoxaNPort Express DE-311 RS-232/422/485 Device Server, Switch, Accelerometer ETNA (Figure 2).

The Cathedral of Saint Alexandru and Saint Nicholas of SULINA. The local system for connection to the existing monitoring network: ODU - outdoor unit, IDU - indoor unit, BDID - WIMAX antenna, ETNA2 accelerometer (Figure 3).

The Arnota Monastery. The local system for connection to the existing monitoring network: ETNA accelerometer, tp-link Switch light wave ls105g, Huawei Router model B311s-220 (with IP purchased from Internet Service Provider; Network Connection Solution: Orange Card Subscription) (Figure 4).

Balta Alba Block of flats. The local system for connection to the existing monitoring network: ODU - outdoor unit, IDU - indoor unit, BDID - WIMAX antenna, ETNA2 accelerometer (Figure 5).

Figure 2. The connection system, Bucharest

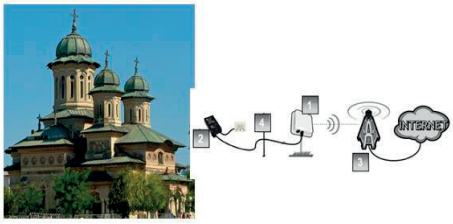

Figure 3. Position and the connection system, Sulina

Figure 4. Position and the connection system - Valcea

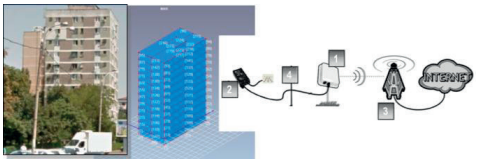

Figure 5. Position and the connection system - Bucharest

In the case of each case study, the purpose was to obtain data, received through the made connections that would allow later processing and interpretation.
Thus, in the following figures, the acceleration in the basement of the building, the velocity monitoring from the ambient vibration, the acceleration during the detonation from the limestone quarry, the operational modal analysis (OMA) in real time – with the identification of the dynamic characteristics of the structure and the damage assessments are shown (Figures 6, 7, 8 and 9).

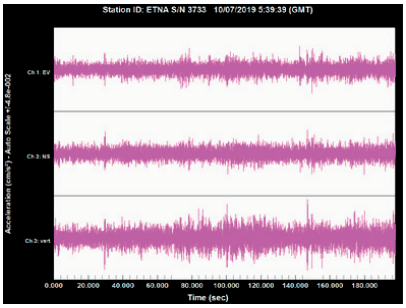

Figure 6. Acceleration monitoring in the basement of the building. INCD URBAN-INCERC

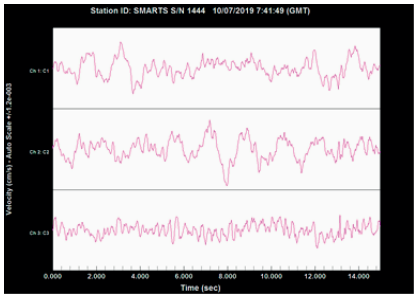

Figure 7. Velocity monitoring from the ambient vibration. The Cathedral of SULINA

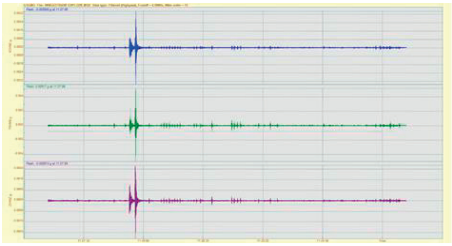

Figure 8. Acceleration during the detonation from the limestone quarry. The Arnota Monastery

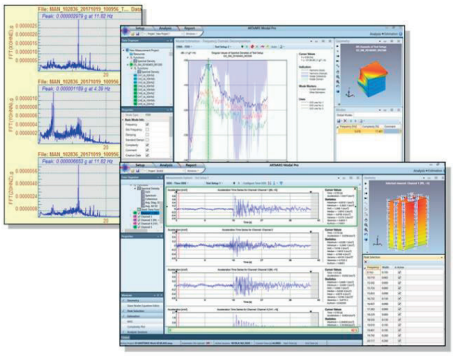

Figure 9. Operational modal analysis (OMA) in real time - identification of the dynamic characteristics of the structure. Damage assessments. Balta Alba Block of flats

CONCLUSIONS

Research conducted in INCD URBAN-INCERC converges towards the development of a large monitoring system capable, in the future, to allow remote identification, in a very short time after a seismic event, of possible dangerous changes in the condition of the instrumented buildings (Dragomir et al., 2012; 2017; 2019; Alexe et al., 2006).
The temporary instrumentation and/or (permanent) monitoring of a building, under the conditions specified by the codes P130/1999 and P100-2013, is a necessity fulfilled through the studies elaborated within this research.
The completion of the registered and processed data, from the sites where seismic sensors (free-field type, or in buildings) were installed, provides a clearer picture of the level of local accelerations, specific to different soil conditions (Dobrescu, 2013; Dobrescu et al., 2017), and soil-structure interaction (Dobre et al., 2013) and of compared to the values of the accelerations from the seismic zoning map. As a future stage, after determining the vibration level through temporary instrumentationand/or (permanent) monitoring, different vibration active and-semi active control systems can be adopted in order to minimize the vibrations in real time (Luca et al., 2015; Pastia et al., 2016).

ACKNOWLEDGEMENTS

Results are part of the project “Research on the implementation of an integrated system for ensuring the security of the constructed space,

with semi-automatic generation of PGA maps provided by seismic actions or other vibratory sources and quick evaluation of vulnerability of instrumented buildings" (PN19 33 01 01).

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

URBAN RESEARCHES FOR RISK MITIGATION IN BUCHAREST CITY AREA

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Abstract

The paper analyses the behaviour of the soil/subsoil characteristics in the Metropolis of Bucharest under seismic movements with the goal of highlighting the potential damage induced by future strong events. For better understanding the specificity of seismic effects from earthquakes originating in Vrancea region were carried out several national and international research works to assess seismic hazard for Bucharest. Will be presented the last results of the 21st century research programs, with a lot of practical results: several drills in the most critical zones of the city, with hundreds of samples on which were done dynamic tests, static ones and downhole measurements for v_p and v_s profiles. An analysis of the continuously recordings by accelerometers was done, over the Bucharest area. The paper emphasizes the importance of the accumulated data for understanding the dynamic behaviour of the soil under Bucharest and how it influences the impact of future seismic hazards. Better knowledge of seismic hazard will lead to mitigation of building vulnerability to future seismic movements.

Key words*: geotechnical tests H/V ratio, seismic risk, Vrancea earthquakes.*

INTRODUCTION

Romania is a country with a relatively high level of seismic hazard and in the perspective of a future strong earthquake the main risk-exposed area is Bucharest city (Dilley et al., 2005). With a continuously increasing building stock (of more than 131000 assets, 44% of them being constructed before 1963, according to 2011, National Census), it was more imperative the need of very useful information about structures for engineering community, in order to assess the structural integrity and also for authorities, in case of emergency after a strong earthquake.

Before the strong seismic event of 1977 design codes and studies were made, but these were not quit exactly in accordance to the constructed reality since there was no more major earthquake recording to reflect local characteristics of intermediate-depth events. The March 4, 1977 (M_w = 7.4) earthquake had severely affected almost the whole outside area of the Carpathians Arch. In the capital city, Bucharest, as well as in other areas, seismic intensity exceeded with one grade and more the intensity existing in seismic norms at that time. The damages consisted in 25 residential blocks that collapsed (in downtown Bucharest), 3 were demolished after being heavily damaged and 100 had serious damage with the necessity for emergency rehabilitation.

After this situation there was a complete change in perception about earthquakes, reflected in codes and studies about effective seismic risk mitigations measures. Still, nowadays in Bucharest there are more than 40000 buildings erected before 1940, which raises concerns about their safety in future strong seismic events.

The paper offers the possibility to conduct basic research on the urban seismic wave field as well as to perform combined structural and hazard analysis for Bucharest. The knowledge of soil layers content underneath the Bucharest surface is an important step in performing a complete analysis of the seismic hazard in Bucharest. These goals could be attained with highly costs. To achieve these, in the early 21st century, cooperation programs were undertaken with the Collaborative Research Centre (CRC461) “Strong Earthquakes” at the Universität Karlsruhe (TH), Germany. As part of these programmes common seismological experiments were conducted in Romania. Especially in Bucharest, high-quality seismic data were acquired during the URS (URban Seismology, 2003/3004) Project. Within this

project 32 state-of-the-art broadband stations were continuously recording in the metropolitan area of Bucharest for 10 months (Ritter et al., 2005).
Following, a NATO international programme was launched through were performed drillings on the city area followed by different tests. A homogeneous dataset of geotechnical parameters of the soils and rocks of the uppermost layer's underneath Bucharest were obtained and used to complete seismological measurements across the city. The paper presents the data obtained from boreholes and the analysis of data continuously recorded by accelerometers, over the Bucharest area. An analysis of the soil amplification and spectral response was performed, and a method for computing the oscillation period of the soil is presented, applied to city area.

MATERIALS AND METHODS

Geological data about Bucharest

Bucharest, the capital of Romania, with more than 2.5 million inhabitants, is considered a highly-most earthquake-endangered metropolis in Europe. All disastrous earthquakes are generated within a small epicentral area – the Vrancea Source - about 160 km North-East of the Bucharest (Figure 1, Balan et al., 2014).

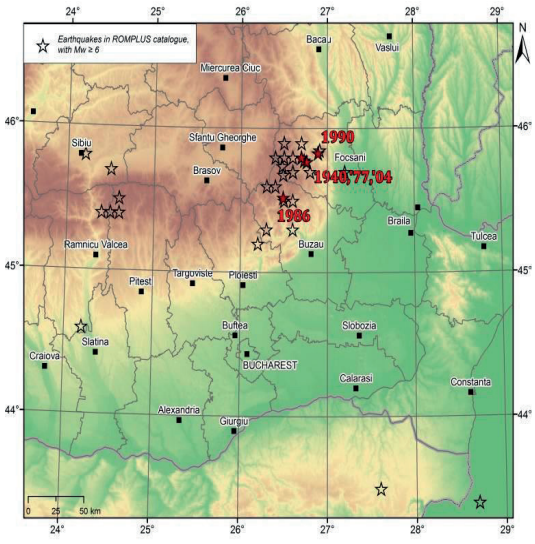

Figure 1. Major earthquakes ($M_w \geq 6$) described in the ROMPLUS Catalogue, and the location of Bucharest

The city of Bucharest is built on young, partly unconsolidated and water-saturated sediments of the Dambovita and Colentina river systems and their surrounding plains. Dambovita valley appeared like a long corridor approximately 22 km long. Its width varied from 650 m, in some places in the centre of the city, to about 4 km at its eastern exit, before being regularized in the last century (Mihailescu, 1924). Also, there are lakes in the city. For example, one of them, the lake "Lacul Morii" (the Lake of the Mill) is an unusual feature, formed by the man-made dam on river Dambovita in the 20th century.
Geological, geotechnical and hydro-geological drillings in the city have made it possible to know what is included in successive subsoil deposits (Ciugudean-Toma et al., 2007).
The Quaternary geology of Bucharest City is characterised by seven sedimentary layers (complexes), with different lithology, geotechnical characteristics and variable thicknesses (Mandrescu et al., 2007; 2008). The unconsolidated sedimentary layers in the area of Bucharest amplify the seismic shear-waves which may cause severe destruction (Cioflan et al., 2011; Manea et al., 2016). Thus, disaster prevention and mitigation of earthquake effects is an issue of highest priority for Bucharest and its population.

Geophysical and geotechnical methods for surveying the subsoil of Bucharest

Along the year's numerous geotechnical drills, geophysical measurements, geotechnical tests, etc., were done for analysing the role of the subsoil, beneath the capital for a correct appreciation of the hazard due to the strong earthquakes which affected the city in the last centuries.
Especially in Bucharest, high-quality seismic data were acquired, obtaining a useful and diverse dataset providing important information on the seismic amplitude variation across the area. The site studies have a major contribution to the mitigation of seismic risk. In this concern, the continuously monitoring of the buildings, which offer data from the micro tremors, vibration and the noise, seismic or non-seismic, prove to be useful (Balan et al., 2019; Dragomir et al., 2019).

One of the most important elements in hazard evaluation of Bucharest zone is a modern ground acceleration network which has been upgraded in the last years up to over 23 stations (and 160 seismic stations in Romania - National Seismic Network of National Institute of R-D for Earth Physics) with easy handling data (accelerations/velocities easy to transform in displacements). A dense network is needed in order to identify seismic events and compute correlation functions between the recorded ground deformation and a seismic movement.
Within the URban Seismology Project (URS) which was a joint achievement between the Collaborative Research Centre 461 (CRC461) at the University of Karlsruhe, Geophysical Institute, and the National Institute of R-D for Earth Physics (NIEP) in Bucharest. The aim was to measure seismological broadband waveforms in the city area of Bucharest. Continuous mode recording at 32 sites with broadband sensors, sampling rate 100 Hz (which allows us to study signals of up to 50 Hz), with GPS time synchronization and removable 6.4 GB hard disks, on 3-6 channels was achieved for 10 months. These data are the basis to verify predicted site amplification effects as well as other research topics (Figure 2).

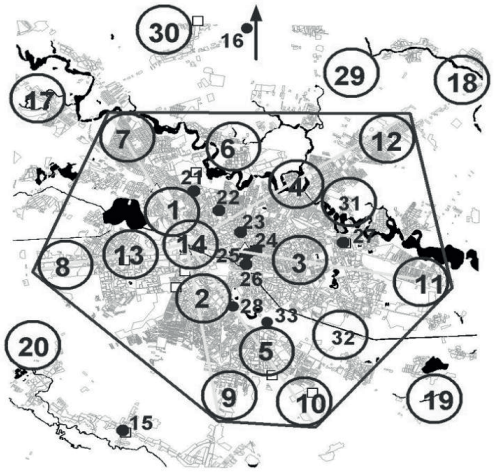

Figure 2. URS sites in Bucharest
(URban Seismology Project)

The recorded waveforms of this experiment provided a rich and unique source for the study of the seismic wave field and the structure within a major urban region (Figure 3).

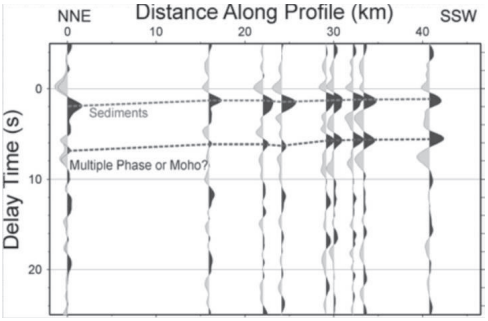

Figure 3. Receiver function sections across the metropolitan area of Bucharest from NNE (URS06) to SSW (URS07). Stack of up to 8 tele seismic RFs filtered from 0.083-0.5 Hz with two correlated phases
(Ritter et al., 2005)

Another extended program was NATO Project "Site-effect Analyses for the Earthquake-Endangered Metropolis Bucharest, Romania" (NATO SfP Project No. 981882, 2008). The aim of the project was to gather more geotechnical and geophysical data to fill gaps between already existing data about the subsoil of Bucharest.

Data gathering and processing

To acquire basic data for subsoil layers in a homogeneous way, from unexplored zones, were selected 10 boreholes in Bucharest area. At these boreholes were done seismic measurements and geotechnical analysis of the core samples. From these we determined representative dynamic parameters of the soils and rocks. These dynamic parameters were used as input for linear and non-linear waveform modelling to estimate the seismic amplitude amplification at specific sites in Bucharest. These modelled waveforms were compared and calibrated with observations from seismic stations in the city. The results from the site-effect analysis were gathered in an updated seismic micro zonation map of Bucharest (Marmureanu, 2016)
One important component of engineering seismology is to evaluate the role of the near-surface soil layers. These layers, on which buildings and other constructions exist, can have a wide range of influences on the ground

shaking. For example, loose soils or sediments can amplify the ground motion or water-saturated sediments can produce soil liquefaction. These phenomena can then cause complete yielding of the ground during earthquake shaking with the result of catastrophic collapse of building. This underground is especially prone to strong shaking and even amplification of earthquake waves including resonance and ground liquefaction.

Therefore, the specific overall goal of the NATO project was to obtain a homogeneous dataset of geotechnical and geophysical parameters in the shallow (< 100 m), unconsolidated soil and sediment layers. Its accomplishments consist in: 10 new 50 m deep boreholes, were drilled in the metropolitan area of Bucharest (Figure 4). Complete lithological profiles with about 250 recovered core samples for geotechnical analysis were gathered in order to recover sample cores for static and dynamic tests and to measure vertical seismic profiles. The 10 boreholes are placed near existing seismic station sites to allow a direct comparison and calibration of the borehole data with actual seismological measurements. At all ten boreholes were conducted downhole measurements for v_p and v_s profiles.

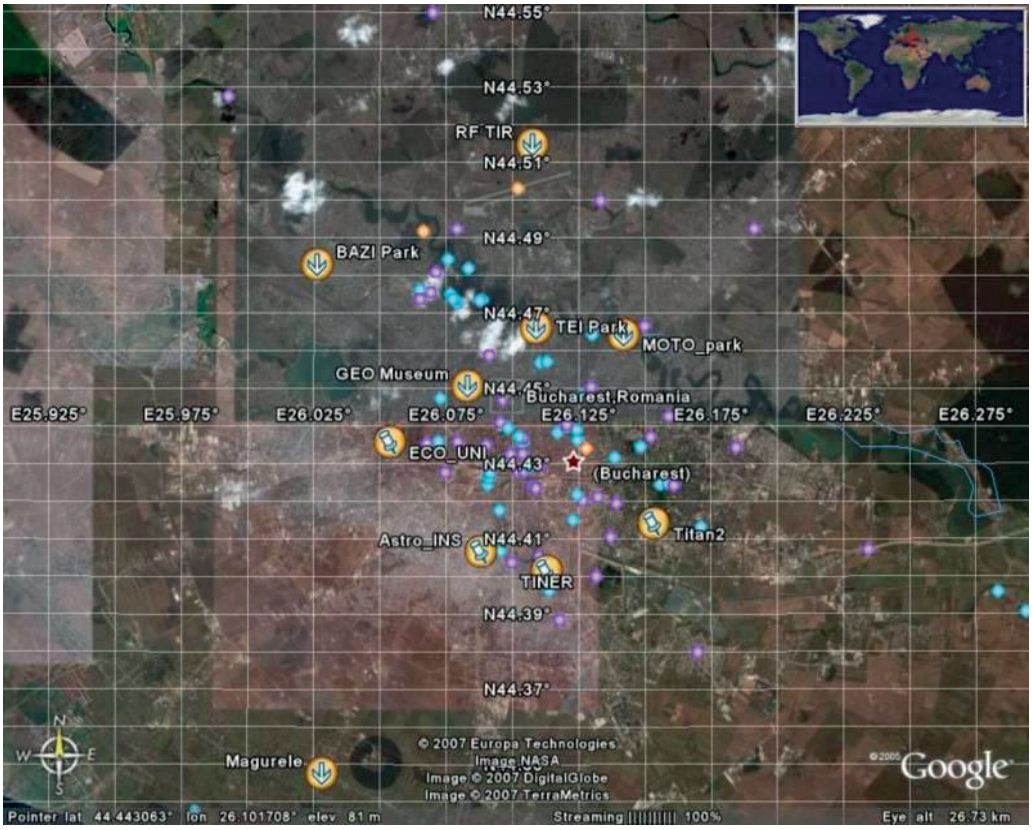

Figure 4. Map of the Bucharest City area with location of the 10 boreholes (NATO SfP Project, 2008).

The 250 soil and rock samples from the drilling sites were carefully selected without disturbances (sampling as it was recovered from the tube of the drilling machine) and partly disturbed (soil samples which had no proper consistency). Samples were subjected to geotechnical tests (static and dynamic) with the help of resonant columns and dynamic triaxial.

With all these data were performed seismic analyses. Here is presented one of them, which allows to obtain fundamental period of the soils deposits by H/V ratio method. This ratio gives

us not only information about resonance period but also on the corresponding amplification, sustained by numerous studies (for example Balan et al., 2008; Grecu et al., 2008) showing that the H/V ratios with peaks around fundamental frequency corroborates to the surface soft soil strata where exists an emphasized impedance from more rigid strata situated below.

The seismic events chosen for the H/V spectral ratios computation were selected by taking into account the recordings quality and the magnitude higher than 3.5. They belong to a data base which consists in events recorded in the time period of interest (source: ROMPLUS, "Romanian Earthquake Catalogue"). The H/V ratios computations were performed with J-SESAME software program for the noise and with "H/V-ratio" software for the seismic events (developed by Oncescu et al., 2007). This J- SESAME software program was advanced in the frame of European SESAME Project (Site Effects assessment using Ambient Excitations). The spectral ratios are computed for seismic events and for noise, at each seismic station, as shown in the Figure 5, denoted by the name of the station. The spectral ratio curve is period-dependent. The dashed lines are the root mean square (rms) of the H/V ratio. The average shear wave velocity for the layers above Fratesti has values between 340m/s (in the South-East) and 390 m/s in the North-Western part of the city (results obtained through down-hole computation) (Mandrescu et al., 2007; Bala, 2009; Bala et al., 2009).

The geological structure (Mandrescu et al., 2000; Moldoveanu et al., 1999), corresponding to the deep sedimentary formation of the city, was compiled as a simplified model, and employed to obtained a velocity structure together with quality factors. This information corroborated with the spectral ratio data, obtained from simulation of the seismic movement as corresponding to stronger events could indicate that dangerous amplifications in the long period range could be expected in this city area in case of strong Vrancea earthquake (Cioflan et al., 2009; Apostol, 2008).

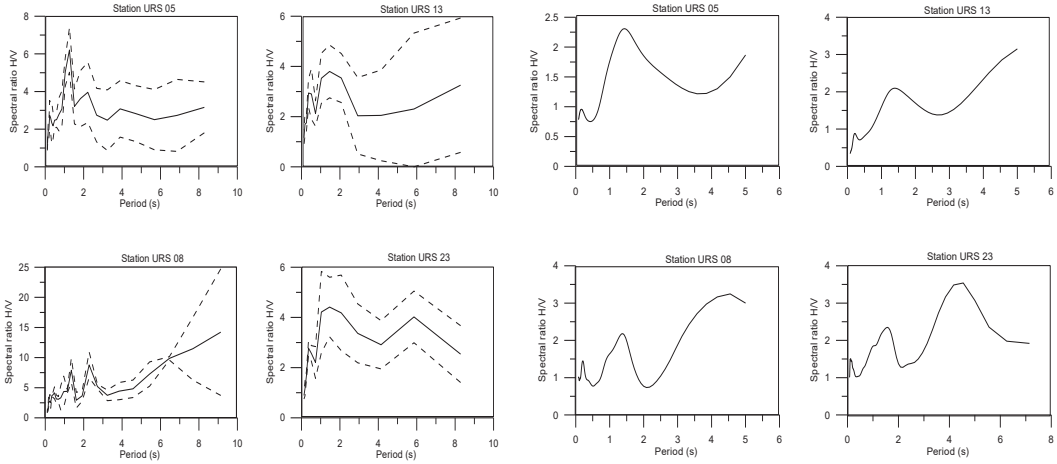

Figure 5. The spectral ratios H/V computed for the URS05, URS08, URS13 and URS23 seismic stations: (a) for seismic events and (b) for noise

This technique provides realistic estimates of spectral amplifications and can supply, when necessary, the lack of strong motion recordings for the "target" site.

The used method makes it possible to obtain at low cost and exploiting large quantities of existing data (e.g. geotechnical parameters, surface geology data, seismological data), a realistic seismic input at surface.

These data set can be fruitfully used by civil engineers for designing new seismo-resistant constructions.

RESULTS AND DISCUSSIONS

From geophysical-geotechnical processing:

- The aim was to measure seismological broadband waveforms in the city area of Bucharest.
- Continuous recording at 32 sites with broadband sensors, sampling rate 50 Hz, 3 channels, have offer a powerful database (between Oct. 2003-Aug. 2004) that is the basis to verify predicted site amplification effects as well as other research topics.
- 10 new, 50 m deep, boreholes were drilled to recover samples for geotechnical laboratory tests and to measure in situ seismic velocities profiles, v_p and v_s.
- Soil samples were processed with the help of resonant columns and dynamic triaxial equipment (see Table 1).
- Were performed 400 geotechnical analysis of samples from 6 Quaternary layers, improved v_s30 mapping, spectral amplification curves for the 10 sites and investigation of seismological measurements across the city.
- Was obtained a unique, homogeneous dataset of soil-mechanic and elasto-dynamic parameters of the subsurface of Bucharest.

Table 1. Geotechnical tests (selection) for the 10 sites

Operation	Number	Objective
Drilling	10 boreholes	Drilling and Probing Operations
Resonant column tests	58	Dynamical parameters for linear and non-linear modeling
Triaxial tests (dynamical, undrained); edometric tests, maximum and minimum compactness	15	Dynamical and mechanic parameters
CU Triaxial test	4	Standard geotechnical experiment
Angle of repose	11	Standard geotechnical experiment
Granulometry	54	Standard geotechnical experiment
Maximum and minimum compactness	6	Standard geotechnical experiment
Determination of e_min and e_max	11	Standard geotechnical experiment
Determination of liquid and plastic limit	4	Standard geotechnical experiment

- A comparison and calibration of the borehole data with actual seismological measurements.
- This researcher helped to develop an optimized seismic micro zonation of the metropolitan area of Bucharest which can be implemented for the future urban planning.

From H/V measurements:

Table 2 presents a comparison of the fundamental period of the soils package from lithological columns from drills F1 (Eastern Bucharest), F2 (downtown) and F3 (South Bucharest) (NATO Project SfP 981882) calculated with the empirical formula $T = 4\ h/v_s$ (h is the thickness of the layers, v_s is the average transverse waves velocity) and assessment of fundamental period with spectral ratio method H/V. The drills are in the vicinity of seismic stations URS05, URS08, URS13 and URS23 for which was computed the spectral ratios for seismic events and noise.

CONCLUSIONS

This database is a valuable collection of elastic and dynamic parameters of the Quaternary sedimentary layers obtained by direct and indirect measurements, and it was continuously updated during recent projects (BIGSEES and POSEIZON) with much more processed records for significant earthquakes after year 2008. The paper emphasizes the importance of the accumulated data (geotechnical, geophysical and seismological) for understanding the behaviour of the soil under Bucharest at last seismic events and how it will influence the impact of future seismic hazards.

The seismic hazard assessment combined with local effects evaluation ensures the local seismic hazard coherency as important steps in risk mitigation process, through a realistic structural seismic response, that could be used for improving design norms.

Table 2. Calculation of fundamental periods of sites

Drills	Fundamental period evaluated with the method H/V [s]	Fundamental period calculated with the empirical formula T=4 h/v_s [s]	Fundamental period calculated from ambiental noise [s]
F1	URS08 = 1.45 URS13 = 1.5	1.42	1.38
F2	URS23 = 1.45	1.523	1.56
F3	URS05 = 1.48	1.39	1.42

However, all the data collected on seismic hazard and buildings behaviour during medium earthquakes were discussed with researchers and designers for planning measures for rehabilitation of old buildings and construction of safe ones.

These research programs helped to develop an optimized seismic micro zonation of the metropolitan area of Bucharest which could be implemented for future urban planning.

ACKNOWLEDGEMENTS

This paper was carried out within Nucleu Program MULTIRISC, supported by MCI, project no. PN19080102.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

EFFECT OF CHANGES IN THE ROMANIAN LOWER SECTOR DANUBE RIVER HYDROLOGICAL AND HYDROTHERMAL REGIME ON FISH DIVERSITY

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Abstract

Climate variability and change has negative impact on fisheries ecosystems. Climate change can manifest a pervasive effect on freshwater ecosystems, by altering biodiversity patterns, abundance and distribution of species, biological interactions, phenology and organisms' physiology, performance and fitness. Central and Southern Europe, including Romania, is considered to be one of the most vulnerable regions affected by changes in the climate system. Therefore, the aim of the study was to evaluate the influence of Danube River water level and temperature regime, atmospheric thermic regime, from the last 3 years (2017-2019), on ichthyofauna diversity and abundance in the Lower Sector of the River. The year 2018 registered the highest values for water levels and the year 2019 recorded the maximum values for air temperatures, in all hydrometric stations. A general conclusion of this research is that the capture level of peaceful (non-ichthyophagous) fish species are higher compared to raptor (ichthyophagous) fish species. Based on these results, there is strong recommendation to incorporate climate variability and change in the modelling of fisheries management approaches to reduce the impacts of climate variability and change on fisheries-based livelihoods.

Key words*: climate change, Danube River, fish diversity, global warming, pontic shad.*

INTRODUCTION

Quick and persistent rises in temperature are expected to occur during the next decades (Diop et al., 2018). Global warming does not just affect the atmosphere and its effects have extended to the aquatic environments as well (Hannesson, 2007).

This phenomenon generated an increase in global temperature (ranging from 1.8 to 4.0°C), a change in weather patterns and hydrodynamics, and water level rise (Madeira et al., 2016).

Such climate changes negatively influence the fish migrations and habitat, augmenting fish stocks in some places and decreasing them in others (Hannesson, 2007).

Temperature is one of the most important environmental variables associated with aquatic life and its variability (Linderholm et al., 2014). Warming of aquatic systems is implicated in mass mortality, increased disease, hypoxia, species invasions, phenological shifts in planktonic food web dynamics, physiological limitation in oxygen delivery and increased costs of metabolism (Byrne, 2011).

According to Madeira et al. (2016) and Linderholm et al. (2014) early life stages are highly vulnerable to water temperature increase. Thermal windows widths are narrower for egg, larvae and spawners stages of fish, compared to juveniles and adults (Madeira et al., 2016). Thus, early exposure to stress in development can result in latent deleterious downstream effects, because performance of later ontogeny depends on the success of early stages (Byrne et al., 2013).

This process is called "development domino effect". In case of fisheries and aquaculture production, deviation from the optimal thermal range can affect fish growth rate, harvest or catch size and cause stock displacement of commercial species (Blanchet et al., 2019). As well, warming of freshwater systems (such as ponds and lakes) will affect access to water, which is the main constraint on these land-based production systems (Blanchet et al., 2019).

In the future, global warming, through its effect on water temperature, will manifest a strong influence on stock dynamics and harvest levels (Diop et al., 2018). The interaction of fishing

with climate variability and change will influence fish species size, structure and composition of fish populations (Ng'onga et al., 2019).

The freshwater sector, including wild captures and aquaculture, relies exclusively on fish and represents less than 3% of the total European seafood production volume (Blanchet et al., 2019). The sensitivity of seafood production volume caused by exposure to warming of the ambient water was previously assessed based on the index of biological sensitivity (BS) (Blanchet et al., 2019). Freshwater fish species produced in European aquaculture have a high biological sensitivity index ranging (BS > 0.5), due to a long-life span and a high age at sexual maturity (Blanchet et al., 2019). According to Blanchet et al. (2019), Romania presents a relatively low vulnerability (BS = 0.45) to warming because the country aquaculture production is based on the common carp. In her study, Byrne (2011) highlighted the need for a regional approach in assessment of ecosystem change and risk to species.

During the last decade, Romania has experienced the highest summer temperatures in the last 100 years (Ionita et al., 2013; Rimbu et al., 2015). Also, global warming related to extreme climate events such as extreme precipitation or drought, can modify the water cycle causing abnormal fluctuations of water level (Cheng et al., 2019). Therefore, the aim of the study was to determine the influence of Danube River water temperature and level regime on fish stock structure and diversity, in the last 3 years (between 2016 and 2019).

MATERIALS AND METHODS

The study area is represented by the Lower Sector of Danube River, respectively Braila (170 river kilometer), Galati (150 river kilometer) and Tulcea (70 river kilometer) (Figure 1).

The water temperature (T°C) and level (cm) were daily recorded in the hydrometric stations and the data was provided by Galați Lower Danube River Administration. In this study, the maximum and minimum values of water temperature and level were selected for each month, in order to point out the effect of extreme climate events.

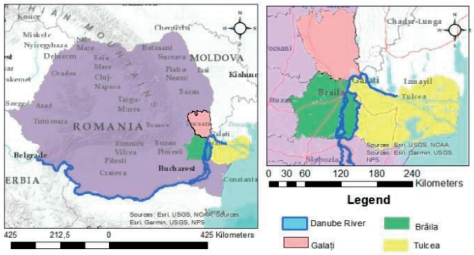

Figure 1. GIS mapping of the studied area

In the South-East part of Romania, commercial fishing is undertaken in the Danube Delta Biosphere Reserve and total fish catches are reported in the following geographical units: Danube River, Gorgova-Uzlina, Dranov Island, Black Sea and Black Sea basin, Matita Merhei, Razim-Sinoe, Rosu Puiu, Somova Parches, Sontea-Fortuna. The highest values of fish capture are reported in Danube River area, thus, in this study, the data recorded within this area has been analysed. The data recorded for the reported total fish capture between the years 2016-2019 was provided by the Danube Delta Biosphere Reserve Authority.

The following fish species are reported as capture in Danube River fishing area: *Abramis brama* (Linnaeus, 1758), *Alosa caspia* (Eichwald, 1838), *Alosa immaculata* (Bennett, 1835), *Leuciscus aspius* (Linnaeus, 1758), *Barbus barbus* (Linnaeus, 1758), *Blicca bjoerkna* (Linnaeus, 1758), *Carassius gibelio* (Bloch, 1782), *Cyprinus carpio* (Linnaeus, 1758), *Esox lucius* (Linnaeus, 1758), *Pelecus cultratus* (Linnaeus, 1758), *Perca fluviatilis* (Linnaeus, 1758), *Rutilus rutilus* (Linnaeus, 1758), *Scardinius erythrophthalmus* (Linnaeus, 1758), *Silurus glanis* (Linnaeus, 1758), *Sander lucioperca* (Linnaeus, 1758), *Tinca tinca* (Linnaeus, 1758), *Vimba vimba* (Linnaeus, 1758).

The identified fish species were separated into two groups, based on the fish feeding regime, as following: non-ichthyophagous group (freshwater bream, caspian shad, white bream, prussian carp, common carp, roach, rudd, vimba bream, tench) and ichthyophagous group (shad, asp, barbel, northern pike, wels catfish, european perch, pike-perch, sichel).

Species diversity was expressed by calculating the biomass diversity index of Simpson (DI),

according to Tian et al. (2006). Thus, the following formula was applied:

$$DI = 1 - \sum_{i}^{n} \frac{Y_i(Y_i-1)}{Y(Y-1)} \quad (1)$$

where Y_i represents the quantity of fish species items and Y represents the sum of total n items, for each of the studied years. In general, Y is the number of individuals, but units of weights (tons) are accepted as well (Tian et al., 2006). **DI** value ranges from 0 to 1, where 0 represents the community composed of only one species.
Statistical analysis was performed by using Origin Pro Software. In order to evaluate the normality of data distribution, Kolmogorov-Smirnov normality test was performed, followed by the variance test One-Way Anova and Tukey test.

RESULTS AND DISCUSSIONS

The mean annual highest water temperature in Braila Station was registered in 2019 (17.16 ± 8.39°C) and the lowest in 2017 (16.25 ± 9.07°C) (Figure 2). In case of the water level, the annual mean highest value was recorded in 2018 (345.25 ± 190.46 cm) and the lowest (298.91 ± 109.50 cm) in 2017 (Figure 2). Despite the upward tendency, water temperature and level values did not register significant differences ($p > 0.05$) in all studied years, in Braila Station.
In Galati Station, the mean annual highest water temperature was registered in 2019 (16.86 ± 8.62°C) and the lowest in 2017 (16.35 ± 9.41°C) (Figure 3.). In case of the water level, the highest mean annual value was recorded in 2018 (343.91 ± 173.17 cm) and the lowest (297.25 ± 102.14 cm) in the year 2017 (Figure 3.). Even though there is an upward tendency from one year to another, the differences registered in case of water temperature and level values were not significant ($p > 0.05$) in all studied years, in Galati Station.
The highest mean annual water temperature in Tulcea Station was registered in 2019 (17.15 ± 8.52°C) and the lowest in 2017 (16.20 ± 9.28°C) (Figure 4). In case of the water level, the highest annual mean value was recorded in 2018 (221.5 ± 118.30 cm) and the lowest (190 ± 74.14 cm) in 2017 (Figure 4). However, in Tulcea Station, the differences registered in case of water temperature and level values were not significant ($p > 0.05$) in all 3 studied years.

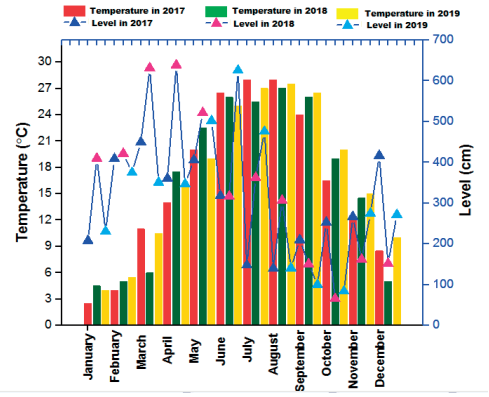

Figure 2. Water temperature and level in Danube River, Braila Station

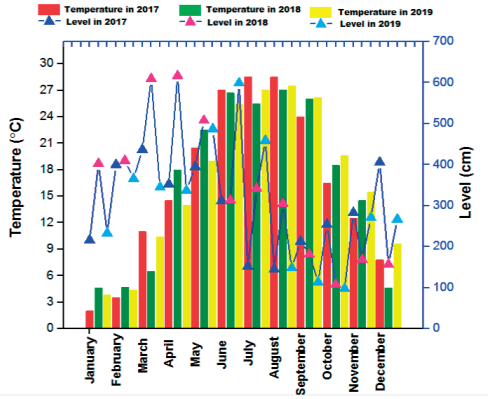

Figure 3. Water temperature and level in Danube River, Galati Station

The means highest water temperatures were registered in August for all stations and studied years. In case of the water level, the mean highest levels were recorded in March, for the year 2017 in all studied stations, in April, for the year 2018 in all studied stations and in June, for the year 2019 in all studied stations. The year 2018 registered the highest water levels in all stations, due to the unusual and heavy rainfall in the form of snow, sleet and rain, followed by snow melting phenomena (Galati Lower Danube River Administration, 2019). In 2017, the lowest water levels were recorded in August, in all sampling stations and

in 2018, 2019, the lowest levels were registered in October.

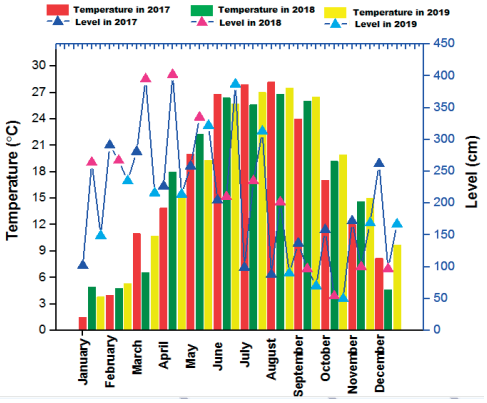

Figure 4. Water temperature and level in Danube River, Tulcea Station

The correlation analysis (Pearson coefficient) revealed that in 2017, water temperature and level were negatively correlated, in all studied stations (Pearson coef. = -0.50). In 2018 and 2019, the values registered for water temperature and level, in all the studied stations, did not manifest a correlation relationship (Pearson coef. < 0.5).

The total fish catches reported from Danube River, within the sector situated in Danube Delta Biosphere Reserve, was as it follows: for 2017 a total of 704.832 tons, for 2018 a total of 652.517 tons and for 2019 a total of 1 032 tons (Figure 5). In 2017 and 2019 the highest catches were reported for *A. immaculata* (263, respectively 348 tons), whereas in 2018 the highest catches were reported for *C. gibelio* (244 tons) (Figure 5). The decrease of reported *A. immaculata* catches in 2018 may be caused by the extreme flooding phenomenon manifested in that year. According to Smederevac-Lalić et al. (2018), extreme spring floods have a negative influence on survival of pontic shad eggs and larvae, due to high turbidity. However, flooded terrestrial vegetation provide suitable spawning substrate for phyto-philic and phyto-lithophilic cyprinids, such as the prussian carp (Janac et al., 2010). In addition, flooded vegetation provides efficient refuge against predators, high food availability and higher temperature to support the rapid growth of many juvenile fish (Janac et al., 2010). The high water temperature may be beneficial for fish species from the ichthyophagous group, such as the northern pike, by stimulating the growth rate of juveniles, through elevations of individual metabolic rates, and also through the extension of the local growing season for northern pike (Szczepkowski, 2006; Winfield et al., 2008). However, if northern pike eggs are incubated at a temperature above 15°C, larval abnormalities are expected to increase and premature hatching could occur, preventing the functional attachment of yolk-sac larvae to substrate and sank to the bottom where toxic conditions are encountered (low oxygen, presence of hydrogen sulfide) (Hassler, 1982). This phenomenon could increase larvae mortality rate by 40%.

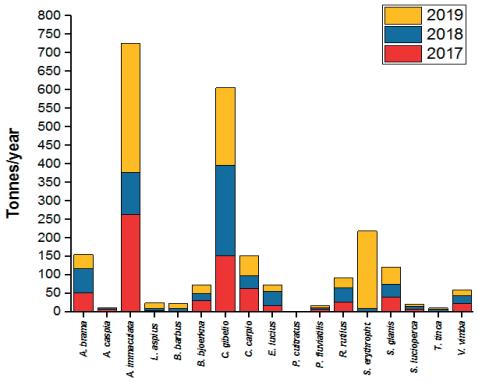

Figure 5. Quantitative distribution of different fish species captured from Danube River

Other ichthyophagous fish species, such as the perch and pikeperch, can be disadvantaged by the early water warming during spring season, which negatively affects the survival of larvae, due to early hatching and increased risk of exposure to cold weather, as well as starvation during subsequent development (Kokkonen et al., 2019). According to Lappalainen et al. (2003), at a water temperature higher than 20°C, the number of normally hatched larvae decreases. Furthermore, it is well known that during warm springs and summers, the spawning of pikeperch occurs earlier, but if the temperature drops suddenly, spawning may be interrupted (Lappalainen et al., 2003).

The raising water temperature can affect fish reproduction as well. For instance, the

pikeperch requires a wintering period to induce puberty and slightly higher temperatures, that are still well below 20 °C, to ideally progress vitellogenesis (Swirplies et al., 2019). Gonad maturation can be completely inhibited at temperatures higher than 20 °C, by preventing energy allocation to the gonad and increasing fish growth rate (Swirplies et al., 2019).

The highest values were reported for fish capture from the non-ichthyophagous group and within the group *C. gibelio* recorded the highest capture as biomass (Table 1). In the ichthyophagous group, the highest value was recorded in case of *A. immaculata* capture.

Table 1. The share of non-ichthyophagous and ichthyophagous fish capture from total

Year	Non-Ichthyophagous	Ichthyophagous
2017	51%	49%
2018	68%	32%
2019	56%	44%

The values reported for fish capture did not register significant differences ($p > 0.05$) between the studied years.

As well, when compared, the values reported for fish capture in the two groups (non-ichthyophagous and ichthyophagous) did not manifest significant differences ($p > 0.05$), in all studied years.

The DI values show a decreasing trend in fish diversity from the year 2017 to year 2019 (Figure 6). When calculated for each group, the DI registered higher values in case of the non-ichthyophagous group (DI = 0.756), compared to the ichthyophagous group (DI = 0.396), in the year 2017. The same phenomenon was observed in the year 2019, when the non-ichthyophagous group registered higher values (DI = 0.720), compared to the ichthyophagous group (DI = 0.396).

In case of 2018, the DI was similar for both groups (DI = 0.653, respectively DI = 0.651). This fact is associated to a change in the reported catches from the ichthyophagous group, respectively a decrease of *A. immaculata* capture and an increase of capture within the rest of the species which belong to this group.

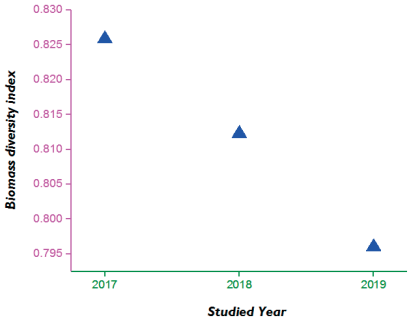

Figure 6. Annual changes in the estimated diversity index

A very strong negative correlation (Pearson = -0.999) was identified between water temperature and DI, in case of all studied years. Thus, high water temperature is associated to low fish diversity. In this study, it is observed that especially the fish species from the ichthyophagous group suffer a decline in biodiversity. This fact was confirmed by Korzeniewska and Harnisz (2020) as they mentioned that water heating has a negative impact and limit the occurrence of fish species that prefer colder environments (*E. lucius, P. fluviatilis, S. lucioperca*).

CONCLUSIONS

Water temperature in the lower sector of Danube River manifested an upward tendency in the last 3 years, registering the highest mean values in 2019.

The water level shows an increasing trend during the studied timeline, with the highest values recorded in 2018, due to extreme floods manifested in that year in the Lower Sector of Danube River. Fish diversity in the Lower Sector of Danube River recorded a decreasing trend, during the years 2017-2019 and the total capture of peaceful (non-ichthyophagous) fish species are higher compared to raptor (ichthyophagous) fish species.

The correlation analysis revealed a negative correlation between water and temperature, as well as between water temperature and fish diversity. Based on these results, there is strong recommendation to incorporate climate variability and change in the modelling of fisheries management approaches to reduce the impacts of climate variability and change on fisheries-based livelihoods.

This study can be used for the development of biodiversity protection strategies and for future research, in order to create mathematical models, which can predict long-term fish biodiversity in Danube River.

ACKNOWLEDGEMENTS

The authors are grateful for the support of Galati Lower Danube River Administration and Danube Delta Biosphere Reserve Authority for providing the data analysed within this article.
The authors are grateful for the technical support offered by ReForm - MoRAS through the Grant POSCCE ID 1815, cod SMIS 48745 (www.moras.ugal.ro).

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE IMPACT OF THE INSUFFICIENTLY TREATED WASTE WATER DISCHARGE ON THE AQUATIC FAUNA OF AN OUTLET

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Abstract

The inadequate and insufficient treatment of the waste water into a treatment plant endowed with two stage (mechanical and biological, using a treated system with fixed biofilm and a system for treatment and sludge dewatering) and its discharging into a natural stream that supplies a fishing stock, determined an inappropriate aquatic life. The continuous discharge of the water which contains insufficiently oxidized organic and chemical substances (due to non-functionality of the treated biological stage) and the exceeding of the maximum concentration for the quality indicators: ammoniacal nitrogen, CCOCr, CBO_5 and detergents decreased the soluted oxygen from the water, the anaerobic biodegradation of the organic matters, ammonia intoxication and the generation of H_2S as the lapse of the atmospheric pressure during the precipitations. The effects of the water pollution were manifested in suffocation and mortality of the fishing fauna.

Key words*: aquatic fauna, domestic water, impact, pollution, spill.*

INTRODUCTION

The sewage-treatment plant in SC Apa CTTA Alba, branch Sebes has two sewage-treatment plants which are discharged in the town mains of Daia Romana. Each treatment plant is endowed with two stages (mechanical and biological) and a system for treatment and sludge dewatering in the bag unit. The treatment plant Daia Romana 1 is located at the entrance of the town and was designed for a maximum flow rate of 150 mc/day, but due to a malfunction, it was transformed in a pump plant (Figure 1).

Figure 1. The Treatment plant Daia Romana 1

The treatment plant Daia Romana 2 was working only with its mechanical stage, the biological one was not work since putting it into operation and being designed for a maximum flow rate of 1050 mc/day. At the same time with the pumping of the untreated water from the treatment plant 1, it is found that the designed treated flow rate of the treatment plant 2 was exceeded, given that this plant could not treat from the point of mechanical view either, because it exceeds the maximum capacity of the treatment plant 2 while operating at full capacity (1050 + 150 = 1200 mc/day) (Figure 2).

Figure 2. The Treatment plant Daia Romana 2

The Daia pond is part of a fishing stock of a company from the studied area and represents the first pool which is supplied with the water of the Valea Daii creek. This has a total area of 49.54 ha, the crystal surface being of 35.5 ha and a water depth at fishing level of 1.8 m.

Because, in the section of Valea Daii creek, between the treatment plant 2 and the fishing stock there is not a basin to allow a natural biological treatment of the waste waters, the biological untreated water from the treatment plant discharges directly into the first pool of the fishing stock, by Daia creek. Additionally, from a waterway mouth located at about 5 m of Daia creek, it is discharged the untreated water (Figure 3). Thus, the fishing stock is polluted with the discharged water from the two treatment plants, by Daia creek.

Figure 3. The discharging of the untreated water from a waterway mouth located by the Daia creek

The fishing stock's purpose is the production, the primary processing or the refrigeration of the products and the fish merchandising. The working time of the fishing stock is 24 hours/day, 365 days/year, and the production capacity is 120-140 t fish/year.

The large quantities of the inadequate and insufficient treatment of the waste water reached in the Daia pond of the fishing stock by Daia creek, resulted in the exceeding of the maximum concentration for the quality indicators of the waste water. Thus, the water that supplies the fishing stock is inappropriate to the aquatic life, changing the water characteristics of the Daia pond and causing the mortality of the fishing stock.

Fish is very sensitive to the inappropriate qualities of the waters, this could live just in a rich oxygen environment (the oxygen content > 3 mg/l) and free of toxic substances (pH = 6 - 8, ammonia nitrogen < 1 mg/l, phenols < 0.02 mg/l, CBO_5 < 5 mg/l, H_2S -free and detergents or surface-active chemical substances - free).

MATERIALS AND METHODS

To emphasize that the fishing mortality was caused exclusively by the systematic pollution of the Daia creek, that supplies the Daia pond of the fishing stock, due to the insufficient and inadequate treatment of the waste waters, in the sewage-treatment plants Daia Romana, it were sampled weekly/monthly/trimestral a number of 107 waste water samples from the treatment plant, during March 2016 - May 2018. The waste water samples were analysed by specific methods and were determinates the following quality indicators:

- pH (pH units) - potentiometric method.
- TP (total particulates) (mg/l) - gravimetric method, by filtering and oven-drying.
- Filterable residue (fixed), (mg/l) - gravimetric method, by oven-drying.
- CCOCr (mg O_2/l) - volumetric method, using the automatic system of overflowing back and volumetric titration with $K_2Cr_2O_7$.
- CBO_5 (mg O_2/l) - electro-chemical method of analyse, using the reading automatic system of the solute oxygen demand.
- Ammonium (mg/l) - spectre-photometric method.
- Retrievable substances (mg/l) - gravimetric method with solvents.
- Detergents (mg/l) - chromatographic method.

The obtained concentration values were compared with the maximum permissible limits, according to the monitoring frequency (weekly, monthly and trimestral), established by the water rights permits no. 64/March, 3rd 2016; 225/August, 8th 2017 and 264/September, 9th 2017 (Table 1).

Table 1. The maximum permissible limits for the quality indicators of the waste waters

Quality indicator	Maximum permissible limit
pH (pH units)	6.5-8.5
TP (particulates) (mg/l)	200/240
Filterable residue (fixed) (mg/l)	2000
CCOCr (mg O_2/l)	400
CBO5 (mg O_2/l)	215/240
Ammonium (mg/l)	30
Retrievable substances (mg/l)	20
Detergents (mg/l)	0.5

For each analysed quality indicator, the obtained concentration values were graph represented, using the water samples analysed from the point of view of each indicator, from the 107 waste water samples and there were identified the causes responsible for the fishing mortality.

RESULTS AND DISCUSSIONS

After the analyses of the waste water samples the following has been observed:

- The pH indicator falls into the regulated limits for the 106 analysed waste water samples, with the exception of the measurement done in November, 11th 2016, when the value of 9.3 pH units was recorded, namely an exceeding of 9.41% over the maximum permissible limit (Figure 4).

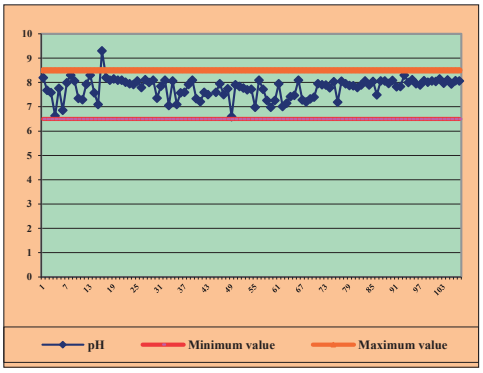

Figure 4. The fluctuation of the obtained values for the pH quality indicator determined in the waste water samples during March 2016 - May 2018

- MTS indicator (total particulates) recorded exceeding's for 23 of 100 measurements. The biggest value, 690 mg/l is registered in May, 5th 2016, 3.45 times bigger than the maximum permissible limit established for 200 mg/l (Figure 5).

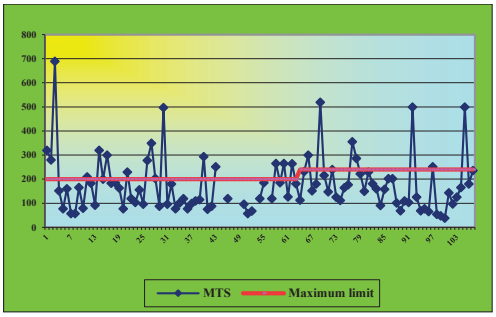

Figure 5. The fluctuation of the obtained values for the MTS quality indicator determined in the waste water samples during March 2016 - May 2018

- Filterable residue indicator (fixed) recorded exceeding's for 2 of 35 measurements, the biggest value being 3452 mg/l in June, 7th 2016, 1.72 times bigger than the maximum permissible limit (Figure 6).

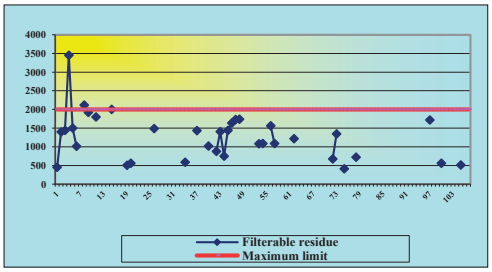

Figure 6. The fluctuation of the obtained values for the filterable residue indicator determined in the waste water samples during March 2016 - May 2018

- Chemical oxygen demand (CCOCr) recorded exceedings for 95 of 107 measurements, the biggest value being 1907.7 mg/l in September, 12th 2017, 4.76 times bigger than maximum permissible limit (Figure 7).

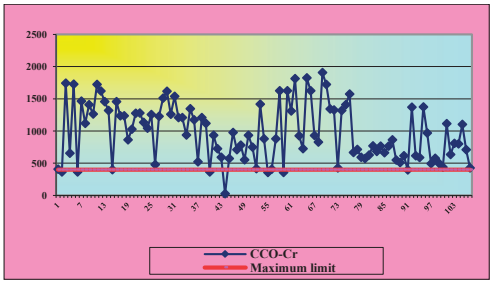

Figure 7. The fluctuation of the obtained values for the chemical oxygen demand indicator determined in the waste water samples during March 2016 - May 2018

- Biochemical oxygen demand (CBO_5) recorded exceeding's for 64 of 97 measurements, the biggest value being 1456 mg/l, recorded in November, 11th 2016. This being by 6.77 times bigger than the maximum permissible limit established for 215 mg O_2/l (Figure 8).

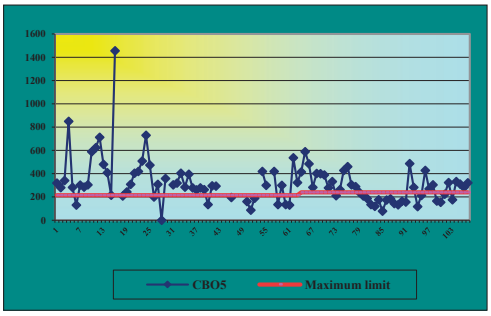

Figure 8. The fluctuation of the obtained values for the biochemical oxygen demand indicator determined in the waste water samples during March 2016 - May 2018

- Ammonium indicator recorded exceeding's for 103 of 107 measurements, the biggest value being 385.6 mg/l, recorded in May, 10th 2016, by 12.85 times bigger than maximum permissible limit established for 30 mg/l (Figure 9).

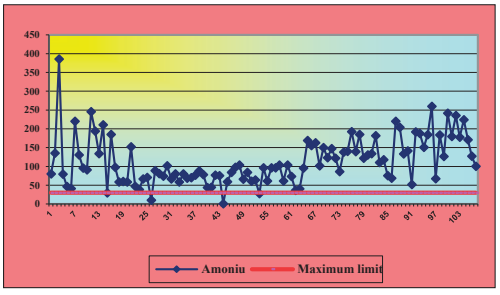

Figure 9. The fluctuation of the obtained values for the ammonium indicator determined in the waste water samples during March 2016 - May 2018

- Retrievable substances indicator recorded exceeding's for 2 of 14 measurements, the biggest value being of 72 mg/l, recorded in June, 7th 2016, by 3.6 times bigger than maximum permissible limit established for 20 mg/l (Figure 10).
- Detergents indicator recorded exceeding's for all three measurements, the biggest value being of 10.65 mg/l recorded in January, 3rd 2018, by 21.3 times bigger than maximum permissible limit of 0.5 mg/l (Figure 11).

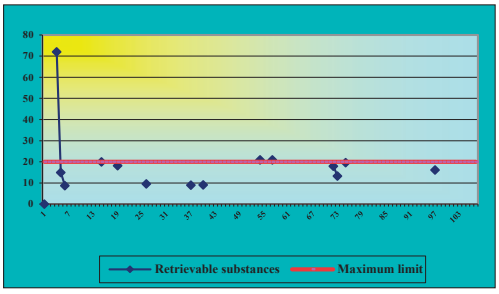

Figure 10. The fluctuation of the obtained values for the retrievable substances indicator determined in the waste water samples during March 2016 - May 2018

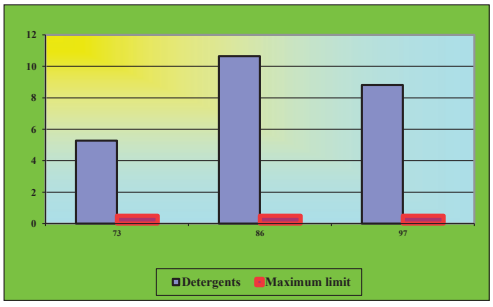

Figure 11. The fluctuation of the obtained values for the detergents indicator determined in the waste water samples during March 2016 - May 2018

The inadequate and insufficient treated waste water from the treatment plant Daia Romana reached using the Daia creek water in the first pond of the fishing stock. Due to the large area and to the volume of the creek water, the pollution effects on fishing fauna did not occur instantly.

The exceeding of the maximum permissible limit of the ammonium, CBO_5 and CCOCr indicators due to the non-operating of the biological treatment stage, demonstrates that the waste water of the treatment plant Daia had a high oxidable impurities insufficiently oxidized, which reaching the emissary Daia creek and in the Daia pond, led to the lower of the oxygen concentration dissolved into the Daia pond water, to the stopping of the oxidation aerobe processes of the insufficiently oxidized impurities and to the development of the biological anaerobic processes.

The high content of the detergents from the waste water led to the changement of the

superficial properties of the Daia creek and of the Daia pond, lowering the self-purification water capacity and to the reducing of the oxygen transfer into the water up to 70%.
Furthermore, due to the lowering of the air pressure, during the precipitations and to the anaerobic biodegradation of the organic matters, it occurred the development and the emission of the hydrogen from the accumulated sludge on the fishing pond bottom.
Technically, the sewage treatment plant had not the adequate treatment capacity, because:
- The screen auger was in open air and friable during the winter, being non-operating in the negative temperature periods;
- The sand filer or the fat collector was not endowed with the sand collecting pump and it was sealed off;
- The homogenizer basin was not endowed with mechanical mixing device or with airing system, enabling the piling of the dead sludge, an important source to generate the sulphurated hydrogen;
- The airing system of the basin enabled a low transfer of the oxygen into the waste water, unlowering the CBO_5 and CCOCr concentration from the waste water;
- The transfer rate of the water between basins were very high and did not allow the reducing of the nitrogen substances by nitrification/non-nitrification, enabling a high concentration of ammonium ligand into the waste water discharged into emissary;
- The sludge dewatering system was an empirical one and did not enable the high-speed discharging of the sludge water, unlowering the particulates concentration (TP) from the discharged water from the treatment plant into the emissary;
- The ammoniacal nitrogen and phosphor concentrations of the discharged water from the treatment plant were much higher than at the admission due to the entrainment of the dead sludge;
- Only 30% of the suspensions and the biochemical consumption of the oxygen were treated;
- The exceeding's of the quality indicator concentrations owed by using an inadequate treatment method with fixed biofilm treatment system.

These cumulated aspects led to the asphyxia of the fishing fauna, recording a mortality of 39.080 kg (Figure 12).

Figure 12. The asphyxia of the fishing fauna due to the pollution of the basin water

CONCLUSIONS

The treatment plants 1 and 2 from Daia Romana in Apa CTTA Alba, Sebes branch, did not work at the designed parameters because the biological stage and the sludge intendancy installations did not run and the mechanical stage of the treatment plant 2 was overstrained due to the taking of the untreated waste waters from the treatment plant 1.
The goal of the Daia pond is to stock fish in the polyculture.
Due to water samples and to the quality indicators were recorded exceeding's of the maximum limits established for the particulates (TP), the biochemical oxygen demand (CBO_5), the chemical oxygen demand (CCOCr), ammonium, retrievable substances and for detergents.
The fishing stock was polluted with discharged water from the treatment plant of the SC Apa CCTA Alba, the aquatic life being improper because the discharged water from the treatment plant was in a such quantity and concentration that changed the water characteristics from the ponds and put in danger the fishing stock.

The asphyxia and the fishing mortality from the Daia pond were caused by the waste water insufficiently treated and polluted with organic and chemical substances insufficiently oxidized, ammoniacal nitrogen and detergent that reached into Daia pond by Daia creek led to the lowering of the oxygen dissolved into water, the anaerobe biodegradation of the organic matters with the generation of the sulphurated hydrogen and with ammonium poisoning.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

ANALYSIS OF THE BEHAVIOR OF WORKS TO LIMIT WATER EROSION IN RIVER BASINS

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Abstract

The erosion generated by water, called synthetically water erosion, especially caused by the stream of water induces, the continuous change of the watercourse with significant imbalances of form and path, but also if it is the aquatic ecosystem, or a series of many others negative changes in the riparian areas of the minor riverbed, with material damage and sometimes clear loss of human lives. In time, constructive measures have been developed and applied, located in the riverbeds, to manage and minimize the impact of this phenomenon. The monitoring of the behavior of these works shows the beneficial effect on the limitation of erosion, but it also reveals the negative effects of the hydrodynamic action of the water on their structure and stability, eventually on their durability. The present paper proposes a synthetic analysis of the causes and ways of degradation of the main types of works used in engineering practice to limit the erosion of the watercourses. The analysis is based on an extensive documentary and field study carried out on concrete cases, on a series of rivers in the river basins of Moldova. The causes that led to the observed degradation are highlighted, respectively the solutions by which these shortcomings could be avoided in the future. It highlights the increased efficiency and the longer life of the new types of works used for this purpose, respectively the works based on the use of geocontainers.

Key words*: degradation, erosion, gabions, geocontainers.*

INTRODUCTION

The main objective of this work is to analyze the use of some hydrotechnical works that can be performed to ensure the protection of localities and social economic objectives, against the erosion process produced by the watercourse.
The erosion produced by the watercourse is the mechanical process exercised by the water of the river during floods on the bed of the riverbed and the banks where the particles of soil and rock are weakened, dislocated and entrained.
This process is accentuated during the floods in the areas where the river has additional energy and has high speed, being influenced by the transport of the alluvium from upstream to downstream, the nature of the soil crossed by the watercourse and the slope of the land.

The intensity of erosion can be normal being equal to the natural remaking of the soil and accelerated being faster than the natural remaking.

Depending on the area of action on the ground, there is surface erosion (it develops on relatively large surfaces) and depth erosion (is the advanced form of surface erosion that is pronounced after a certain concentration direction giving rise to permanent and action destructive formations. (Nicola O., 2013)
Types of erosion produced by the watercourse:
Linear erosion - occurs in the riverbed along the waterline, ie where the depth is high and the turbulence is active;
Regressive erosion - occurs on any leveling along the river bank, but the tendency is to reduce the slope, by withdrawing and ceasing it upstream;
Lateral erosion - is the mechanical process by which river water loaded with alluvium acts on the steep banks of the riverbed, frequently in the meandering concavities (Baloiu V., 1967);
Torrential erosion - it acts in the depths and in the area of the banks, it is formed during periods of heavy rainfall by concentrated water currents in the slope areas and at the edge of the terraces

where the soil is poorly cohesive (Radoane N., 2004).

MATERIALS AND METHODS

This paper proposes an analysis the use of erosion control works, with classic gabions and geocontainers from an economic point of view, and their behavior in the areas located on the rivers of the Siret river basin.
The analysis of the works from an economic point of view was performed through the Windoc Deviz program, and the behavior of the works was performed through field verifications and periodic monitoring.

Erosion control works, general aspects

Hydrotechnical schemes and works are important for our country due to the varied conditions of soil, climate, relief, and watercourses variation.
The erosion control hydrotechnical works contribute by their effect to the protection and improvement of the soil, the defense of agricultural lands and environmental factors. Also, through erosion control works i can be ensured localities and roads protection against erosion process or landslide.
Erosion control works used could be:
- Cross works:
- groyne;
- bottom sill;
- dams.

- Longitudinal works:
- gabion works;
- support walls;
- concrete and rock walls;
- prefabricated works.

- Regularization works:
- rock and gabion dams

(Oncia S., 2016).

Gabion works

Classic gabions are construction elements consisting of parallelepiped or cylindrical boxes, and mattresses, made of metal frames and zinc-plated wire mesh, filled with river stone or broken stone.
Box type gabions are 1 m high, 1-1.5-2 m wide, and 2-6 m long.
The gabion frame gives resistance, therefore is made of steel having diameters of Ø 10-18 mm or of galvanized steel bars. The gabion sides are made of galvanized wire mesh Ø 2.8-5 mm, single or double twisted in square or hexagonal mesh of 4-8 cm. The mesh size and the diameter of the wire are chosen according to the filling stone size. (https://www.scrigroup.com/casa-masina/constructii/Modernizarea-tehnologiei-de-pr14156.php)
Alternative gabions are rectangular prismatic elements, constructed of a metal reinforcement and a metal mesh, with hexagonal, double twisted mesh.
The mesh can be hot galvanized, galvanized aluminum or PVC coated. All the gabions are constructed of core wire with a diameter of 2.7 mm and have an opening of 100 mm, the gabions are divided with internal diaphragms arranged at 1 m.
Gabions are available in the following standard sizes:
- 1 m x 1 m x 1 m;
- 2 m x 1.5m x 1 m;
- 2 m x 0.5 m x 0.5 m;
- 2 m x 1 m x 0.5 m;
- 2 m x 1m x 1 m;
- 4 m x 1m x 0.5m;
- 4 m x 1 m x 1 m;
- 6 m x 2 m x 0.5 m.

(https://www.maccaferri.com/ro/)
The gabions are used for the protection of the banks, local protection of the infrastructure of the bridges, buried bottom thresholds, support walls for the protection of the slopes, they can be used in the areas with lateral erosions encountered on the watercourses and torrential formations (Figures 1 and 2).
The gabions are usually placed over the gabion mattresses, it is recommended that these gabion mattresses be placed on a layer of rolls of twigs running in the direction of the water flow.
Gabion hydrotechnical structure are elastic and can be placed according to the configuration of the land and are resistant to degradation.
In the case of floods with coarse alluviums, the wire can be destroyed in time, for the protection in time of the wire used in the gabions they are protected with a concrete layer.
The execution of the gabions is complex and the costs are significant.

Figure 1. Classic gabion work, 200 m length, on Putna river in the village of Valea Sarii, Vrancea county (photo taken by the authors)

Figure 2. Alternative gabions work, 450 m with a length on Oreavu stream, Urechești locality, Vrancea county (photo taken by the authors)

Geocontainer works

Geocontainers are made of woven or non-woven geotextiles made of polypropylene or other polymers. These geocontainers can be made in standard dimensions but also for each work individually, with shapes and dimensions adapted to the needs of the applicattion.

Standard dimensions of geotextile weight is about 600 g/m^2.

a - 1.14 m x 2.28 m;

b - 1.45 m x 2.38 m;

c - 1.30 m x 2.65 m.

For high strength and safe handling, they can have reinforcement straps, hanging straps, as well as a lid with a filler to prevent sewing on the construction site. In this way, they become casket that, after landing on the site is filled with local materials - natural granular aggregates.

Geocontainers can be in the form of bags, parallelepiped, in the form of mattresses or tubes (Figures 3, 4, 5 and 6). The variety of shapes gives them the advantage of being used for different types of applications such as the hydrotechnical field, bringing significant advantages in the following directions:

- the replacement of the classic solutions of embankments or bottom thresholds, with the use of geocontainers, leads to significant reductions in the costs of implementation;
- the solutions using geocontainers have proved, in practice, to be ecological and environmentally friendly solutions;
- geocontainers made of non-woven geotextiles are well resistant to mechanical shocks, deforming and absorbing the impact force;

- can successfully replace any type of gabion having the advantage that they can be filled with any type of material;
- achievement of bottom sill or other hydrotechnical structures without the condition of working in dry environment;
- shows the advantage that they can be filled with any type of local material, with concrete or ballast stabilized with cement (http://roff.ro/index.php/catalog-produse/item/10-geocontainere-netesute).

Figure 3. Geocontainer appearance Avram Al. M., 2020)

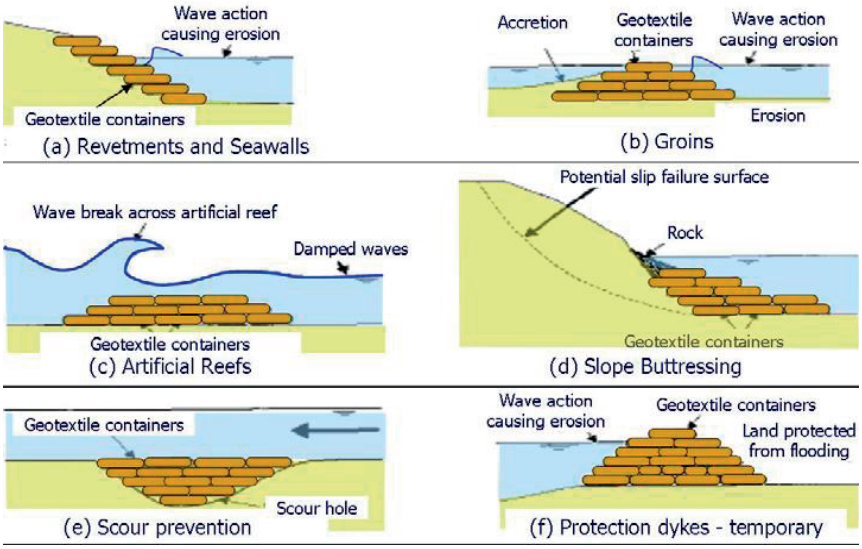

Figure 4. Models of geocontainers works (Young C. K., 2008)

Figure 5. Geocontainer work in the form of haulers, 500 m length on Siret river, Suraia locality, Vrancea county (photo taken by the authors)

Figure 6. Longitudinal geocontainer work, 240 m length, Ramnicu Sarat river, Ramnicu Sarat locality, Buzau county (photo taken by the authors)

Economic evaluation of erosion control works

For the economic evaluation of the erosion control works, two models of works were made in the Google Sketchup program that are used and applied on the rivers from the Siret river basin (Figures 7 and 8).

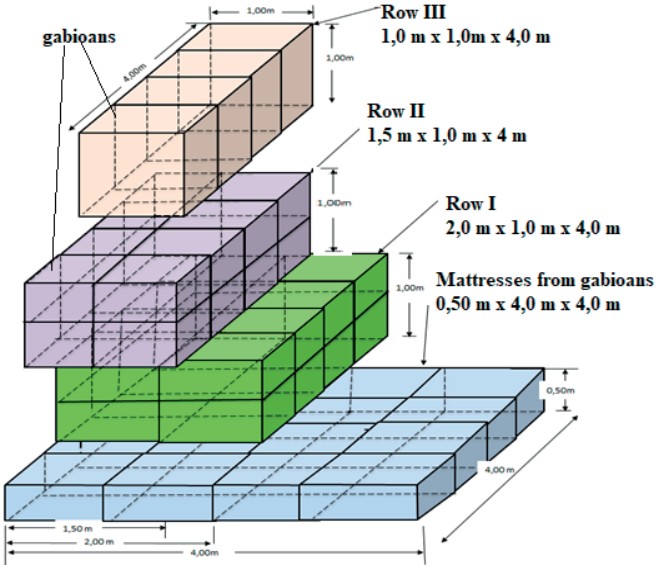

Figure 7. Gabion work scheme considered for calculation (modeled by Google Sketchup by the author)

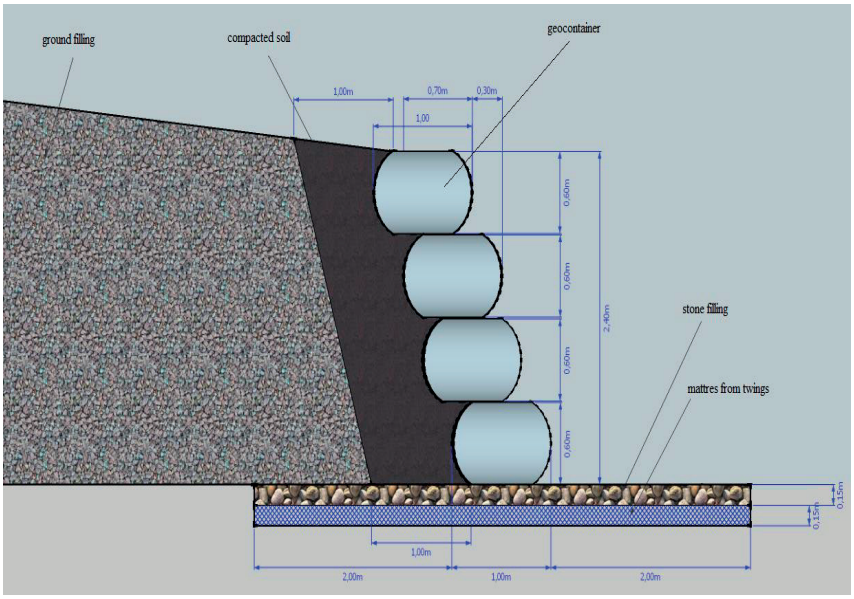

Figure 8. Geocontainer work scheme considered for calculation (modeled by Google Sketchup by the author)

Economic evaluations

The economic evaluation of the execution of the works from gabions and geocontainers was made from the point of view of the resources used, materials, equipment, transport and duration of execution, for works with a length of 100 m and 200 m (Figures 9, 10 and 11).

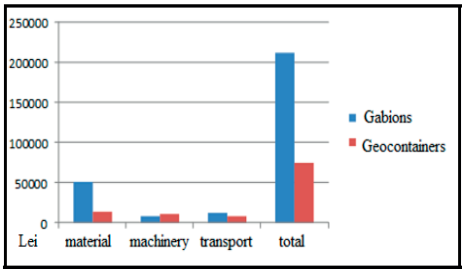

Figure 9. Economic calculation for gabion and geocontainer works of 100 m length execution (data processed and obtained from Windoc Deviz)

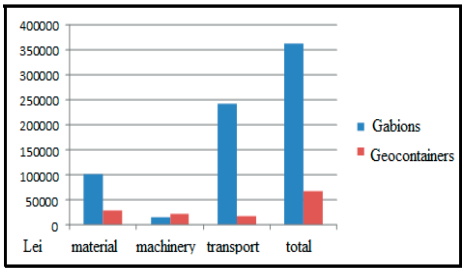

Figure 10. Economic calculation for gabion and geocontainer works of 200 m length execution (data processed and obtained from Windoc Deviz)

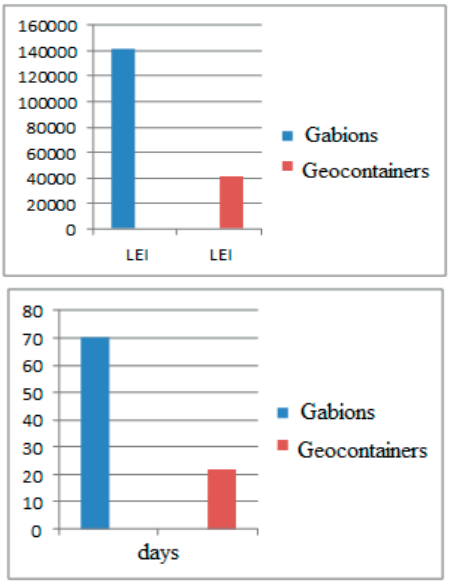

Figure 11. Economic calculation for labor cost and execution period for gabion and geocontainer works of 100 m length (data processed and obtained from Windoc Deviz)

Degradation of erosion control works

Degradation of gabion works

The degradation of the gabion works is a process as a result of the destructive action exercised by external geomorphological and chemical agents, by decreasing the thalweg quota, the displacement of the soil behind the work and the destructive action due to corrosion.

The overturning of the gabion works

Overturning is the phenomenon of moving a body from its normal position by rotation around a certain point/line leading to fall to one side or upwards (Figures 12).

Causes:

- High flows of the watercourse that exceeded the structure crest level;
- The transport of coarse river deposits during the floods that affected the mattress from the base of the work;
- Filling instability behind the work.

Figure 12. Gabion works of 300 m length, degraded by overturning, Putna river, Tulnici city, Vrancea county, Q=570 m^3/s (photo taken by authors)

Degradation through slip

The slip represents the smooth movement, without encountering any resistance, when two bodies in contact move one against the other tangentially, without rolling (Figures 13).

Causes:

- High flows of the watercourse that exceeded the work crest level;
- Unstable foudation soil;
- Filling instability behind the work.

Figure 13. Gabion works of 2700 m length degraded by slip Putna river, Vidra locality, Vrancea county, Q = 670 m^3/s (photo taken by the authors)

Degradation by lowering the riverbed quota

The deepest line along a river means the one that follows the lower part of the riverbed of a watercourse, varies according to the slope of the land, the nature of the rocks in the riverbed and influences the location and evolution of the hydrotechnical works (Figure 14).

Causes:

- High differences between the river source and the river discharge point;
- Exploaitation of mineral aggregates.

Figure 14. Gabion works of 200 m length degraded by the decrease of riverbed quota, Coza river, Tulnici, Vrancea county (photo taken by the authors)

Degradation caused by the transport of river deposits and floats

In areas with spontaneous forest vegetation in the minor riverbed or in the area of the banks, during the floods the banks are eroded and the trees are dislocated and then transported. Trees can narrow or even block water section and can destroy the wire mesh of gabion structures (Figure 15).

Figure 15. Gabion works of 300 mlength degraded by floats, Zabala river, Naruja locality, Vrancea county (photo taken by the authors)

Degradation of geocontainer works

Degradation of geocontainer works by lowering the riverbed quota (Figures 16, 17, 18).

Causes:

- Exploaitation of mineral aggregates;
- Variation of water flow rates.

Figure 16. Degradation of geocontainer works by reducing the riverbed quota, Siret river (photo taken by the authors)

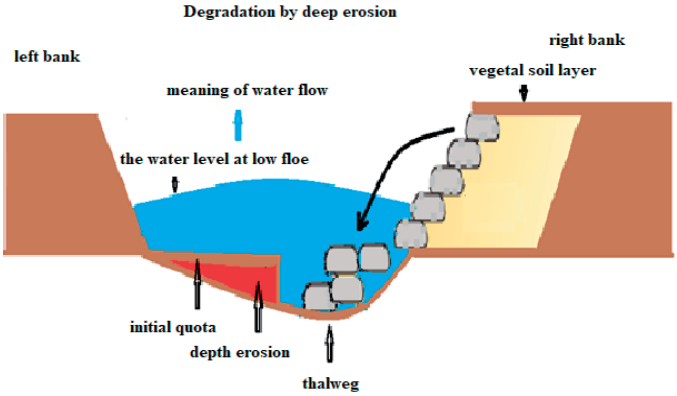

Figure 17. Degradation of geocontainer works by reducing the riverbed quota - scheme made by authors

Figure 18. Degradation of geocontainer works by lowering the elevation of the riverbed and relocating the geocontainer, Siret river, Suraia locality, Vrancea county (photo taken by the authors)

Degradation by vandalism

Vandalism is an action that involves intentional destruction or damage to an object. It can be made by cutting or firing the bags. If the work is set on fire, it will be completely destroyed. Vandalism is a great danger for geocontainer work (Figures 19).

Figure 19. Geocontainer works degraded by vandalism, Siret river, Vadu Rosca, Vrancea county (photo take by the authors)

RESULTS AND DISCUSSIONS

Following the economic evaluation of the execution of gabion and geocontainer works, the obtained result shows that the geocontainer works are carried out with much lower costs than the works in gabions.
The execution period of geocontainer works is much shorter than the execution of works in gabions. Geocontainer works can be used to arrange an erosion area that needs to be resolved quickly.
From the point of view of degradation phenomena, geocontainer works are less affected than gabion works and, to the same extent, there are fewer losses from an economic point of view.

CONCLUSIONS

Gabion hydrotechnical works are difficult to put into operation and require a specialized team for laying the stone and the costs for making the gabions are high.
There are many forms of degradation in gabions and they can be caused by several causes.
The wire used in the gabions can be destroyed by the transport of alluviums during the floods, the environmental factors favor their degradation.
Damaged gabions works can no longer be repaired or reused and do not allow the development of fauna and flora in the environment.
Geocontainer hydrotechnical works can be used in longitudinal works and are easy to put into operation.
The filling inside the works from the geocontainers is made with local material and does not require additional costs and can be used in saline areas and they are not vulnerable to the environment factors.
Geocontainers works are elastic due to the flexibility of the geotextile and the characteristics of filling materials, they could be degraded but the structures are not completely destroyed.
The total degradation of geocontainer structures can be caused by vandalism, by cutting or firing the bags.
The river deposits transport made up of gravel and boulders is easier to maintain in the case of longitudinal works, and in the area of rivers with medium flows.
Geocontainer hydrotechnical works are environmental friendly and allow the development of flora and fauna within the habitats.
The results presented in this paper come from filed measurements and economic values are made by computation. The behavior and the evolution of the gabion and geocontainer hydrotechnical works were tracked for their use in erosion preventing and control generated by watercourse.

ACKNOWLEDGEMENTS

We thank the Doctoral School and the staff of the Technical University of Constructions Bucharest for their support in carrying out and completing their studies.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

STUDY OF WATER EUTROPHICATION EVOLUTION FOR THE LAKE COLIBITA, BISTRITA NASAUD COUNTY

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Abstract

The paper presents researches carried out during the period 2008-2018 regarding the evolution of the eutrophication process in the Lake Colibita, Bistrita Nasaud County. The research mainly pursued two objectives: the evolution of lake water quality from the eutrophication point of view under real environmental conditions of the area and studied lake; application of the "Surface Modelling System" software program of modelling, analysis and design of surface water in the field conditions specific to the studied lake, both to verify the accuracy of the field and laboratory analyses performed, as well as to expand the researches on other similar lakes in the country.

Key words*: eutrophication, nutrients, modelling, monitoring, surface water quality, trophicity.*

INTRODUCTION

The information elements needed to measure and control the process of eutrophication of lakes water relate mainly to the depth, volume and regime of discharges, to the internal concentrations of nutrients and algae, to the possible harmfully proliferation of algae and other aquatic plants, to the reduction of the oxygen content of the deep lakes waters, to the destruction of the resulting fish, the annual nutritional contributions, the popularity and the characteristics of the soils occupation of the respective river basin (Agafitei A. et al., 2010; Agafitei A., 2017; 2019).

The fight against eutrophication can target both the fundamental causes and the effects (reducing the nutritional contributions to the aquatic plants from the river basin or periodically harvested from the surplus aquatic plants). The most useful seems to be the combination of the two ways.

The fundamental approach can be limited, as far as possible, to the general objectives of managing the eutrophication process.

In most cases, it has been shown that acting on the causes of eutrophication is more effective, easier to remedy than the process of mitigating effects.

A control program based on treating the eutrophication symptoms represents the only viable alternative. Such a program would also contribute to mitigating the negative effects of the eutrophication process (Agafitei A., 2017).

The abundant literature that appears continuously on the concrete cases of eutrophication is increasingly aware of the difficulties of interpretation and typological classification of the basins affected by this pollution process.

We consider that only analysing a number of essential and edifying components of the subsystem and integrating them into a complex ecosystem image, dominated by a systemic integral interpretation, associated with a cybernetic vision, can lead to a correct understanding and interpretation of the eutrophication phenomenon (Agafitei A., 2013).

Eutrophication begins wherever people live, and ends with damage to resources we all use and enjoy; it starts when nutrients get into waters, feed algae, which grows and blocks sunlight, eventually, the algae dies too.

Bacteria digest dead plants, using up remaining oxygen, and giving off carbon dioxide. Fish and other wildlife became unhealthy, or die without oxygen (Agafitei A., 2013).

Protecting water resources starts with sound agricultural and correct waste management practices (Figure 1).

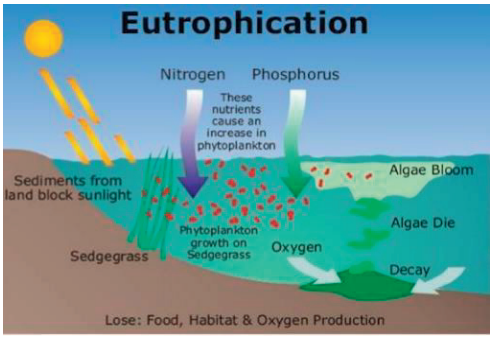

Figure 1. Scheme of the eutrophication process

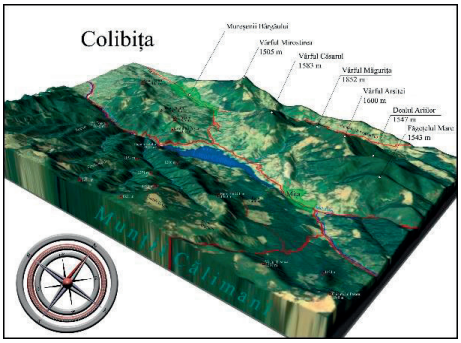

Figure 2. Colibita Lake, Bistrita Nasaud County

MATERIALS AND METHODS

The Colibita dam is located on the upper course of the Bistrita Transilvana (Ardeleana) River, at approx. 400 m upstream from its confluence to Repedea pr, on the administrative territory of Bistrita Bargaului, from Bistrita Nasaud County.

The access to the site is made on DN 17 (Bistrita - Vatra Dornei), and subsequently on DJ 173A (Prundu Bargaului - Colibita).

The accumulation is located within the site of community importance ROSCI0051 Cusma.

The total area of the site is 44084 ha, according to the Standard Form Natura 2000, so it can be started that the surface of the accumulation, on about 320 ha is insignificant in relation to it. The accumulation has been in operation for over 30 years, so it is already an integral part on this protected natural area.

The accumulation of the same name, delimited by the dam and the mountain slopes, was realized both in order to provide a necessary reserve for the water supply of the localities located downstream on the Bistrita Transilvana River, up to the confluence with the Sieu River and their defence (population, transport infrastructure, water supply networks, sewerage, electricity, gas, telecommunications, agricultural land, livestock farms, etc.) against floods.

The Colibita Lake has a surface of 375,4 ha, a volume of 94,27 mil m^3, and a length of about 5 km (Figure 2).

Colibita Lake is currently an important tourist destination for water sports enthusiasts; it has a large surface, and extraordinary views.

The complex water park is renowned in the area (Figure 3).

Figure 3. The complex water park of the Colibita area

Our research aimed the monitoring of lake's water quality, during the period of 2008-2018, regarding the eutrophication process evolution, and was structured on several levels: of, documentation, field, and a synthesis of results obtained by using the "Surface Modelling System" software program of modelling, analysis and design of surface waters in the field conditions.

Calculus of the important factors in the evolution of the trophicity degree of a lake starts from the premise of the use of complex indicators, reflecting not a state of the moment (accidental discharges, thermal pollution etc.), but a tendency, as well as the influence of several primary indicators (temperature, transparency, lightning, depth, circulation etc.).

These factors are: saturation in oxygen, chemical consumption of oxygen, appreciated in $KMnO_4$, the mineralization capacity of the lake (CCO-Mn/O_2 report), N_t/P_t report between nutrients, mineral N/PO_4, and phytoplankton biomass.

The application of the "Surface Modelling System" (SMS) software program of modelling, analysis and design of surface waters in the field conditions specific to the studied lake, it aims to verify the accuracy of the field and laboratory analyses performed since 2008 to 2018 (Agafitei A. et al., 2010; Agafitei A., 2013; 2019).

Water quality models are usually classified according to model complexity, type of receiving water, and the water quality parameters (dissolved oxygen, nutrients, etc.) that the model can predict. The more complex the model is, the more difficult and expensive will be its application to a given situation.

The behaviour of these models is well understood and has been studied more intensively than have other parameters. Basic nutrient indicators such as ammonia, nitrate, and phosphate concentrations can also be predicted reasonably accurately, at least for simpler water bodies such as rivers and moderate-size lakes. Predicting algae concentrations accurately is somewhat more difficult but is commonly done in the United States and Europe, where eutrophication has become a concern in the past two decades. Toxic organic compounds and heavy metals are much more problematic.

Surface Modeling System (SMS) is the most advanced software system available for performing surface-water simulations in a three-dimensional environment. The reduction of nutrient inputs to water and control of eutrophication locally are shared responsibilities, involving a range of stakeholders. In taking forward this strategy, there are working Government departments, other environmental regulators, industry and interest groups (Agafitei A. et al., 2010).

Tackling eutrophication will be a long-term commitment, linked to the general objective of contributing to sustainable development (Ryding S.O. & Rast W., 1989; Scheffer M., 1998).

Reducing nutrient contributions from sewage treatment works and agricultural sources will be particularly important. In some instances it will be necessary to go beyond the sewage treatment measures set out in the Urban Waste Water Treatment Directive.

Principal hydro-chemical parameters of water quality which were analysed are: air temperature (annual average of 7.5 ÷ 8^0C), with warm winters (January's average of 4 ÷ -6^0C), and summers with moderate temperatures (July's average of 16 ÷ 17^0C); water lake transparency regime, with maxims of 6 m in Dam section, and of 3 m in "Lake's Tale" section, in October, because of low precipitations from this period; then between 2 and 10 m in November, so we can say that water of Colibita Lake is included in eutrophic - oligotrophic category, with moderate transparency.

In the following of ecological succession Bistrita River - Colibita Lake, physical-chemical parameters were considered as basic criteria in analyzing habitat changes and then biotic ones (Agafitei A., 2013; 2017). Also, hydro-chemical researches we made in lake (2008-2018) considered the principal aspects of the new habitat: morph-metric characteristics (depth, length, and width), water mass dynamic, level oscillations, atmospheric conditions influence, and lake biotic development. For every considered year, we measured the following values (average on depth) of the most important parameters of trophic degree: COD/O_2, phytoplankton biomass, saturation in O_2, COD, and N_{min}/PO_4. For 2008 year, using the mathematical correlations proposed by Caraus, I.D. in 2008, we obtained values between 6,4286 and 7,1002, using mentioned relations; results that Colibita Lake could be considered as an oligotrophic lake, that confirm our previous land conclusions.

For estimate some correlation and logarithmic equations to describe relations between some important water quality parameters from Colibiţa Lake, we considered the following parameters, respectively correlation: dissolved oxygen, function of temperature; organic matter, function of dissolved oxygen; and nitrogen, function of total phosphorus (Caraus I.D., 2002). It was used the average values of the considered parameters, for the analyzed period of time, at h = 20 m depth, in section 1-1 located between two important stations.

In the same way, we could establish correlation between every water parameter; in every lake section we have data, for any depth (Figure 4).

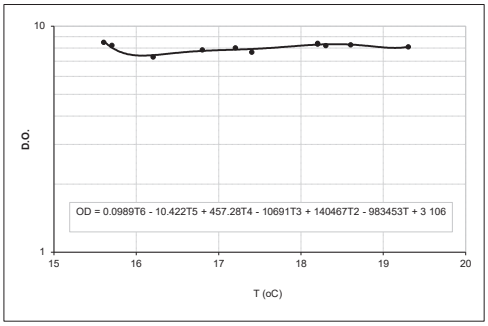

Figure 4. Correlation between D.O. (mg/L) and temperature values (^0C)

Using SMS program, between two sections 1-1 and 2-2 established with lake's data, conform existing norms, at h = 20 m, for each node (point), SMS knows automate plane coordinates (x, y) of nodes, in function of three points were we have the coordinates to create the program.

Nodes were made in points where we have data for the selected (wanted) field (lake) parameters. We made the same action for every wanted hydro-chemical parameter (Figure 5).

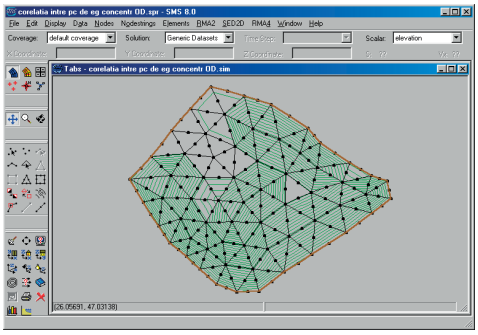

Figure 5. Polygon in MESH mode for dissolved oxygen parameter

On the contour bounded for the data taken from Colibiţa Lake, according to the Romanian standards, at h = 20 m, for each node (point) the SMS program automatically introduces the coordinates in the plane (x,y) of the nodes, according to the three points with coordinates introduced at the beginning, at the request of the program.

The nodes were fixed where the data are known: the values of the selected indicators, from field (lake), at the desired coordinates.

The values for all these points on and from the delimited contour were entered in the program, for each node, in an identical mode for every studied water quality parameter.

In the same manner, we could make any correlation, using SMS software, for every wanted hydro-chemical or biological parameter of the studied lake (Agafitei A., 2017; Leinster P., 2000).

Calculus of the trophic degree, following the algorithm proposed by Caraus I.D. in 2002, concluded to integrating our lake into oligotrophic lakes category.

This result, obtained from mathematical calculus, confirm conclusions made in the experimental field (on lake) after analysing physical - chemical, biological and bacteriological characteristics observed in land researches, between 2008 and 2018.

In the same context are integrated graphic correlations regarding evolution of annual average values of hydro-chemical parameters from Colibita Lake, in the analyzed period of time, into a section (1-1) of this lake, between two important stations, at h = 20 m water depth.

These graphic correlations with logarithmic equations to describe relations permit to establish connections between any two water quality parameters for Colibita Lake (Leinster P., 2000; Caraus I.D., 2002).

RESULTS AND DISCUSSIONS

From the quantitative point of view, primary production appears, in the analysed lake, as an expression of plankton activity, of the whole ecosystem's state, mode and organization degree (Leinster P., 2000; Agafitei A., 2013; 2019).

Algae cenozis structure modification, with an increase of green algae, especially of *Clorococcalae*, also of blue ones and of *Euglenae*, in our lake's ecosystem, due, in time, to a certain increase of biological productivity and at degradation of water quality, with not-wanted consequences on these, also on the environment.

Using SMS software, we can establish correlation for points with the same concentration values for any required parameter important for the monitoring of the

eutrophycation phenomenon in the considered storage lake.
For most management purposes, the worst case will be high summer temperatures, which exacerbate problems with dissolved oxygen and algal growth, and low flows, which lead to high concentrations of BOD and other pollutants. Dynamic models will need time-series data on flows, temperatures, and other parameters. In addition to hydraulic data, models require base-case concentrations of the water quality parameters of interest (dissolved oxygen, mercury, and so on).
These are required both to calibrate the models to existing conditions and to provide a base against which to assess the effects of management alternatives (Agafitei A. et al., 2010; Agafitei A., 2017).
The models also need discharges or loads of the pollutants under consideration from the sources (e.g., industrial plants) being studied. The types and amounts of data needed for a given application are specific to the management question at hand (Leinster P., 2000; Ryding S.O. & Rast W., 1989; Scheffer M., 1998).

CONCLUSIONS

The study led to some major conclusions for the involved researches.
A point often overlooked in the real-world application of water quality models is that they are a means of achieving a set of management objectives, not an end themselves. In many cases, it may not be necessary to use a water quality model at all, even when it is known in advance that a project will affect water quality.
Managers should remember that the accuracy of model projections is severely constrained by the quality and quantity of the available data used to calibrate and test the models. The hypothetical examples given above explicitly assume that these data are readily available, but this will often not be the case in practice.
With characteristic parameters entered into the program, it automatically checks them. Thus, using SMS program, we conducted a conceptual model of the variation in concentrations of dissolved oxygen, organic matter, NH_4, and total P in the network.
In the same manner, we can obtain correlations between important indicators for surface water quality in any lake or watershed.
The results for the analysed indicators chosen correspond to previous research conducted on water of the Colibita Lake.
They support the mathematical and graphical calculations and fit the lake water in terms of in the oligotrophic category.
We obtained the same results applying mathematical calculus with Caraus's researcher formula for the entire lake. In the same manner, we can extend the model for any depth of the lake and also for any storage lake.
Expanding research for the whole surface of the lake, possibly taking into account other water depths, we can draw conclusions about trophic lake fits, but also on water quality in the lake, depending on the parameters (data) as known to it.
This study aims establishing the degree of trophicity based on comparison of some trophicity parameters, characteristic of the studied lake: the oxygen regime, phytoplankton biomass, some nutrients with the limits recommended by standards, for a certain trophic stage, and obtaining some goodness notes, from 0 to 10, with the following equivalent:
0-2: polytrophic lake, with the equivalent value 1;
2-4: eutrophic lake, with the equivalent value 3;
4-6: mesotrophic lake, with the equivalent value 5;
6-8: oligotrophic lake, with the equivalent value 7;
8-10: ultraoligotrophic lake, with the equivalent value 9 (Caraus I.D., 1986; 2002; Agafitei A. et al., 2010; Agafitei A., 2019; Ryding S.O. & Rast W., 1989).
The "SMS" program verifies the field data automatically, signalling errors that may occur, thereby contributing to the accuracy of our results.
For the future research we have in aim to extend our work and to build a regional centre of study for hilly lakes of the Moldavian area, Romania, which is rich in such storage lakes.
Other important water quality models used to predict and control surface water pollution are related in Table 1.

Table 1. Short description of water quality models

Model	*Comment*
WQAM	Set of methods or mathematical tools used for preliminary analysis of changes in water quality due to changes in loadings. Unlike the other examples, WQAM is not a computer model per se but a collection of simple methods and procedures.
QUAL2E	Steady-state model for simulating well-mixed rivers and streams. Commonly used for assessing the impact of changes in point-source discharges on water quality. Especially suited for analyzing the effects of nutrients on algal concentration and dissolved oxygen. Widely applied in the United States and elsewhere.
WASP	Flexible, compartmental modeling structure for analysis of a wide variety of pollutants in almost any type of water body. The most powerful and complex of the models discussed here, it also requires more data and expertise for successful application. Extensively applied to water quality assessments in rivers and streams.
CE-QUAL-RIV1	Intended primarily for simulating the dynamics of highly unsteady stream flows, such as those occurring during flood events. Consists of a module for water quantity linked to one for water quality. Although the quantity module has seen numerous applications, the quality module is less widely applied than WQAM, QUAL2E, or WASP.
HEC-5Q	Developed primarily for analyzing water flows and water quality in reservoirs and associated downstream river reaches. It can perform detailed simulations of reservoir operations, such as regulating outflows through gates and turbines, and vertical temperature gradients in reservoirs.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

INTERACTION OF WATERWAYS LOCATED IN KARST FISSURE AREAS AND GROUNDWATER

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Abstract

The paper aims to present the impact of the waterways Dunare - Marea Neagra, respectively Poarta Alba - Midia, Navodari on both the groundwater and the groundwater catchments located in the vicinity of the waterways and currently in operation for water supply of the cities. Arranged waterways dug in the aquifer store rock, without sealing meassuries, can have both quantitative and qualitative impact on the adjacent groundwater. In order to determine the quantitative changes caused by the waterways on the aquifer layers besides the monitoring of this process, mathematical models can be used adopting different scenarios of water flow, depending on the existing hydrogeological conditions, as well as the possible changes created by the anthropic activities. Groundwater pollution is characterized by low rates of contaminants propagation. In the case of surface water, the impact of a pollutant source on the ecosystem is fast, and once the pollutant source is removed, the ecosystem returns to its original state. In the case of groundwater, due to both the low propagation speeds and the specific remediation mechanisms, the return to the initial state after the removal of the contaminants involves special, long-lasting and costly measures. This study takes into account the geological structure of this area, and the karst-fissure aquifer, as well as the existence of numerous groundwater catchments used to meet the water requirements of the localities in the area.

Key words*: groundwater, groundwater catchments, karst-fissure aquifer, Romania, waterways.*

INTRODUCTION

The research area of the present paper is located in the North of Southern Dobrogea, in the region between the Capidava - Ovidiu and Rasova - Costinesti faults, the Danube and the Black Sea (Figure 1).

Provision of water supply in the localities in South Dobrogea, including those in the seaside area and in the city of Constanta, have as a majority water sources fronts for catching with wells drilled. Water catchments exploit two hydrostructures with regional development: a free-level hydrostructure, embedded in calcareous formations of the Sarmatian age, called the upper Sarmatian aquifer and a lower hydrostructure partially free and predominantly under pressure, of medium depth, embedded in calcareous-dolomitic formations of Jurassic-Cretaceous age, called the Jurassic - Cretaceous lower aquifer complex.

The Sarmatian upper aquifer is a free-level, groundwater aquifer for South of Dobrogea, which feeds on rainfall and diffuse water losses from irrigation systems (Moldoveanu, 2018).

The Jurassic-Cretaceous lower aquifer complex represents a unitary aquifer in relation to the entire southern Dobrogea territory. In large proportions, about 60% of the southern Dobrogea territory, the aquifer is under pressure, while in the vicinity of the Danube River and in the South, there is an area where this aquifer is with free-level (Zamfirescu et al., 1994).

In the research area, groundwater circulates through karst-fissure environments, which can be formed from underground channels, with different dimensions. The circulation of water in these environments takes place from the sectors in which the water seeps from the surface of the limestone massif, and flows to the other end, place where the drainage of the groundwater (lakes and the Black Sea) occurs (Moldoveanu, 2018).

With the commissioning of the waterways Dunare - Marea Neagra and Poarta Alba - Midia, Navodari, the flow regime through these aquifers changed and subsequently remained constant. An important cause would be that from a constructive point of view, the two waterways are not watertight in the bottom

area, allowing in certain sectors the communication of the surface water with the groundwater (Moldoveanu, 2019).

Interaction of waterways with aquifers

From a geological point of view, the formations of sedimentary blanket (of which the store rocks of the two hydrostructures are part) are discordantly arranged on an old crystalline foundation. They present an uneven spatial distribution, which leads to the idea that their sedimentation took place in an active dynamic zone, of structural blocks with different positions (high or low), in different geological stages.

The geological and structural elements are shown in Figure 2 - Structural map of the investigated area.

The thickness of the lower Jurassic - Cretaceous permeable carbonate formations is higher towards the west, reaching the vicinity of the Danube at 1000 m and decreases in steps to the east (seaside area). Above these formations are deposited, especially in the eastern half, packages of semipermeable rocks of Senonian, Eocene and Badenian age.

In 2018, level measurements were made in the observation wells in the vicinity of the waterways. Based on these measurements, the hydrodynamic map of the Jurassic - Cretaceous lower aquifer was prepared (Figure 3).

In the sector investigated in the present paper, the Sarmatian limestones are generally absent and therefore the upper hydrostructure may rarely appear.

The continuous interaction between surface waters and groundwater embedded in karst-fissure aquifers presents specific elements, especially as they are adjacent to seaside areas:

- The main aquifer supplying areas and, implicitly, the formation of karst-fissure aquifers are determined by the favorable geological situations, where the carbonated rocks meet on the surface of the land (up to date) and allow the infiltration of precipitation directly into the layer or through the thalweg of valleys (Albu, 1981).
- The main aquifer discharge areas (drainage) are located in the marine coastal sectors or in natural lakes located near them.
- The existing interference between surface waters (rivers, valleys, lakes or lake systems bordering seaside areas, irrigation channels, waterways, etc.) and groundwater have produced important changes in the water flow regime. These can be rigorously observed by measurements and by drawing up hydrogeological maps with hydrodynamic spectrums (Moldoveanu, 2018)
- In the situation of the waterways exploitation, they may constitute: artificial supplying areas, for certain sectors where were executed and intersect the upper part of the karst-fissure aquifer or drainage areas, in areas where the waterway level quota is lower than the groundwater level quota (Moldoveanu, 2018).
- With the increase of hydrodynamic resources, given the relatively high flow rates of aquifers, there are high risks of occurrence of pollution phenomena coming from agricultural activities (Technical Archieve National Administration Romanian Waters, 2010-2017).

In general, the water level quota in the waterways imposes the flow regime in the karst-fissure aquifer in the area where it is located and, implicitly, it may create pollution risks if it supplies the aquifer to water.

Modelling of interaction between waterways and aquifers

Groundwater flow and pollutant transport from an aquifer can be described by analytical or numerical integration of the fundamental equations of hydraulic diffusivity and hydrodynamic dispersion (Zamfirescu, 1997).

Initial and subsequent time conditions in the aquifer field are imposed on these equations. They are also imposed boundary conditions (at the limit), given by values of Dirichlet-type functions or of its derivatives (Neuman-type conditions) on the bounderies of hydrostructure development (Fetter, 1994).

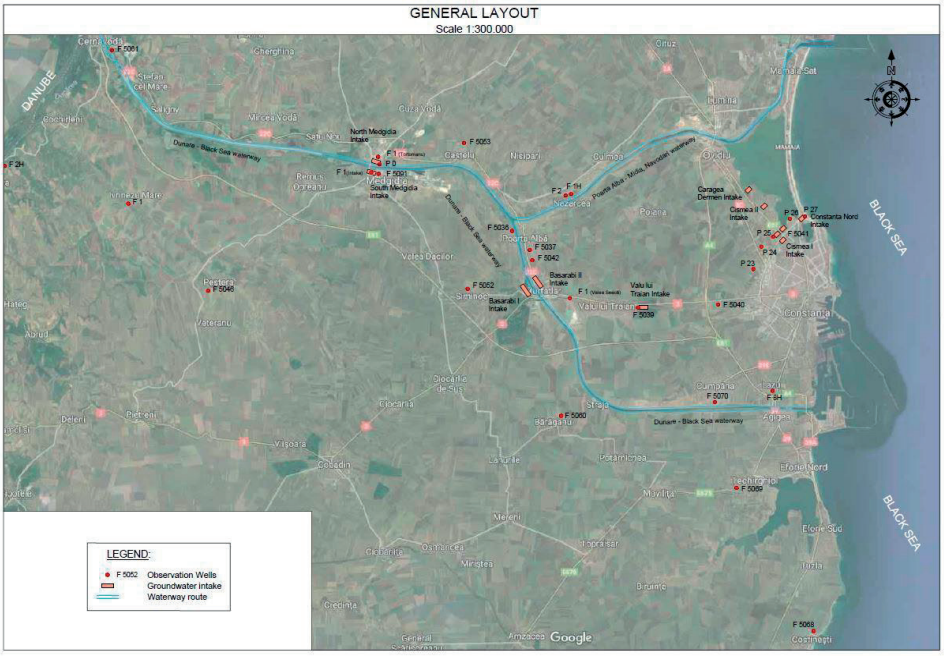

Figure 1. General layout of the investigated area (Moldoveanu, 2019)

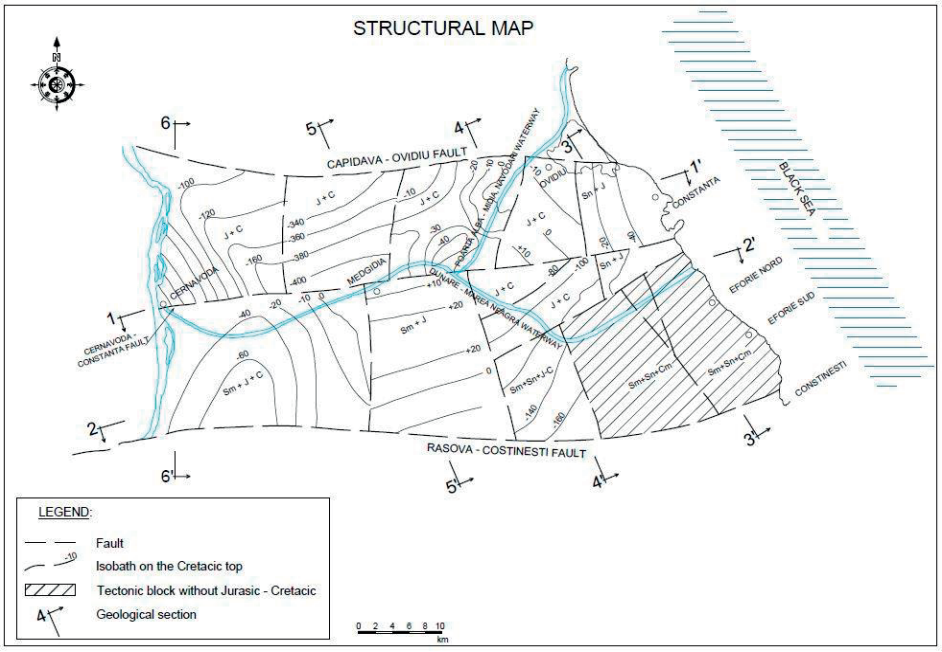

Figure 2. Structural map of the investigated area (Moldoveanu, 2018)

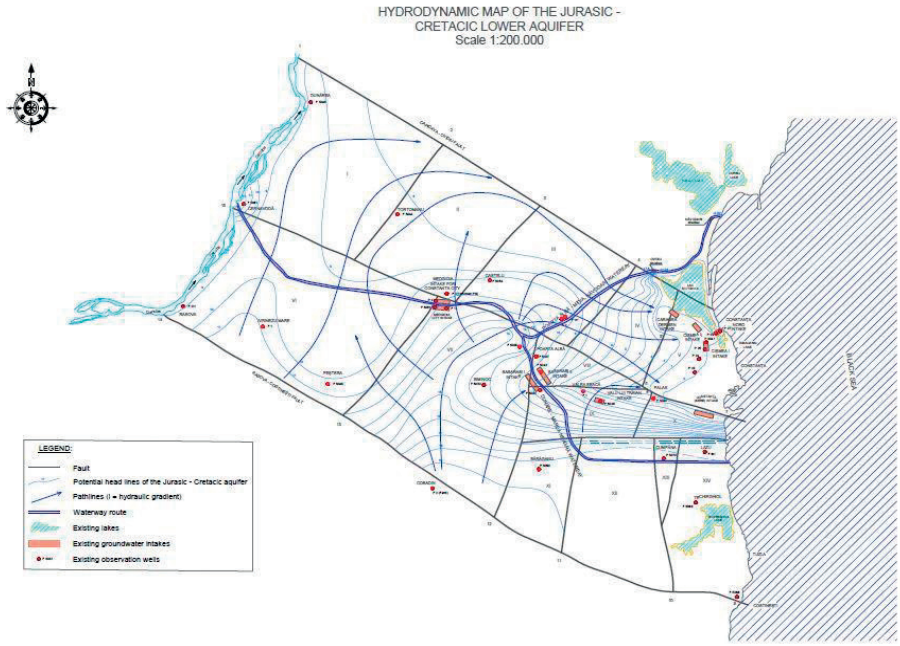

Figure 3. Hydrodynamic map of the Jurassic - Cretaceous lower aquifer

The construction of the flow pattern of the lower aquifer was carried out using the GMS soft.

The studied area covers an area determined by: 68 km - length, respectively 32 km - width, discretized in a network of cells with variable dimensions depending on the areas of interest analysed. Thus, the horizontal dimensions of the discretization cells are generally 1000 m x 1000 m, but they have a finer discretization of 500 m x 500 m in the groundwater catchments areas, for a greater accuracy of the results. The heights of the discretization cells are equal to the thicknesses of the Jurassic - Cretaceous lower aquifer, intercepted in observation wells, and are between 12.80 m and 1205.33 m.

The construction of the Jurassic - Cretaceous lower aquifer flow model was accomplished by introducing lithological data, boundary conditions, observation wells and catchment wells in the calculation program.

The lithology of the Jurassic - Cretaceous lower aquifer was determined by interpolation, using as base data the thickness of the aquifer detected in each observation well.

The boundary conditions imposed for the creation of the hydraulic model were determined by interpolation, based on the hydrodynamic map of the Jurassic - Cretaceous lower aquifer. Also, both the Siutghiol Lake and the section of the waterway the Poarta Alba - Midia, Navodari, which is in direct contact with the Jurassic - Cretaceous lower aquifer (located between the Ovidiu lock, respectively 3 km upstream in the waterway) will benefit from a 1.25 m imposed potential.

The hydrostatic levels from the observation wells were measured in 2018.

The exploited flows values from the groundwater water catchments located in the adjacent areas to the waterways, which supply the Constanta city, Medgidia and Basarabi towns and the Valul lui Traian commune were provided by the water operator Raja Constanta (Technical Archive RAJA, 2018).

The water level quotas in the Dunare - Marea Neagra and Poarta Alba - Midia, Navodari waterways have different values depending on the sections, according to the provisions from the operating and waterways maintenance regulations. On the north-eastern section of the Poarta Alba - Midia, Navodari waterway, in the area where the waterway is in direct relation with the lower aquifer, the water level quota

measured after the Ovidiu lock is 1.25 m above Black Sea. The same 1.25 m water level quota height was introduced to Siutghiol Lake (Avadanei, 2012).

RESULTS AND DISCUSSIONS

After the model calibration, the calculated hydrodynamic map of the Jurassic - Cretaceous lower aquifer (Figure 4) was obtained.
The flow directions resulting from the model calibration are mainly oriented South-West - North-East, (Figure 5). Locally, in the area delimited by the Lazu - Cumpana and Cernavoda - Constanta faults, the hydraulic conductivities have low values, and the flow directions are oriented South - North. At North of the Cernavoda - Constanta fault, they return to the South-West - North-East flow directions and have high hydraulic conductivities.
In the area of Ovidiu lock, on the Poarta Alba - Midia, Navodari waterway, a local disturbance was observed, determined by the direct hydraulic connection between the water in the waterway and the aquifer. Also, there were disturbances in the Constanta, Basarabi and Valu lui Traian groundwater catchments areas.
Subsequent to the model calibration procedure, particles were introduced into the cells corresponding to the groundwater catchments, and these generated the supply areas of the wells.
This procedure is called "backward-tracking" and is used to determine the supply areas of the wells. In figure 6, it can be seen that most of the catchment wells are supply from the southern border of the domain, except for the wells from the Constanta Nord, Cismea II and partially Cismea I groundwater catchments, which are supply from the northern border and sometimes from Siutghiol Lake.

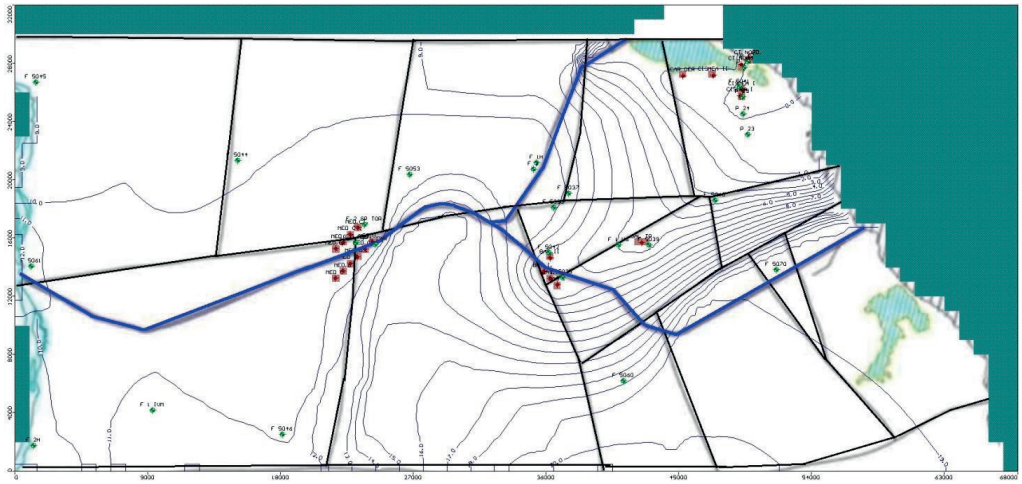

Figure 4. Calculated hydrodynamic map of the calibrated model

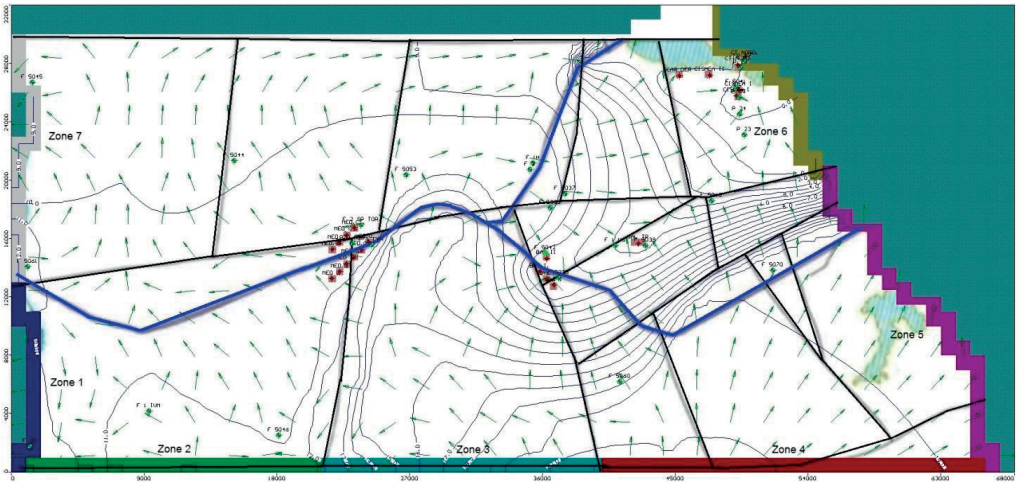

Figure 5. Flow directions through the calibrated model and delimited areas for determining the flow balance sheets

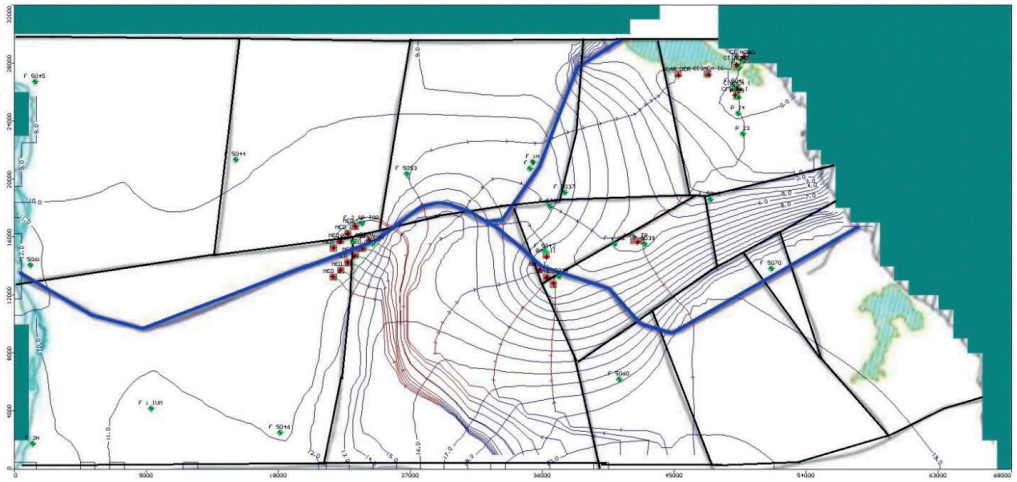

Figure 6. Supplying areas for the catchment wells

As shown in Figure 6, if the hypothesis of an advective pollutant transport is adopted, respectively the pollutant displacement is realized only after its the water flow, the model shows that in present there is no danger of contamination of the catchment wells with water from the Poarta Alba - Midia, Navodari waterway.

Based on the calibrated model, certain areas were drawn on the eastern, southern and western borders to create a balance sheet. Thus, in Table 1, there are shown the inflow and outflow values in the areas with constant level (Siutghiol Lake and section between Ovidiu lock and 3 km upstream), in catchments and in each delimited zone (Figure 5).

Table 1. Balance sheet for calibrated model

Crt no.	Border	Inflow mc/day	Outflow mc/day
1	Situghiol lake + section 3 km PAMN waterway	91180	21014
2	Groundwater catchments	0	345550
3	Zone 1	75296	10133
4	Zone 2	39667	53862
5	Zone 3	483650	348500
6	Zone 4	474800	0
7	Zone 5	12840	366340
8	Zone 6	152160	939070
9	Zone 7	287610	353520

CONCLUSIONS

In the researched area in this paper, the North of Southern Dobrogea, more precisely the area between the Capidava - Ovidiu and Rasova - Costinesti faults, is noted the presence of an aquifer with regional extension embedded in Jurassic - Cretaceous limestone rocks called the lower aquifer.

In South of the investigated area there is a free-level aquifer with a phreatic character for South Dobrogea, which feeds on rainfall and diffuse water losses from irrigation systems, called the upper Sarmatian aquifer.

After the commissioning of the Dunare - Marea Neagra and Poarta Alba - Midia, Navodari waterways, the flow regime through these aquifers was abruptly changed, but over time it was balanced. This led to the adoption of the hypothesis of a stationary - conservative flow through the Jurassic - Cretaceous lower aquifer.

After the numerical model was realized and its calibration, the calculated hydrodynamic map of the Jurassic - Cretaceous lower aquifer, the flow directions and the supply areas for the catchment wells were obtained. Also, the model generated a balance sheet of flows in the areas with constant imposed potential (Siutghiol Lake and the section between the Ovidiu lock and 3 km upstream), in the groundwater catchments and on each zone marked in Figure 5.

The supply areas for catchment wells are generally from the southern border with Bulgaria. However, it is noted for the catchment wells from Cosntanta Nord, Cismea II and partially Cismea I source, the supplying areas come and from the northern border and sometimes, when exceeding operating flows and from Siutghiol Lake.

In the waterway Poarta Alba - Midia, Navodari, on the sector between Ovidiu lock and upstream 3 km, the Jurassic - Cretaceous lower aquifer is intercepted by the waterway. This allows direct communication between surface waters, represented by the waterway and rainwater, and the lower aquifer.

The water quality from the catchment wells is influenced in almost all the catchments studied by the waters of the waterway. The only exception is the Medgidia Nord catchment in which the water quality from the wells is not influenced by the waters of the waterway. This is due to the construction of the wells, which have depths between 350 and 400 m, and the definitive columns are perfectly insulated by cementation (about 150 m) against communication with phreatic aquifers.

Corroborating all this information, interference was observed between the waterways and the groundwater in the area of the water catchments, both quantitatively and qualitatively.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the Technical University of Civil Engineering of Bucharest, the Department of Hydraulics Engineering and Environmental Protection, of the National Administration Romanian Waters and also of the RAJA Constanta water operator.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE VARIATION OF TEMPERATURE AND RAINFALL IN THE MUNICIPALITY OF CLUJ-NAPOCA IN THE INTERVAL 1979-2019

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Abstract

The city of Cluj-Napoca is located in the central part of Transylvania. It covers an area of 179.5 km^2, at an average altitude of 335 m. The climate of Cluj-Napoca is moderately continental, characterized by cold winters, with temperatures often below freezing (0°C or 32°F), and mild or pleasantly warm summers and the precipitation amounts to 595 millimetres. Meteorological data were provided by the meteorological station ADSCON Telemetry of University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca. In this study it was determined and analysed the annual average temperature, monthly temperature and the minimum and maximum average and monthly precipitation and annual average. Due to the geographical positioning, the city of Cluj-Napoca presents a tendency to increase the temperature and the precipitations are maintained in the normal regime with small seasonal changes.

Key words*: climatic parameters, deviation, rainfall regime, thermal regime.*

INTRODUCTION

Climate refers to the average weather of an area including the general patterns of atmospheric conditions, seasonal variation and weather extremes averaged over a long period (Vinay, 2009). Climatic conditions over an area are determined by the temperature, rainfall, wind, humidity, atmospheric pressure etc. (John, 2012).

Climate plays an important role in every sphere of human activity (Dhorde et al., 2009). Temperature and rainfall are the most important factors that determine the climate of an area. Changes in temperature and rainfall patterns are observed along with increasing frequency and intensity of extreme weather events such as floods, droughts, heat waves, tornadoes (Kamlesh Pritwani, 2019). InterGovernmental Panel on Climate Change (IPCC, 2007) stated a 0.6°C (0.4 to 0.8°C) increase of global temperature during the period of 1901 to 2001, indicating warming of the earth in the last few decades. However, IPCC (2013) mentioned that the global surface temperature towards the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP model scenarios except RCP2.6. Most scientists believe that the warming of the climate will lead to more extreme weather patterns (heat, waves, droughts, strong winds, and heavy rains) such as: more hurricanes and drought, longer spells of dry heat of intense rain (depending on where you are in the world). Scientists have pointed out that Northern Europe could be severely affected with colder weather if climate change continues as the arctic begins to melt and send fresher waters further south (Reddy, 2015; Lusted Marcia Amidon, 2018).

The consequences of these changes pose significant risks to human health, agriculture, freshwater supplies, and supply of other natural resources that are vital to our economy, environment, and quality of life (Mall et al., 2017; Barnes et al., 2013; Yang et al., 2015).

MATERIALS AND METHODS

The city of Cluj-Napoca is located in the central part of Transylvania (Figure 1). It covers an area of 179.5 km^2, at an average altitude of 335 m. The climate of Cluj-Napoca is moderately continental, characterized by cold

winters, with temperatures often below freezing, and mild or pleasantly warm summers and the precipitation amounts to 595 millimetres.

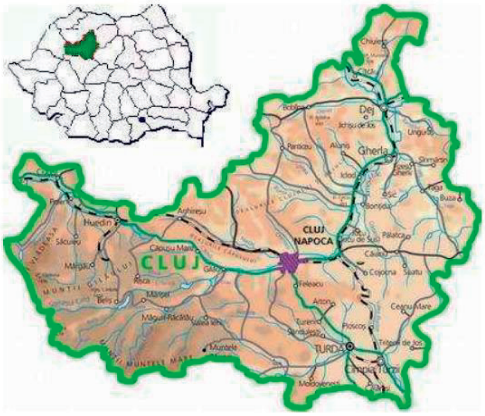

Figure 1. Cluj-Napoca City (Source: http://apmcj.anpm.ro/upload/72057_01-Cadrul%20natural.pdf)

Some West-Atlantic influences are present during winter and autumn. Winter temperatures are often below 0°C (32°F), even though they rarely drop below −10°C (14°F). On average, snow covers the ground for 65 days each winter.

In summer, the average temperature is approximately 18°C (64°F) (the average for July and August), despite the fact that temperatures sometimes reach 35°C (95°F) to 40°C (104°F) in mid-summer in the city centre. Although average precipitation and humidity during summer is low, there are infrequent yet heavy and often violent storms.

During spring and autumn, temperatures vary between +13°C (55°F) to +18°C (64°F), and precipitation during this time tends to be higher than in summer, with more frequent yet milder periods of rain.

Meteorological data were provided by the meteorological station ADSCON Telemetry of University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca.

In this study were determined and analysed the annual average temperature, monthly temperature and the minimum and maximum average and monthly rainfall and annual average in the period of 1979 to 2019.

RESULTS AND DISCUSSIONS

Temperature

Air temperature is an important climatic factor along with precipitation. The analysis of this parameter at the weather station in Cluj-Napoca reveals an average annual temperature of 8.3 °C, with average amplitude of 4.1 given by the values: the maximum average of 11.3°C registered in 2019 and the minimum average of 7.2°C, registered in 1985. In figure 2 we can observe a colder period recorded in 1980 with 7.5°C and 1985 with 7.2°C. In the period 1981-1997 we can observe a more constant temperature than normal with small deviations and a warmer period between the period 1998-2006. Between 2007 and 2019 we can see a significant increase in the frequency of hot years. The annual thermal average exceeding the multiannual average with over 2°C in 6 situations over a period of 5 years (2014, 2015, 2017-2019).

The evolution of temperatures on seasons shows a slight non-uniformity in recent years due to the phenomenon of climate change with very hot summers and cold winters. Winter is a cool season with temperatures falling below -20°C. The lowest temperature was recorded on January 23, 1963 with -34.2°C, low temperatures were also recorded on January 13, 1985 with -26°C. In the last 20 years there have been no temperatures below -23°C. Spring is a transitional season with higher temperatures. In March there are usually winter manifestations with moderate snowfall and low temperatures until mid-April. In May, temperatures were higher than normal.

Summer is a hot season with temperatures between 20-30°C. But sometimes there are high temperatures such as +38.5°C on August 25, 2012, the previous record being +38°C recorded on July 24, 2007. The hottest summer days are July and August. But most of the time the temperature felt is higher than the temperature recorded due to several factors such as humidity and wind. In the city of Cluj-Napoca due to the phenomenon of climate change in the summer periods there are several days with temperatures exceeding +30°C.

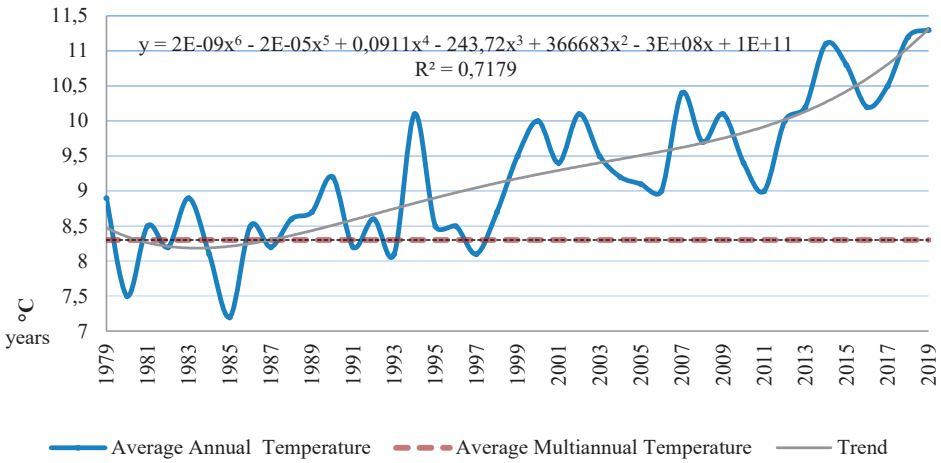

Figure 2. The average annual temperature variation compared to the multiannual average and their trend of evolution in Cluj-Napoca, between 1979 and 2019

Autumn is colder in Cluj-Napoca due to the air front coming from northern Europe. Until mid-September, summer temperatures can still be recorded, after which it gradually cools down. The transition from summer to autumn is quite fast and most days are recorded with rainfall and windy days. Thus, at the end of October, at the beginning of November, the frequency of days with temperatures below 0°C increases. But during the days there are positive temperatures between 5 and 15°C. Table 1 shows the deviation of the annual thermal averages between the period of 1979 to 2019.

Table 1. The deviations of the thermal values from the multiannual thermal average and the rating of the years between 1979 and 2019 in Cluj-Napoca

Year	Annual average °C	Deviation	Description
1979	8.9	0.6	slightly warm
1980	7.5	-0.8	breezy
1981	8.5	0.2	breezy
1982	8.2	-0.1	breezy
1983	8.9	0.6	slightly warm
1984	8.1	-0.2	breezy
1985	7.2	-1.1	cold
1986	8.5	0.2	breezy
1987	8.2	-0.1	breezy
1988	8.6	0.3	breezy
1989	8.7	0.4	breezy
1990	9.2	0.9	slightly warm
1991	8.2	-0.1	breezy
1992	8.6	0.3	breezy
1993	8.1	-0.2	breezy
1994	10.1	1.8	warm
1995	8.5	0.2	breezy
1996	8.5	0.2	breezy
1997	8.1	-0.2	breezy
1998	8.7	0.4	breezy
1999	9.5	1.2	warm
2000	10.0	1.7	warm
2001	9.4	1.1	warm
2002	10.1	1.8	warm
2003	9.5	1.2	warm
2004	9.2	0.9	slightly warm
2005	9.1	0.8	slightly warm
2006	9.0	0.7	slightly warm
2007	10.4	2.1	warm
2008	9.7	1.4	warm
2009	10.1	1.8	warm
2010	9.4	1.1	warm
2011	9.0	0.7	slightly warm
2012	10.0	1.7	warm
2013	10.2	1.9	warm
2014	11.1	2.8	very warm
2015	10.8	2.5	warm
2016	10.2	1.9	warm
2017	10.5	2.2	warm
2018	11.2	2.9	very warm
2019	11.3	3	very warm

The maximum negative deviations are between -1.1°C in 1985 the year being characterized as cold and -0.8°C in 1980, the year being characterized as breezy. The deviations of the annual positive thermal averages show maximum values of +2.1°C in 2007, +2.8°C in 2014, +2.5°C in 2015, +2.2°C in 2017 the years being characterized as warm and in 2018 and 2019 the years have been characterized as very warm, respectively +2.9°C and +3°C.

Rainfall

The precipitation regime in Cluj-Napoca municipality is influenced by the geographical positioning and the circulation of air masses with western predominance. The analysis of the annual values of precipitation and the multiannual average is 590.08 mm.

The graphical analysis (Figure 3) highlights the years 1982, 1983, 1990, 1996, 1998, 2000, 2001 with precipitations recorded below 300 mm/year. In recent years we can see an increase in annual quantities of positive precipitation compared to the multiannual average (1994, 2010, 2014 and 2016).

The evolution of the average precipitations over seasons presents a non-uniformization from year to year. In winter, the rainfall regime is deficient compared to the other seasons. The average rainfall in December is 33.2 mm and in January registering 26 mm. February is the driest month of the year with precipitations below 23.2 mm. The form of rainfall is solid but due to climate change the weight of rainfall in the form of rain is increasingly common in recent years.

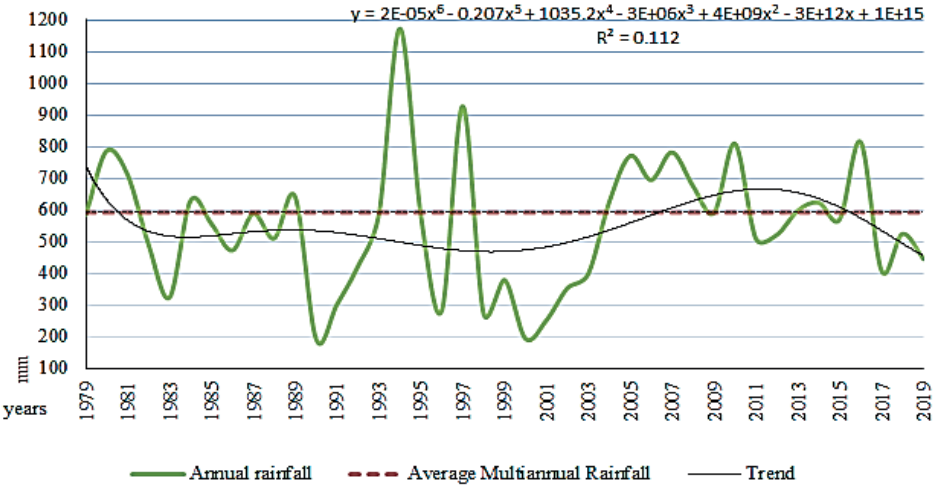

Figure 3. The variation of the average annual precipitation amounts compared to the multiannual average and the evolution trend in Cluj-Napoca, between 1979 and 2019

In the spring, the most abundant precipitation is recorded starting with the second half of March. The average rainfall in March is 25 mm, in April is 42.8 mm and in May 74.3 mm. In summer, the largest amount of precipitation is recorded due to the phenomenon of climate change in a very short time. In June, the highest precipitation amounts are recorded on average 86 mm. In July there was 84.3 mm and in August there was a decrease of the precipitation regime by 66.8 mm. In the summer months there are also severe weather events such as: thunderstorms, electric shocks and hail. In autumn, the precipitation regime is deficient in the month of September, with an average of 32.7 mm, in October 29.7 mm and in November 30.1 mm. At the beginning of November, the first signs of winter usually appear: haze, frost, pole, snow.

Table 2 shows the amount of annual precipitation between 1979 and 2019. The smallest precipitation amounts were recorded in 1983, 1990, 1991, 1992, 1996, 1998, 1999, 2000, 2001, 2002, 2003 and 2017 with precipitation amounts between -28.59 and 67.25 mm, years characterized by excessive

drought. The highest amounts of precipitation were recorded in the years 1980, 1994, 1997, 2005, 2007, 2010 and 2016 with precipitation amounts between 30.22 and 1170.18 mm, being characterized as excessively rainy. In the rest of the years, rainfall was recorded in the limit of normal values.

Table 2. The deviations of the annual precipitation quantities from the multiannual average and the grading of the years between 1979-2019 in Cluj-Napoca

Year	Annual Sum	Deviation	Deviation %	Description
1979	583.66	-7.14	-1.20	Normal
1980	785.57	197.77	33.47	Excessive rainy
1981	710.13	119.33	20.19	Very rainy
1982	489.47	-101.33	-17.15	Very dry
1983	323.85	-266.95	-45.18	Excessive dry
1984	627.40	36.6	12.58	Rainy
1985	555.77	-35.03	-5.92	Normal
1986	471.7	-119.1	-20.15	Very dry
1987	587.23	-3.57	-0.6	Normal
1988	509.52	-81.28	-13.75	Drought
1989	640.31	49.51	8.38	Slightly dry
1990	192.01	-398.79	-67.5	Excessive dry
1991	301.51	-289.29	-48.96	Excessive Dry
1992	421.88	-168.92	-28.59	Excessive dry
1993	585.78	-5.02	-0.84	Normal
1994	1170.18	579.38	98.06	Excessive Rainy
1995	582.99	-7.81	-1.32	Normal
1996	281.98	-308.82	-52.27	Excessive Dry
1997	925.63	334.83	56.67	Excessive rainy
1998	273.12	-317.68	-53.77	Excessive dry
1999	378.42	-212.38	-35.94	Excessive dry
2000	193.43	-397.37	-67.25	Excessive dry
2001	251.75	-339.05	-57.38	Excessive dry
2002	352.55	-238.25	-40.32	Excessive dry
2003	398.05	-192.75	-32.62	Excessive dry
2004	624.87	34.07	5.76	Normal to rainy
2005	769.36	178.56	30.22	Excessive rainy
2006	693.69	102.82	17.41	Very rainy
2007	780.83	190.03	32.16	Excessive rainy
2008	674.10	83.3	14.09	Rainy
2009	590.09	-0.71	-0.12	Normal
2010	807.78	216.98	36.72	Excessive rainy
2011	508.49	-82.02	-13.88	Drought
2012	520.74	-70.06	-11.85	Drought
2013	596.57	6.51	1.10	Normal
2014	622.85	32.05	5.42	Normal
2015	569.72	-21.08	-3.56	Normal
2016	813.35	222.55	37.66	Excessive rainy
2017	407.95	-182.85	-30.94	Excessive dry
2018	523.75	-67.05	-11.34	Drought
2019	444.98	-145.82	-24.68	Very dry

CONCLUSIONS

Due to the geographical positioning, the city of Cluj-Napoca presents a tendency to increase the temperature and the precipitations are maintained in the normal regime with small seasonal changes.

The analysis of the temperature in Cluj-Napoca between 1979 and 2019 established that there is a sharp increase in the temperature values after 2000. The hottest years were 2014, 2015, 2017, 2018 and 2019, with a difference from the multiannual temperature included in range +2.2 °C and +3°C. The smallest deviation from normal was recorded in 1985 with -1.1°C.

The increase of precipitation is not as great as the increase of temperatures but it is maintained in normal parameters with positive or negative deviations from the normal. The highest amount of precipitation was recorded in 1994 with 1170.18 mm. The smallest amount of precipitation was recorded in 1996 with 281.98 mm.

It can be said that the city of Cluj-Napoca is affected by climate change and its consequences. It is expected that in the coming years there will be fluctuations of the weather through very high temperatures and without precipitation or through abundant precipitation in short intervals. It is also possible that the city of Cluj-Napoca could not cope with this uncontrolled growth of the population and its irreversible changes that already impose natural limits by destroying the environment. Thus, it is urgent to prepare local and national climate change strategies.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

STATISTICAL ANALYSIS USED IN EVALUATION OF WATER QUALITY FROM WELLS IN ALBA COUNTY, ROMANIA

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Abstract

Drinking water must be health providing, clean, devoided of pathogenic bacteria, viruses or parasites. Wells water should be checked periodically to determine if it complies with European standards, especially when these waters are used by the population. The aim of this paper is to assess the number of aerobic bacteria, nitrites and ammonium content for 7 location (Alba Iulia, Rosia de Secas, Cenade, Sancel, Spring, Ciugud, Ohaba) from Alba County, Romania. The results show that anthropogenic pollution affecting water quality from wells. The microbial growth varies between 42 CFU in source from Ohaba and 440 CFU in Ciugud. Starting from the nitrogen cycle, for the interpretation of the data a simple linear regression was performed. For all the casese, also a multiple regression was conducted to investigate the relationship between chemical parameters and the bacterial growth. A significant correlation between the microbiological growth and its nitrites and ammonium content was observed.

Key words*: aerobic mesophilic bacteria, ammonium, statistics, nitrites, pollution, quality, wells water.*

INTRODUCTION

Potable water of good quality is a social requirement, and is essential for the maintenance and development of life on our planet. Human activities interfere with natural water cycle. Constantly increasing human population increase demands on exploitation of existing resources including water (Chowdhury, 2013). The water from wells is not treated and is often subjected to chemical and microbiological pollution from anthropogenic sources (Khatri and Tyagi, 2015).

The Romanian Law no. 311/2004 (L.311, 2004) witch modify and revise the Law no. 458/2002 (L.458, 2002) on drinking water quality, it is harmonized with the legislation of the European Union-Directive 98/83/EC (Directive 98/83/EC) on the quality of water intended for human consumption. These provide the following limits: TVC/ml<20. Law 458 no longer specifies limits for wells water, but only for drinking water.

In Romania, the interpretation according to STAS 1342 (STAS 1342, 1991) agrees to the following limits: CFU/ml<300. But, from 2006 the analysis on water samples have been performed according to Water Law, no. 458/2006.

The living organisms, the "dead" organic matter, the mineral and organic compounds dissolved in an aquatic ecosystem there are not biologically and chemically inert. They were in permanent transformation. Thus, between the components of the ecosystem are created complex relationships that ensure the evolutionary stability of these components or the dynamic equilibrium of the system.

Nitrogen is an important nutrient in aquatic ecosystems. It is found in water in many forms: molecular nitrogen, nitrogen oxides, ammonia, nitrates and nitrates.

In the ecosystem, nitrogen enters the biogeochemical cycle, determined by a complex network of interactions of factors in the aquatic ecosystem. Algae can use both free nitrogen from water and ammonium salts (NH_3) and after exhaustion, nitrogen (NO_3^-) (Botnariuc and Vadineanu, 1982).

Bacteria have an important role in nitrogen cycle in the aquatic ecosystem and the nitrogen transformations are reversible. The sense of the processes is mainly dependent on the

concentration of dissolved oxygen (Berard, 1993).

The purpose of the study is to test in time the quality of drinking water from wells in Alba County, Romania. The study results show that the number of mesophilic aerobic bacteria for water (public sources) have values that exceed the limits for potable drinking water and also for nitrates, nitrites content, but only with some minor exceptions. The aim of the study it is also to determine the correlation between these parameters.

MATERIALS AND METHODS

Study Area and Water Sampling Points

The study monitors for 5 years the chemical and microbiological parameters and also correlates the indicators for the wells water. For the purpose of application, the evolution of nitrates and nitrites content and the number of mesophilic aerobic bacteria for several wells water from Alba County were followed quarterly, in order to compare the results and to estimate the correlations between them.

In Figure 1 is presented the map area of Alba County, Romania and the sampling points.

Figure 1. The map of wells water sampling points from Alba County

The locations from Alba County area used for sampling the water are: 1 - Alba Iulia town; 2 - Ciugud village; 3 - Ohaba village; 4 - Spring village; 5 - Rosia de Secas village; 6 - Cenade village; 7 - Sancel village.

The research focused mainly on the areas of county with potential for risk and with a history in terms of water pollution. Water samples were collected from public wells between 2013 and 2017.

Analysis methods

Determination of total number of bacteria growing at 37°C (SR EN ISO 6222/2004; 8199:2008). The method consists in inoculation, by including, of a quantity of 1-2 ml from the sample or decimal dilutions (10-1 and 10-2), into a Petri plate in 10-15 cm^3 nutritive gellose (melted and cooled at 45°C); after the solidification of the gellose the plates are incubated 37 ± 2°C, for 44 ± 4 h. The colonies are counted both those at the surface, and the ones within the gellose.

The methods of rapid spectrophotometric determinations involve the use of the spectrophotometer Spectroquant NOVA 60 (SQ) and SQ specific kits (with reagents and reaction tubes). Following the work pattern from the kit, we read the SQ. The value appears on the screen (Metoda diagnostic medical veterinar, 2004). Ammonium: Kit SQ domain 0.010-2 mg/l NH_4-N or 0.01-2.58 mg/l. It is drop 0.5 ml from the sample in the reaction tube and homogenised. Is added a dose of NH_4-1K, closed, shake, and, after 15 min. readed. In high alkaline solutions, the nitrogen ammonia is present almost totally as ammonia, reacts with hypochlorite ions resulting in monochloramine, which reacts with substitute phenol and forms a blue indocarbolitic derivative. Nitrites: Kit SQ 0.02-1.00 mg/dm^3 NO_2-N or 0.07-3.28 NO_2- NO_2 10 mm tube. 5 ml of sample are drop in the tube. Is added a micro pallet knife of NO_2 -1 reagent and shake until total dissolution. Reaction time: 10 minutes. In acid solution, nitrite ions react with the sulphanilic acid resulting diazonium compound; which then reacts with N-1-naftiletilendiamine dihydro-chloride resulting in a violet red nitro compound.

Statistical analysis

By using the program MATLAB, the experimental data were processed and analysed (Nichici and Cicala, 1996; Vardeman, 1994; Aloman, 1998), obtaining a series of statistic models pointing out the variation of the LogCFU in samples depending on their NH_4^+, respectively NO_2^- content. At first (Iordache et al., 1991), in one variable, a linear function was proposed as follows (1):

$$y = a + b \cdot x \quad (1)$$

respectively a multiple regression (2):

$$y = a + b \cdot x_1 + c \cdot x_2 + d \cdot x_3 \quad (2)$$

where: y - LogCFU/ml;
x_1 - amonium content, mg/l;
x_2 - nitrites content, mg/l
x_3 - time, month.

As indicators of the model adequacy there have been used: the indicator of the precision of the model, R^2 and the correlation coefficient, R (Todinca and Geanta, 1999; Evans, 1996; Gluck, 1977).

RESULTS AND DISCUSSIONS

In the Tables 1, 3, 5, 7, 9, 11 and 13 are presented the results of the tests performed for wells water collected from the four sources of Alba County.

Thus, the experimental results obtained for the well water samples taken quarterly from Alba Iulia, between 2013 and 2017, are presented in Table 1.

Table 1. Experimental results obtained for the water sampled from Alba Iulia

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	168	0.19	0.21
	124	0.21	0.2
	320	0.37	0.35
	136	0.11	0.1
2014	106	0.04	0.1
	360	0.30	0.50
	302	0.50	0.50
	167	0.29	0.16
2015	201	0.14	0.49
	140	0.10	0.24
	232	0.24	0.50
	154	0.10	0.24
2016	120	0.12	0.14
	149	0.29	0.24
	150	0.45	0.31
	148	0.39	0.27
2017	142	0.09	0.52
	194	0.52	0.11
	175	0.38	0.51
	157	0.34	0.42
*NV**	*100*	*0.50*	*0.50*

NV - Normal values according L. 458/2002*

The microbial load of water-analysed samples exceeds permissible limit value from all investigated source from Alba Iulia. The excesses are recorded every year and regardless of the season. The highest recorded value of TVC is 360 colonies in second quarter of 2014, and the highest value of nitrites and ammonium ions is 0.52 mg/l, in 2017. The equations of statistical models obtained are presented in Table 2. The equation is valid on the studied values range. They show the dependence of the microbiological load (y) on the ammonium content (NH_4^+)-x_1, respectively on the nitrite content (NO_2^-)-x_2, for the source monitored in Alba Iulia.

Table 2. The equations and concordance indicators of the established statistical models for the samples from Alba Iulia

Year	The equations	R^2	R
2013	$y = 1.5871 \cdot x_1 + 1.8981$	0.77	0.88
	$y = 1.4997 \cdot x_2 + 1.9094$	0.77	0.88
2014	$y = 1.0941 \cdot x_1 + 1.9764$	0.93	0.97
	$y = 1.03 \cdot x_2 + 2.0301$	0.63	0.80
2015	$y = 0.6612 \cdot x_1 + 2.0076$	0.92	0.96
	$y = 1.3886 \cdot x_2 + 2.0492$	0.82	0.90
2016	$y = 0.6023 \cdot x_1 + 2.0051$	0.86	0.93
	$y = 0.2924 \cdot x_2 + 2.0583$	0.80	0.90
2017	$y = -0.2328 \cdot x_1 + 2.3105$	0.58	0.76
	$y = 0.3121 \cdot x_2 + 2.116$	0.91	0.95

After calculating the model coefficients, it is necessary to make a comparison between model predictions and data from the actual process. The adequacy indicators show satisfactory correlation between the variables considered.

For the multiple regression analysis of the water samples from Alba Iulia the generated equation is (3):

$$Y_{(x1, x2, x3)} = 2.047 + 0.553 \cdot x_1 + 0.531 \cdot x_2 - 0.004 \cdot x_3 \quad (3)$$

with concordance indicators: $R^2=0.73$, $R=0.86$ (strong correlation).

For the samples taken quarterly in the period 2013-2017 from Rosia de Secas the experimental results are presented in Table 3.

Table 3. Experimental results obtained for the water sampled from Rosia de Secas

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	142	0.06	0.24
	250	0.3	0.29
	297	0.33	0.5
	96	0.16	0.17
2014	250	0.18	0.38
	157	0.07	0.11
	206	0.15	0.4
	149	0.09	0.29
2015	106	0.12	0.31

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2016	286	0.3	0.5
	254	0.25	0.43
	165	0.16	0.34
	150	0.16	0.37
	315	0.34	0.5
	240	0.27	0.42
	110	0.23	0.34
2017	150	0.21	0.29
	269	0.5	0.39
	320	0.5	0.5
	186	0.46	0.42

From Table 3 it is notice a considerable increase of mesophilic aerobic bacteria in all periods of year, especially in the second and third quarters of each year. The highest value of 320 colonies is recorded in the third quarter of 2017. Not all values obtained are within the limits allowed by law (100 colonies) for drinking water.

Table 4 presents the equations obtained from the linear regression for the water from Rosia de Secas.

Table 4. The equations and concordance indicators of the established statistical models for the samples from Rosia de Secas

Year	The equations	R^2	R
2013	$y = 1.3818 \cdot x_1 + 1.8368$	0.76	0.87
	$y = 1.4339 \cdot x_2 + 1.9466$	0.64	0.80
2014	$y = 0.5652 \cdot x_1 + 2.1035$	0.51	0.71
	$y = 1.9809 \cdot x_2 + 2.0276$	0.93	0.97
2015	$y = 2.1322 \cdot x_1 + 1.4338$	0.89	0.94
	$y = 2.3119 \cdot x_2 + 1.7963$	0.94	0.97
2016	$y = 2.8245 \cdot x_1 + 1.123$	0.93	0.97
	$y = 2.1045 \cdot x_2 + 1.7479$	0.60	0.78
2017	$y = 1.4264 \cdot x_1 + 1.7745$	0.69	0.83
	$y = 0.89 \cdot x_2 + 1.9735$	0.69	0.83

The correlation coefficients indicate a good correlation of the experimental values and the allure of the proposed equations.

For the multiple regression analysis for the parameters of the water samples from Rosia de Secas the generated equation is (4):

$$y_{(x1,x2,x3)} = 1.926 + 0.867 \cdot x_1 + 0.637 \cdot x_2 - 0.004 \cdot x_3 \quad (4)$$

with concordance indicators: R^2=0.70, R=0.84 (strong correlation).

The water from Cenade area is less polluted. The results obtained for the chemical and micro-biological parameters for the period 2013-2017 are presented in Table 5.

Table 5. Experimental results obtained for the water sampled from Cenade

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	89	0.09	0.34
	93	0.12	0.21
	250	0.31	0.46
	156	0.17	0.38
2014	146	0.08	0.25
	261	0.19	0.47
	292	0.24	0.71
	298	0.25	1.8
2015	104	0.31	0.54
	293	0.38	5.4
	204	0.29	1.6
	96	0.19	0.29
2016	146	0.32	0.35
	260	0.63	0.45
	126	0.25	0.26
	53	0.17	1.2
2017	94	0.35	0.51
	262	0.27	3.71
	140	0.34	0.26
	89	0.42	0.34

Table 6 presents the equations obtained from the linear regression for the water source from Cenade.

Table 6. The equations and concordance indicators of the established statistical models for the samples from Cenade

Year	The equations	R^2	R
2013	$y = 1.7064 \cdot x_1 + 1.5342$	0.71	0.84
	$y = 2.1094 \cdot x_2 + 1.7634$	0.94	0.97
2014	$y = 0.136 \cdot x_1 + 2.2703$	0.41	0.64
	$y = 1.8485 \cdot x_2 + 2.0289$	0.97	0.99
2015	$y = 0.0896 \cdot x_1 + 2.0186$	0.82	0.91
	$y = 2.2837 \cdot x_2 + 1.526$	0.59	0.77
2016	$y = -0.5196 \cdot x_1 + 2.3946$	0.61	0.78
	$y = 1.2668 \cdot x_2 + 1.6671$	0.80	0.89
2017	$y = 0.1157 \cdot x_1 + 1.9823$	0.80	0.90
	$y = -3.1888 \cdot x_2 + 3.2219$	0.82	0.91

For the multiple regression analysis for the parameters of the water samples from Cenade the generated equation is (5):

$$y_{(x1,x2,x3)} = 2.053 + 0.075 \cdot x_1 + 0.972 \cdot x_2 - 0.007 \cdot x_3 \quad (5)$$

with concordance indicators: R^2=0.48, R=0.69 (moderate positive correlation).

The microbiological and chemical results obtained for the water samples taken quarterly from Sancel, from 2013-2017, are presented in Table 7.

Table 7. Experimental results obtained for the water sampled from Sancel

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	88	0.09	0.33
	93	0.11	0.21
	251	0.31	0.47
	155	0.17	0.38
2014	146	0.08	0.25
	262	0.19	0.47
	292	0.25	0.70
	298	0.25	1.80
2015	104	0.31	0.54
	293	0.38	5.4
	203	0.29	1.60
	96	0.19	0.29
2016	145	0.32	0.35
	261	0.63	0.46
	126	0.25	0.26
	54	0.17	1.20
2017	94	0.35	0.51
	261	0.27	3.71
	140	0.34	0.26
	90	0.41	0.33

Table 8 presents the equations obtained from the linear regression for the water source from Sancel.

Table 8. The equations and concordance indicators of the established statistical models for the samples from Sancel

Year	The equations	R^2	R
2013	$y = 2.476 \cdot x_1 + 1.5144$	0.57	0.76
	$y = 1.1526 \cdot x_2 + 1.6234$	0.74	0.86
2014	$y = 1.6555 \cdot x_1 + 1.605$	0.98	0.99
	$y = 20.249 \cdot x_2 - 3.4066$	0.57	0.76
2015	$y = 0.7672 \cdot x_1 + 2.1343$	0.67	0.82
	$y = 0.7332 \cdot x_2 + 2.2707$	0.84	0.92
2016	$y = 1.2209 \cdot x_1 + 1.763$	0.63	0.79
	$y = 1.12 \cdot x_2 + 1.8764$	0.65	0.81
2017	$y = 1.1545 \cdot x_1 + 1.7141$	0.90	0.95
	$y = 0.9346 \cdot x_2 + 1.8038$	0.81	0.90

The concordance indicators prove a satisfactory correlation between the variables considered.

For the multiple regression's analysis for the parameters of the water samples from Sancel the generated equation is (6):

$$y_{(x1,x2,x3)} = 1.675 + 1.406 \cdot x_1 + 0.353 \cdot x_2 - 0.002 \cdot x_3 \quad (6)$$

with concordance indicators: $R^2 = 0.68$, $R = 0.82$ (strong correlation).

The microbiological and chemical results obtained for the water samples taken quarterly from Spring in the period 2013-2017 are presented in Table 9.

Table 9. Experimental results obtained for the water sampled from Sancel

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	189	0.04	0.2
	204	0.02	0.5
	196	0.04	0.32
	185	0.09	0.15
2014	161	0.15	0.49
	290	0.19	1.2
	143	0.02	0.3
	145	0.08	0.28
2015	237	0.23	0.5
	298	0.3	2.17
	159	0.15	0.5
	98	0.09	0.32
2016	124	0.31	0.37
	230	0.55	1.7
	128	0.34	0.28
	167	0.38	0.34
2017	206	0.09	0.45
	242	0.04	0.5
	198	0.1	0.54
	162	0.15	0.24

Table 10 presents the equations obtained from the linear regression for the water source from Spring.

Table 10. The equations and concordance indicators of the established statistical models for the samples from Spring

Year	The equations	R^2	R
2013	$y = 0.1189 \cdot x_1 + 2.2516$	0.98	0.99
	$y = -0.5329 \cdot x_2 + 2.3117$	0.73	0.85
2014	$y = 0.3364 \cdot x_1 + 2.0556$	0.99	0.99
	$y = 1.5555 \cdot x_2 + 2.0754$	0.65	0.80
2015	$y = 0.1789 \cdot x_1 + 2.1043$	0.54	0.73
	$y = 2.2699 \cdot x_2 + 1.8234$	0.97	0.98
2016	$y = 0.161 \cdot x_1 + 2.088$	0.78	0.89
	$y = 1.1272 \cdot x_2 + 1.751$	0.94	0.97
2017	$y = 0.4294 \cdot x_1 + 2.1153$	0.64	0.80
	$y = -1.5857 \cdot x_2 + 2.4516$	0.99	0.99

The concordance indicators show an acceptable correlation between the variables considered.
For the multiple regression analysis of the water samples from Spring the generated equation is (7):

$$y_{(x1,\ x2,\ x3)}=2.202+0.194\cdot x_1-0.290\cdot x_2-0.0002\cdot x_3 \quad (7)$$

With concordance indicators: $R^2=0.49$, R=0.70 (moderate positive correlation).
The results obtained for the water samples taken quarterly from Ciugud during the period 2013-2017 are presented in Table 11.

Table 11. Experimental results obtained for the water sampled from Ciugud

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	248	0.19	0.46
	210	0.24	0.42
	208	0.28	0.41
	167	0.29	0.29
2014	158	0.3	0.24
	252	0.29	0.43
	268	0.28	0.5
	242	0.29	0.48
2015	196	0.24	0.34
	158	0.17	0.27
	244	0.3	0.47
	109	0.11	0.16
2016	204	0.08	0.41
	430	0.5	0.62
	301	0.42	0.53
	224	0.09	0.21
2017	315	0.34	0.59
	440	0.5	0.55
	210	0.31	0.6
	97	0.2	0.13

Nitrites are found due to the pollution of water with organic matter, or by partial oxidation of the amino radical or by reducing nitrate. Their presence indicates a more back pollution of water, but with higher concentrations of ammonia (maximum 0.62 mg/l in second quarter of 2016) shows that the pollution is continuous.
Table 12 presents the equations obtained from the linear regression for the water source from Ciugud.

The concordance indicators prove a good correlation between the variables considered. For the multiple regression's analysis for the parameters of the water samples from Ciugud the generated equation is (8):

$$y_{(x1,x2,x3)}=1.939+0.795\cdot x_1+0.307\cdot x_2-0.0002\cdot x_3 \quad (8)$$

with concordance indicators: $R^2=0.76$, R=0.87 (strong correlation).

Table 12. The equations and concordance indicators of the established statistical models for the samples from Ciugud

Year	The equations	R^2	R
2013	$y = 0.9367\cdot x_1 + 1.9444$	0.95	0.97
	$y = -1.3611\cdot x_2 + 2.6546$	0.77	0.88
2014	$y = 0.8545\cdot x_1 + 2.0005$	0.94	0.97
	$y = -11.474\cdot x_2 + 5.6804$	0.80	0.89
2015	$y = 1.1302\cdot x_1 + 1.8786$	0.97	0.98
	$y = 1.7816\cdot x_2 + 1.8637$	0.97	0.98
2016	$y = 0.6663\cdot x_1 + 2.1481$	0.65	0.81
	$y = 0.6337\cdot x_2 + 2.2703$	0.90	0.95
2017	$y = 1.0523\cdot x_1 + 1.8708$	0.71	0.84
	$y = 2.1436\cdot x_2 + 1.6392$	0.88	0.94

The results obtained for the water samples taken quarterly from Ohaba, from 2013-2017, are presented in Table 13.

Table 13. Experimental results obtained for the water sampled from Ohaba

Year	Microbiological	Chemical	
	CFU/ml	NO_2^-, mg/l	NH_4^+, mg/l
2013	42	0.08	0.24
	190	0.22	0.29
	256	0.28	0.42
	136	0.24	0.36
2014	240	0.34	0.42
	280	0.42	1.4
	210	0.29	0.5
	167	0.24	0.34
2015	201	0.29	0.46
	295	1.14	2.27
	269	0.5	0.75
	201	0.22	0.37
2016	196	0.02	0.49
	410	0.49	1.9
	237	0.5	0.54
	259	0.28	0.42
2017	240	0.5	0.38
	320	1.4	1.02
	157	0.42	0.35
	116	0.34	0.24

The microbiological parameter in correlation with chemical value registered in Ohaba village show that the risk due to consumption of groundwater is significant. The water source exceed the limits allowed by legislation for the number of mesophilic aerobic bacteria - in particular.

Table 14 presents the equations obtained from the linear regression for the water source from Ohaba.

Table 14. The equations and concordance indicators of the established statistical models for the samples from Ohaba

Year	The equations	R^2	R
2013	$y = 3.46 \cdot x_1 + 0.9778$	0.63	0.79
	$y = 3.8135 \cdot x_2 + 1.3292$	0.93	0.96
2014	$y = 0.15 \cdot x_1 + 2.2433$	0.61	0.78
	$y = 1.2111 \cdot x_2 + 1.9525$	0.95	0. 98
2015	$y = 0.081 \cdot x_1 + 2.2985$	0.69	0.83
	$y = 0.1817 \cdot x_2 + 2.2788$	0.76	0.88
2016	$y = 0.1755 \cdot x_1 + 2.2763$	0.84	0.92
	$y = 0.4133 \cdot x_2 + 2.29$	0.47	0.68
2017	$y = 0.4635 \cdot x_1 + 2.0558$	0.71	0.84
	$y = 0.3268 \cdot x_2 + 2.0691$	0.69	0.83

Overall, the concordance indicators show a satisfactory correlation between the variables considered.

For the multiple regressions analysis for the parameters of the water samples from Ohaba the generated equation is (9):

$$y_{(x1,x2,x3)}=2.095+0.173 \cdot x_1+0.073 \cdot x_2-0.002 \cdot x_3 \quad (9)$$

with concordance indicators: $R^2=0.39$, $R=0.62$ (weak correlation).

CONCLUSIONS

The results obtained evidence that anthropogenic pollution affect water quality from wells in the Alba County, Romania. All activities taking place on the surface have an impact on groundwater quality.

The equations of statistical models can approximate microbiological growth in wells water knowing its nitrites content, or ammonium ion ant the time of the year when the sample was collected. Correlation parameters calculated based each on other arguments a satisfactory capacity of prediction for the statistical models. Also, the model predictions can constitute a control criterion for assessing groundwater quality.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

STRUCTURAL LAND PLANNING IN THE IRRIGATION AND DRAINAGE AREAS

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Abstract

The small size of landed properties and the fragmentation of land ownership hinder the use and functioning of the already built-up irrigation and drainage systems in Bulgaria. One of the ways to ensure their efficient work and to guarantee reconciliation of all users' interests, especially towards soil moisture management in their land, is by mutual adjustment of land planning and the technological requirements of those systems. The objective of the paper is to reveal rules for land planning of the irrigated and drained lands, in which the land use requirements meet the water use ones. The background is the concept that agricultural land-use structuring should consider the technological units such as water-supply tracts, IMs and drainage technological parcels. The systematic approach was used since the agricultural land represents an agroecosystem - a natural ecosystem formed and operated by human activity, and tenure interests are concerned. Suggestions for different irrigation technologies are made: furrow irrigation, sprinkling machines, sprinkling installations; drip irrigation; and open drainage systems.

Key words*: irrigation and drainage technologies; irrigation and drainage technological parceling, structural land planning.*

INTRODUCTION

A lot of problems in the nowadays agricultural land use stem from the ceaseless process of division of the landed properties, sales, and inheritance. The small-sized property puts obstacles not only to land cultivation but also to the functioning of the agricultural structures, especially of the irrigation and drainage systems. The built up in the past large-scale irrigation systems require large areas for applying their irrigation technologies: either ownership on large areas or large areas leased, which is a precondition of consolidated land use.

Some of the land market transactions cause fragmentation of land use hence for the worsening of the terrain conditions for amelioration activities. In case of irrigation, some of the problems consist of the following: the arable land diminishes because its primary purpose of the use is changed for canals and for a road network servicing the canals, the canal network becomes denser, water management gets complicated; the land is exposed to surface and slope water erosion hazards, irrigation requires additional investments etc.

One of the proper ways for eliminating the negative effects of the small-sized land property and land-use fragmentation on the functioning of the irrigation systems and for solving the resulting issues is by structural changes in land ownership and use, performed by land consolidation.

Referring to the available sources (Vassilev, 1933; Krekmanov, 1941; 1943; Georgiev, 1947; Davidov, 1978), the idea of land consolidation in Bulgaria dates from the beginning of the 20th century when some farmers acted towards setting spatial conditions for rationalizing of their fieldworks and production. Land consolidation issues were initially regulated by some texts in legal acts from 1921, 1933, while the Cadasters and Land Consolidation Act that was promulgated by SG 127 of 1 Jun 1941 comprised and regulated all the stages of the land consolidation process and the conditions of its implementation. This Act was denominated in 1950 when the socialistic compulsory collectivization started.

The Agrarian Reform of the 90-s of the past century focused on the restoration of land ownership resulted in parceled out property and land-use fragmentariness. The new socio-economic situation and the current technological conditions didn't imply the re-implementation of the old 1941 land

consolidation act. There was a horizon for elaboration on a new one with adequate context.

The practices of the Netherlands and Germany, which are countries with highly developed agriculture, show that water management systems and their functioning are within the national economy priority and should be regulated by a detailed Land Consolidation Act or related legislation or by an analogous section in the Land Development Act (Knoblauch, 1987; Van den Noort, 1987).

Bulgaria has no contemporary Land Consolidation Act yet. At the end of 20th century, several drafts of a Land Consolidation Act have been developed. One of them, dating from 1994 (unpublished and not promulgated) has focused on the areas under irrigation and drainage, especially on the necessity of flow corrections, on the construction of irrigation and drainage canals, on the estimation and the compensation of the losses from destroyed waterway facilities, etc. Today, the Agricultural Land Ownership and Use Act Land (prom SG No. 17 of 1 Mar 1991, last suppl SG No. 61 of 2 Aug 2019 - ALOUA, 1991) guarantees by Art. 4, para 4 the preservation of the already built up irrigation and drainage technique and the function of the equipped lands.

The restoration of the land ownership in irrigation and drainage areas, i.e. land division in these territories, was guided by instructions in Newscast No. 7, 1994 of that-time Land Reform Department of the Ministry of Agricultural Development, Land Use and Land Restoration. The instructions were based on detailed knowledge from preliminary research work (Davidov, 1978). Land division projects of irrigation and drainage lands had to consider the technological units in the irrigation and drainage technologies.

Now, when the Agrarian Reform is over, a lot of shortcomings and omissions in the land division plans are ascertained. The situation of many landed properties is in conformity with the WST, but not with the IM. The existing irrigation or drainage facilities are not taken into account in many projects at all. No assessment of the hydraulic network status was done, thus many canals were destroyed in vain. Soil categorization was considered for rain-fed conditions but not for irrigation ones. This non-compliance causes today serious malfunctioning of the irrigation and drainage systems.

There are three cases, in which specific technological parceling is to be done:

- when there are fields with already built up hydraulic structures,
- when new hydraulic systems are being built or when there are approved draft projects for implementing,
- when a procedure for building hydraulic systems has already started for lands that are included in a consolidation program.

The objective of the paper is to present the main ideas of scientifically based Guidelines for land consolidation design in irrigation and drainage areas and to outline the specificity of this design.

MATERIALS AND METHODS

The specific aspect of a draft land consolidation project in irrigated and drained territories is the mutual adjustment of the requirements for land development (land parceling, land division, land consolidation) (IRALOUA, 1991; Newscast No. 6, 1994) and the requirements for irrigation and drainage technological parceling (Newscast No. 7, 1994). The definitions for the technological parcels in the irrigation and drainage technologies are taken from the Newscast No. 7, 1994, which contains guidelines on the agricultural land division in the areas of the irrigation and drainage systems. The essential technological plots are defined there as follows:

- **Water Supply Tract (WST)** is the area, which is irrigated consecutively in series from a concrete-lined fully discharged canal or pressurized pipeline. At least one of the WST borders is contiguous with that canal or with the projection of the pipeline on earth surface. The water providing line element is equipped with one or more water offtake devices.
- **Irrigation Module (IM)** is a part of a WST that is operated by one offtake device. At least one of the IM borders coincides with a canal or the projection of the pressurized pipeline on earth's surface. Both are equipped with water offtakes.

Designing methods and professional knowledge in the field of Land Development and Irrigation and Drainage Engineering were used for drafting Guidelines for land consolidation design in such areas.

RESULTS AND DISCUSSIONS

Generally, land consolidation of irrigation and drainage areas has to be a specific part of a land consolidation plan. There are particular technological rules to be followed because of the specific function of these territories. The specific aspect of land consolidation in territories under irrigation and drainage is the technological parceling, connected with these activities and the applied technologies. Land consolidation aims at the proper situation of the consolidated parcels so that to enable land use and to facilitate the work of the existing structures. Any of the following particular terms should be fulfilled when consolidating lands:

- a consolidated plot must consist of a whole number of IMs, which are peculiar for the applied irrigation technology;
- an IM must consist of a whole number of landed properties, respectively consolidated plots.

The main activities of land consolidation in areas under irrigation or drainage should consist of the following ones:

1. Gathering the initial information:

Graphic information:

- a 1: 25,000 scale plan of the whole irrigation and drainage system, including the situation of the main elements and devices plotted – water resources, head delivery, and transport canals and pipes, pump stations with their characteristics, etc.;
- a topographic plan (1: 5,000) with detailed information about the waterway infrastructure - canals, pipes, pumping stations, dikes, flow corrections, etc., also with the WSTs and IMs borders plotted and numerical information about them;
- a cadastral plan (1: 5,000) of the landed properties.

Text notes:

- about the technological parceling and its peculiarities in the specific conditions of the given territory;
- a list of the WSTs with initial numerical data; design load factor for them, irrigation application efficiency;
- inventory lists of the hydraulic devices.

2. Fixing the borders and the size of the consolidated territory and the technological plots (WSTs, IMs, rice planted cells and irrigation tracts, drainage areas).
3. Making an inspection of the facilities status and amortization on the spot.
4. Developing a draft project for additional irrigation and/or drainage network if needed.
5. Outlining the irrigation fields by taking into account:

- the available water resources and their probability;
- the water conveyance efficiency of the water distribution net, i.e. its hydromodulus.

In order to evaluate the water supply of the field and tracts, a large-scale water resources - water consumption balances should be used. The water supply probability factor for the irrigation system is calculated by the eq. (1):

$$K_o = \frac{P\%}{75} \quad (1)$$

where $P\%$ is the actual water supply probability of the system.

Further the hydromodulus of every separate WST is estimated as (eq. 2):

$$q = \frac{Q}{F} \quad (2)$$

where: q - the hydromodulus, l/s/ha; Q - the WST canal or pipe discharge, l/s; F - WST surface, ha.

The hydromodulus probability factor of each WST should also be estimated (eq. 3):

$$K_x = \frac{q}{q_0} \quad (3)$$

where: K_x - hydromodulus probability factor, q_o is the standard hydromodulus, l/s/ha (0.70 for gravitational systems and 0.80 for pump systems).

For the water supply probability factor of the WST must be accepted the lower value of the calculated by eq. (2) and (3) value.

The IMs within a WST are consecutively irrigated, following a landowners' schedule.

6. Productivity estimation of the landed properties, participating in the land consolidation project.

7. Developing a draft project for the equivalent exchange of the landed properties.
8. Technological parcelling of the areas under irrigation and/or drainage.
9. Adjustment of the consolidated land plots to the technological plots.
10. Preparing the final documentation that consists of:

Graphic information:

- plans of 1:25,000 and 1:5,000 scale, in which the existing linear and surface elements of the hydraulic network and their easements are drawn;
- the borders of the WTSs;
- the borders of the consolidated plots with their cadastral numbering;
- the newly projected roads;
- information, sketches of the recommended irrigation and/or drainage activities in the consolidated lands.

Text notes, explaining the draft project.

The water distribution net within an IM is owned by the landowners.

Several main cases of water distribution technology are concerned in the Guidelines:

1) Subterranean pipe network with mounted hydrants (Figure 1).

WST has a rectangular form. The number of distribution pipelines determines the number of WST. The length of a WST is equal to that of the pipeline wing and the width is equal to the space between the wings. IM also has a rectangular form but its length is equal to the space between the water distribution pipelines and its width - to the space between the hydrants.

2) Subterranean pipe network with stationary sprinkler stands and drip irrigation systems (Figures 2 and 3).

WST consists of the area of all irrigation batteries that are consecutively watered for completion of an irrigation application. One of the borders coincides with the head pipeline. A sprinkler or a drip irrigation battery area represents the area of an IM. If a consolidated plot is greater than one irrigation battery, then it should consist of integer irrigation batteries. If not - a battery should be given to a group of

Figure 1. A scheme of structural land design in an area equipped with a subterranean pipe network with mounted hydrants

owners so that the total area of their properties should be equal to the area of an irrigation battery.

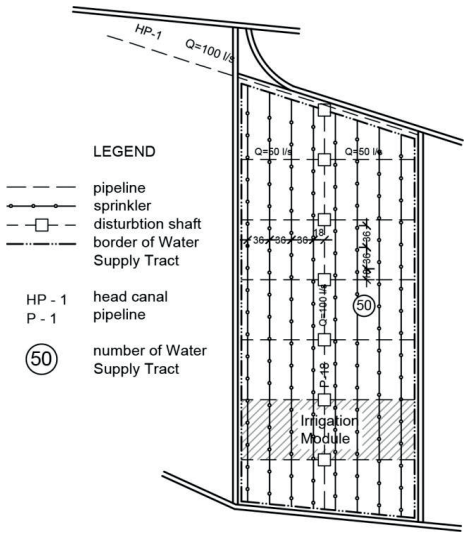

Figure 2. Technological parceling of an area equipped with a subterranean pipe network and stationary sprinkler stands

The borders of their plots should be in conformity with the situation of the sprinklers or of the drip pipelines. The area of one owner should be multiple of the area within four opposite situated sprinklers or should have a rectangular shape when irrigated by a drip pipeline.

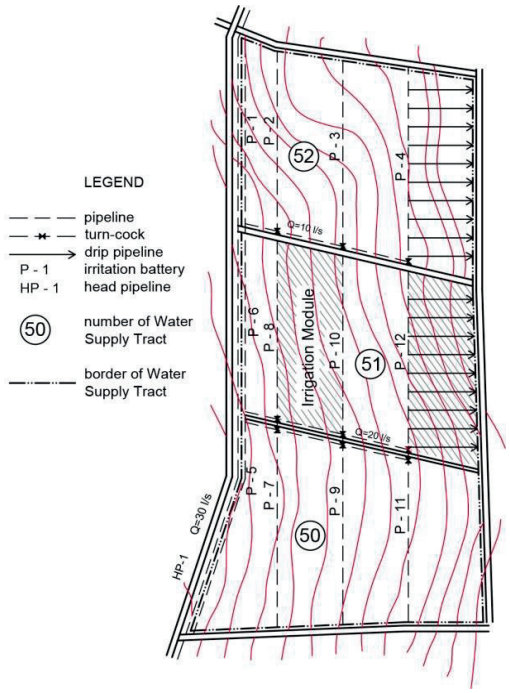

Figure 3. Technological parceling of an area equipped with a drip irrigation system

3) Subterranean pipe network for pivot center machines (Figure 4).

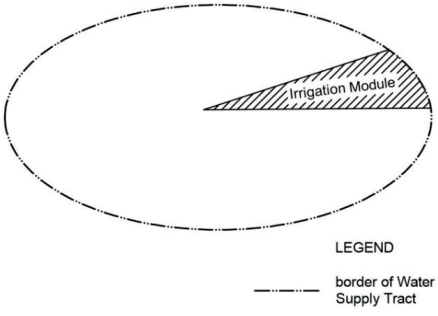

Figure 4. Technological parceling of an area equipped with a pivot center machine

The area of the machine is considered to be a WST. The IMs are parts of the WST with sectoral shape.

4) Open canal water distribution network for furrow irrigation (Figure 5).

WST spreads over the area that is irrigated by the lowest class canal. Its length is equal to the length of that canal and its width shouldn't exceed 200 m, taking into account that the latter follows the slope of the furrows. IM has a rectangular form. Its long side follows the furrow direction. Its short sides lie on two adjacent lowest class concrete-lined canals. IM width is fixed by the space between two adjacent offtake devices, and it shouldn't exceed 100 m.

The landed properties can consist of one or more IMs or be a part of an IM. In both cases, the irrigation efficiency should be taken into account.

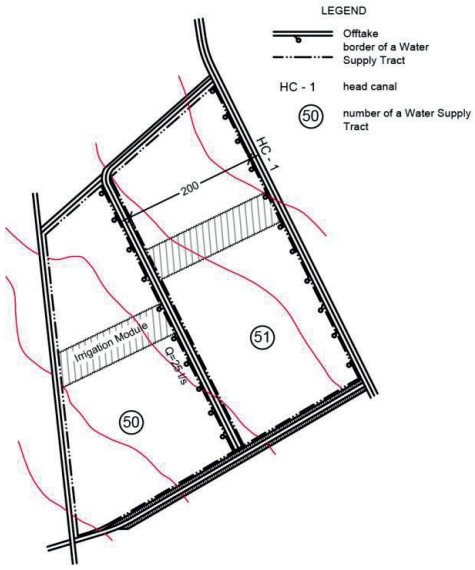

Figure 5. Technological parceling of an area equipped with a subterranean pipe network with mounted hydrants

5) Open canal water distribution network for sprinkling (Figure 6).

WST is the area which is irrigated from one motor-pump aggregate position. It is considered that a pump aggregate of 40 l/s debit serves 30 ha. The one border lies on the open canal; the others follow the general land planning and consolidation requirements. An IM consists of the irrigated area of one portable

sprinkler wing. Both long sides of an IM's are parallel and perpendicular to the open canal.

6) Rice irrigation system (Figure 7).

The technological parcelling of the rice fields is entirely conformed to their specific structure and service. One of the most important things there is that the consolidated landed properties should be equal to the rice field area. If it is smaller, the spare part will be destroyed. The size of the rice field should fulfil the requirement of a full probability water supply of the irrigation system.

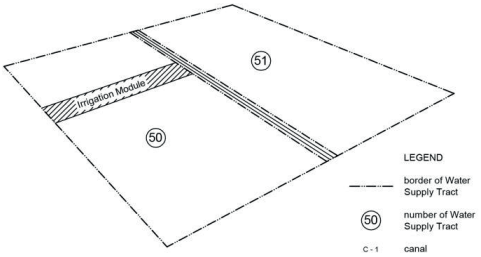

Figure 6. Technological parceling of an area equipped with a rice irrigation system

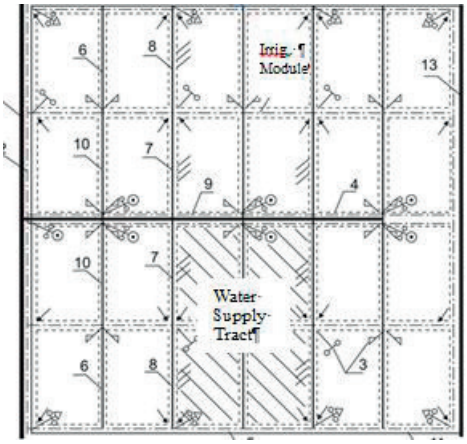

Figure 7. Technological parceling of an area equipped with a rice irrigation system (Source: Volkov, 1997)

7) Open drainage system (Figure 8).

The technological parceling of drainage systems equipped lands should be adapted mostly to the natural conditions of the land. A Drainage Technological Parcel should lie within the area drained by one collector and its draining facilities or within the drained by a single water surplus controlling device (drain ditch, sucker, and additional drains) area. Its configuration and size are conformed to the situation, configuration and size of the drained tract. It is important to have access to the natural and artificial water inlets of the drainage system and to follow the direction of the permanent and temporary water control line elements and of the land reclamation and other field works. The borders coincide with the natural water inlets - rivers, gullies, ravines, etc. They have to tally with the drainage basin borders - the drainage divides and the water diversion lines, head drainage canals and other open delivery or control network canals, main subterranean collectors and other ones of a smaller class that have shafts and other devices on the earth surface. The consolidated land should be equal to the whole drained tract area if possible or be adjusted to the situation of the drains, the shafts, inlets, and other devices.

Figure 8. Technological parceling of an area equipped with a drainage system

The detached drainage tracts should be given to single owners if possible or to a group of owners who would join a cooperative for proper operation of the drainage system.

CONCLUSIONS

The recent agrarian policy of Bulgaria has approved a small-sized property and fragmented ownership. This seems to be a narrow and inadequate frame for the agricultural production processes, a harmful one for land preservation and functioning of all land reclamation infrastructures. Land consolidation is the only way to restore the interests of both - the Nature and the land owners, a tool of approaching sustainable development. Land consolidation project is a

key to a future long-term functioning of the irrigation and drainage systems and to high productivity of reclaimed land. The main activities for creating a land consolidation project and the technical norms should be regulated in a Land Consolidation Act and in the Rules for its Implementation.

When drafting a land consolidation project, the technological parceling of the popular irrigation and drainage technologies have to be considered. Guidelines for harmonization of requirements of land consolidation and technological parceling have been developed. The main concept is that the consolidated plots and the technological plots should be mutually multiples in order to keep the functionality of the irrigation and drainage systems and to guarantee unhindered water use.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Education and Science, Bulgaria and also was financed from Project BN 209/18 of Research, Consultancy and design Centre at University of Architecture, Civil Engineering and Geodesy.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

COMPARISON OF SIMULATION MODELS OF WATER EROSION USING GIS

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Abstract

This paper presents the outcomes of a research on water erosion quantification by GIS-based mathematical stimulation and modelling, carried out in a water catchment area from Romania. This paper presents the outcomes of a research carried out in a water catchment area with high slopes, where intense processes of water erosion emerge. The researchers in this field successfully use two models. The first one is USLE, within GIS Geo-Graph software and the second one is WEEP; the simulation was done in a GIS ArcView environment. The simulation and application of simulation models take place in the same water catchment area (perimeter), under the same conditions and within the same range imposed by each model. This paper contains an analysis of the outcomes and concludes on the visible differences. The USLE model stalling was done by direct measurements in the bordering area of a reservoir, where the silt depositions were measured. As a follow-up to this project, the WEEP model will also be stalled in the water catchment area subjected to study, by using aerophotograms and field data.

Key words*: comparison, GIS, modelling, water erosion.*

INTRODUCTION

At worldwide level, erosion represents one of the most important challenges humankind is facing, vital for the progress and economic stability thereof, for the environment. Out of the overall reserves of fertile soil (approx. 350 billion tons), 2.32 billion tons are eroded; at this pace, the soil reserves might become depleted in approx. 150 years (according to Word Watch Institute, USA, 1990). In Romania, this degradation process (pollution, in the modern ecological sense), covers approximately half (47 %) of the agricultural land of the country, i.e. approx. 7 million ha (Berghoff et al., 2014; Dumitrescu et al., 2014).
All watercourses of the country are characterized by erosion and by a significant transport of alluvial materials generated by both the erosion of land from the reception basins and erosion of water beds and banks (Clinciu et al., 2010; Nistor et al., 2010).
In average, approximately 1550 kg/s of bed loads flow throughout Romania, representing a quantity of 48.9 million t/year, namely an average specific flow of 2.06 t/ha, an extremely high value (Iacobescu et al., 2012; Ionita et al., 2014; Popita et al.,2014; Irimus et al., 2017).
The number of torrential beds, mostly degraded, amounts to approx. 2800, and the average annual transport of alluvial deposits is of 18.3 million m^3, out of which 58% originate from versants and 42% from beds (Biali et al., 2018; Biali et al., 2019; Bilasco et al., 2018; Chendes et al., 2011; Niacsu et al., 2012).
The negative impact of erosion and torrentiality is significant for Romania, in particular on agriculture (due to continuous decrease of soil fertility), on the hydrographic network (due to water beds and storage reservoirs silting), on the communication networks, localities located at versants basis and on the environment (due to pollution, degradation of the microclimate, damages on the landscape, of people living conditions, depopulation), (Biali et al., 2018; Niacsu et al., 2015; Williams et al., 1990).
In this context, the implementation of the Geographic Information Systems (GIS) for the above-mentioned purpose, in our country, is required and justified not only by economic reasons, but also by the safety and celerity ensured by the provision of required information "in real time" (Moore et al., 1992).

MATERIALS AND METHODS

The research of the present paper work was made in several experimental perimeters of the Ghilavesti Inferior hydrographic basin. It belongs to the upper water catchment area of the river

Berheci, in the Unit called Colinele Tutovei, and it is located in the Eastern part of Romania, in Bacau county (Figure 1). The experimental perimeters are located in the lower basin on the left slope at about 1.5 km south of Antohesti catchment). The land, private property, has an area of 9.2 ha and was initially made up of 10 rectangular parcels with width of 20-30 m oriented in the uphill-downhill. The general slope is 14% and the altitude is between 164 m and 210 m. The land studied has been to anti-erosion works by carrying out a number of six terraces. The seven strips oriented in the direction of the level curves have an average width of 40 m and a length of about 340 m except the gussets located at the uphill and downhill extremities of the polygon.

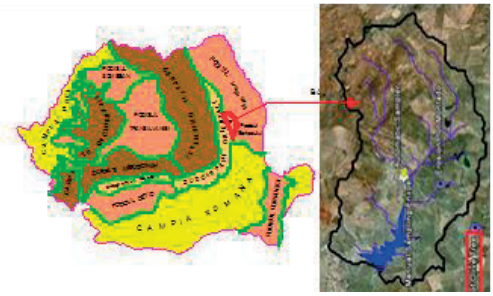

Figure 1. Location of the study area

The two mathematical models used in the project are: ROMSEM (by USLE) and WEEP.

The model USLE (Universal Soil Loss Equation) (Wischmeier et al., 1978) was developed by applying statistical methods on data obtained by experimental measurements and indicates the potential areas subjected to erosion with precision.

The USLE methodology was adapted to the Romanian soil and climatic conditions by the team of researchers of the Institute of Pedology and Agrochemical Researches in Bucharest. Thus, in 1979, Acad. Motoc M. et al. have developed the ROMSEM model (Romanian Soil Erosion Model), using the experimental data obtained at the several research stations in the country (Perieni - Vaslui county, Aldeni-Buzau county, Balcesti - Arges county, Valea Calugareasca-Prahova county and Campia Turzii - Cluj county). This model was reconfirmed in 2002 (Motoc et al., 2002). The estimated annual soil loss is based on the following equation (1):

$$E = K \cdot S \cdot L^m \cdot i^n \cdot C \cdot C_S \quad (1)$$

where:

E - the average annual rate of the surface erosion (t $ha^{-1}yr^{-1}$);

K - the rainfall erosivity factor, evaluated based on the rainfall aggressiveness, obtained as a result of $H \cdot I_{15}$ (H- the amount of precipitation fallen during the entire rain event, I_{15}- the intensity of the torrential nucleus lasting 15 minutes);

S - the soil erodibility coefficient;

L^m - the slope length factor; it is determined using a function, where m = 0.3 for the straight slopes, m = 1.2 for the convex slopes and for the slopes with concave profile m = 0.6;

i^n - where i represents the slope angle (%) and n = 1.4;

C - the cover management factor;

C_s - the correction coefficient for the effect of the erosion control measurements.

The spectacular progress that IT recorded in the last years obviously influenced the performances of the new simulation models of soil erosion.

The modern computer technology, with an inconceivable data storage capacity a few years ago, favored the emergence of new generation of models with an incomparable higher complexity than the previous one. These were made by the concerted effort of some groups of researchers specialized in various field such as mathematics, hydraulic, geology, agriculture, meteorology etc.

The American model Water Erosion Prediction Project - WEPP is perhaps the most representative case. The first version was launched in 1989 after which, about once a year, new improved version followed. During 1990-1994, the Soil Preservation Service of the USA created a friendly user interface in order to significantly ease the insertion of data related to relief, soil and agricultural works.

WEPP is the acronym of Water Erosion Prediction Project; it is based on processes and includes modules for infiltration, drainage, daily water balance sheet, torrential rain intensity, change of soil erodibility, plant growth. WEPP proved an efficient tool in modelling the erosion rate for a large range of climatic and other type of conditions, making it appropriate for approaching the impact of climate changes on soil erosion.

The model was subjected to many tests and compared to the observed data and the Universal Soil Loss Equation, proving satisfactory in most of the cases.
The main input/output data of the WEPP model are present in Figure 2:

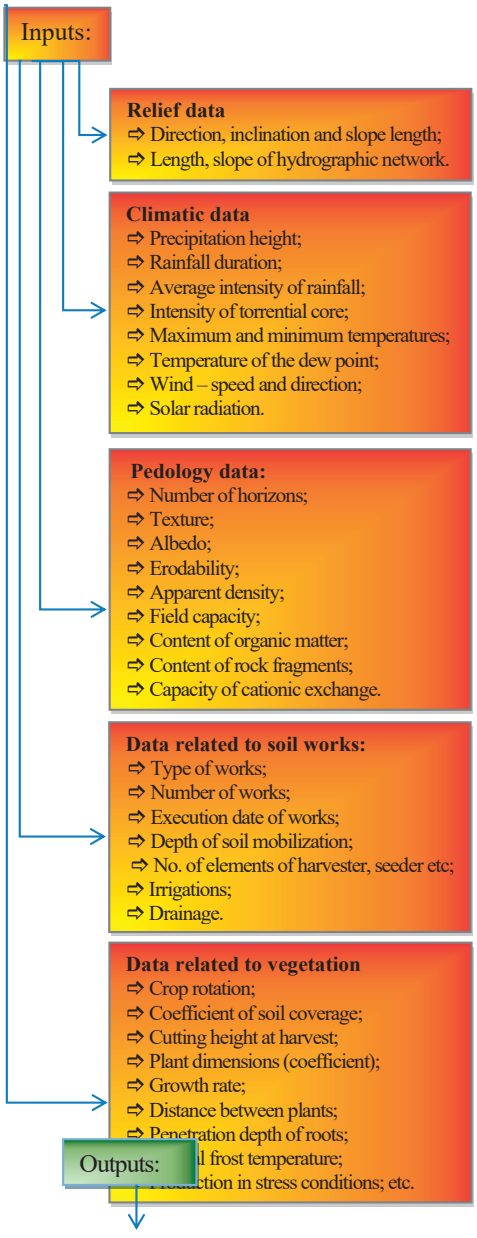

Figure 2. The main input/output parameters of the WEPP model

The effective simulation models of soil erosion, among which WEPP, are designed to work efficiently with GIS (Cochrane et al., 1999). They can use jointly the databases related to: relief, soils, vegetation, anti-erosion works etc. Finally, the capitalization of information obtained by modelling is considerably improved.
WEPP represents an important step forward in the attempt to offer new anti-erosion solutions and to prefigure the impact that such measures will have on the environment. Compared to previous models which, in fact, carried out a statistical analysis on a limited number of data, WEPP is based on process analysis. The most significant advantage consists in the ability of spatial and temporal estimation of soil and water losses on slopes used for agriculture (Burrough et al., 1988; Renard et al., 1996).
The importance of the GIS techniques integration to quantify the surface erosion risk is determined by the speed of the performing operations, the accuracy of the results and the possibility of their spatial representation. The database used for estimating the annual rate of surface erosion based on the ROMSEM model was consisting of the Digital Elevation Model (DEM), with 10 m resolution, the soil map (with information about the type, texture, structure and degree of soil erosion), the land use map, based on Corine Land Cover 2000 and corrected according to the 2005 orthophotos with a 0.5 or 1.0 m resolution, the rainfall erosivity index map in Romania and information about the distribution of soil erosion (Biali et al., 2018).

RESULTS AND DISCUSSIONS

The mathematical model used in order to determine the soil loss is based on ROMSEM

model (Romanian Soil Model - Motoc M., 1983). Due to the fact that the "landscape" factor has a significant weight in the erosion process for gradient areas, the development of the Numerical Land Model (MNT) represented an important step within GIS project, and generated three information layers included in the computation algorithm of erosion-related soil loss.

The Numerical Land Model was obtained by means of interpolation, based on weighted average method for local interpolation (Biali et al., 2018; Haidu et al., 2012)

Based on the map with level curves, the obtained Numerical Land Model (MNT) provided fundamental layers for the GIS project (Biali et al., 2014), such as: Layer 1 - Hypsometric map (Figure 3); Layer 2 - Flowing direction map (Figure 4); Layer 3 - Gradient map (Figure 5); Layer 4 - Flowing length map.

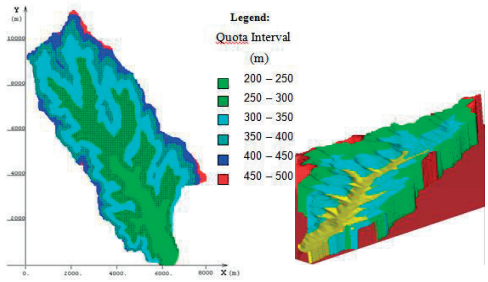

Figure 3. Hypsometric map of b.h. Antohesti. Spatial distribution of average pixel quota (Layer 1) and Digital Terrain Model (DTM) in 3D format

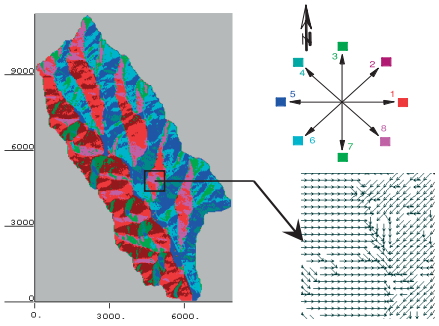

Figure 4. Map of versant exhibition - flowing direction in b.h. Antohesti (Layer 2)

Under the GIS GEO-GRAPH project, the geo-referential data is represented as layers, which facilitates the analysis of space variables and distribution of entities on the reviewed surfaces, and the overall analysis of the acquired information, which implies the concomitant approach of several layers, was performed through the so-called "overlay" technique. The "overlay" technique is based on overlaying or combination operations of several layers (based on specific algorithms – determined by the user), which generates new layers and data and attributes, respectively. These operations may be algebraical, logical, topological etc. and have graphic and non-graphic effects.

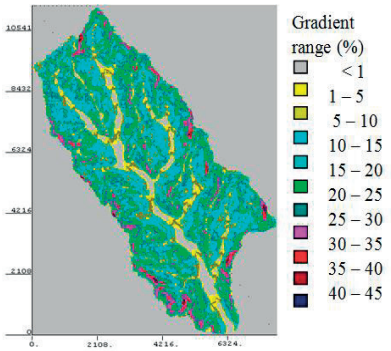

Figure 5. Gradient map (Layer 3)

Based on the status layouts of uses on versants and soil, the spatial topology methods generated the following information layers:

Layer 5 - Versant coverage and agricultural management; Layer 6 - Soil erodibility factor; Layer 7 - Effect of soil protection and preservation actions and works (Figure 6).

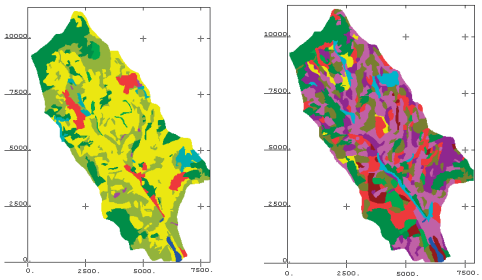

Figure 6. Versant coverage (factor C -Layer 5) and Soil erodibility (factor S-Layer 6)

By integrating the above mentioned seven layers in ROMSEN equation, under GIS Geo-Graph software, we obtained the information layer of the erosion risk - Layer 8 (Figure 7).

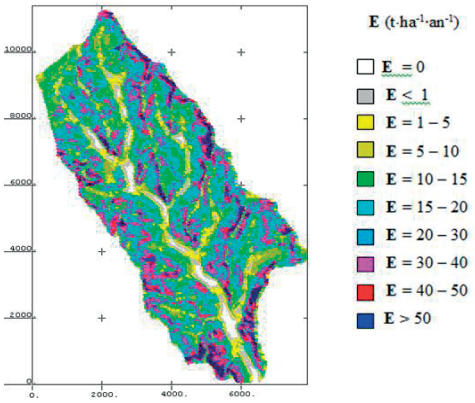

Figure 7. Soil loss due to water erosion in b.h. Antohesti (erosion risk - Layer 8)

For the WEPP model, the simulation results were compared with the data obtained by direct measurements made in the perimeters from hydrographic basin and the liquid and solid drainage was monitored.

About data assimilation we mention that all input data are examined in Table 1. For the WEPP model, we underline that 73% of their total are classified in the category of parameters obtained by direct measurements made in experimental fields. The remaining 16% were assimilated based on US data after the identification of some similarities with the climate and soils of Berheci (Table 1).

Table 1. WEPP input data and data assimilation

Crt. No.	Input data	Measured data	Assimilated	Total
1	Climate	19	1	20
2	Relief	5	0	5
3	Vegetation	13	8	21
4	Soil	14	4	18
5	Mechanical works	4	7	11
	Total	55 (73%)	20 (27%)	75 (100%)

In the future, it is estimated that the share of local data will increase considerably. This will be done in the following ways: by automatic equipment of monitoring climate parameters, equipment of analysis in the field and laboratory of physical-chemical features of the soil, introduction and generalization of the geographic informational system (GIS), access to profile database of Romania.

Talking about simulation results of the WEPP model, the studies related to liquid and solid drainage (with the help of researchers from at Perieni Station) are long term studies.

The drained water was measured by the volumetric method using settling tanks with flow meters of simple divisors type without lateral contraction. The quantity of eroded soil was estimated by measuring the average turbidity of the water from the collection basins. The parcels were planted with wheat, corn and the control sample was considered the strip maintained as permanent black fallow.

Table 2 shows the results of the statistical-mathematical processing of the value measured and simulated. The data analysis was made for each crop. The linear regression equations for the liquid and solid drainages measured on standard and simulated parcels with the WEPP program for 2015-2018.

Table 2. Statistical-mathematical processing of the value measured and simulated

Crop	Erosional drainage	No. of elements	Correlation coefficient R	Equation of linear regression
Fallow	Liquid	49	0,796	Y = -0,125 + 0,744 X
	Solid	49	0,741	Y = 0,213 + 0,881 X
Corn	Liquid	23	0,899	Y = 0,636 + 0,825 X
	Solid	23	0,857	Y = -0,074 +0,763 X
Wheat	Liquid	19	0,347	Y = -0,232 + 0,079 X
	Solid	19	0,712	Y = 0,003 + 0,192 X

a) Liquid drainage

For fallow parcels, 49 events were recorded regarding liquid drainage. The correlation coefficient R = 0.796 shows a good connection between the series of measured values and the simulated ones and the distribution of the point cloud, as Figure 8 shows, is relatively close. Compared to the ideal case when the simulated values would be similar with those measured and the graph points would be located on the diagonal passing through the origin (y = a+bx; a = 0, b = 1), the regression line equation (Y = -0.125+0.744X) has a slight oversize of the simulated values compared to the measured ones. For corn parcels, 23 calculation elements were recorded. The correlation coefficient R = 0.899 shows a good connection between the series of measured values and the simulated

ones and the regression equation Y = 0.636+825X a shows a slight undersize of the simulated values in the 0-5 l/m^2 interval and a small oversize in the 5-35 l/m^2 interval. The case is illustrated in Figure 9.

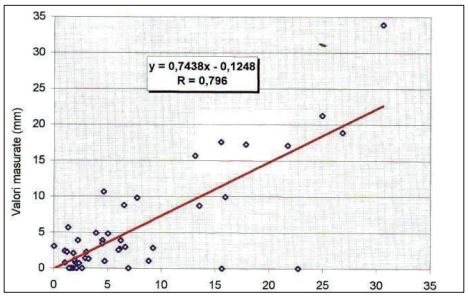

Figure 8. Liquid drainage at fallow

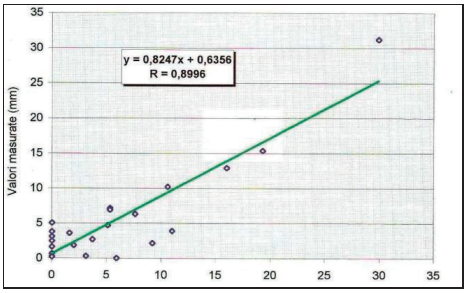

Figure 9. Liquid drainage at corn crop

b) Solid drainage

For the fallow, Figure 10 shows a more pronounced grouping of the cloud of points towards the origin of the coordinate system which indicates that, most of the times, the flows of solid drainage have small values. In more important rainfall events, the solid flows increase exponentially. The correlation coefficient (R = 0.741) a mirrors a connection between the measured and simulated values and for the 0-2 kg/m interval, the simulation results seem slightly oversized.

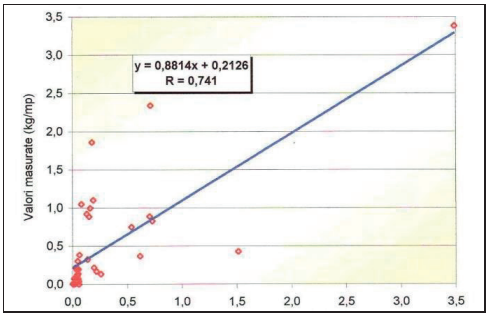

Figure 10. Solid drainage at fallow

For corn crop, most of the points plotted in Figure 11 are grouped on the 0-0.5 kg/m^2 interval and the correlation coefficient R = 0.857 shows a good connection.

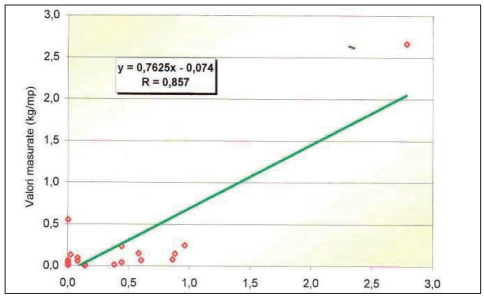

Figure 11. Solid drainage at corn crop

The analysis of this large data volume allowed some major improvements of the soil loss equation:

- Evaluation of the rain indicator of erosion in accordance with the local features of precipitations;
- Evaluation of the soil's erodibility factor;
- Evaluation of the effects of crops and anti-erosion works on the erosion;
- Evaluation of the effects of the interaction between the crop system, productivity level, soil mechanical works and the level of vegetal residues.

Modeling with WEEP showed the look of the maps similar to the result with Geo-Graph but obviously there is a different percentage, there are differences in the final maps (Figures 12, 13, 14).

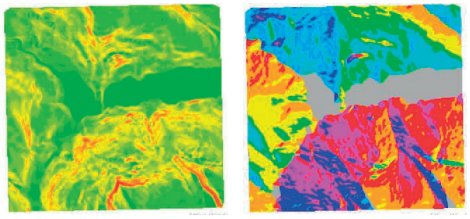

Figure 12. Slope map and aspect map

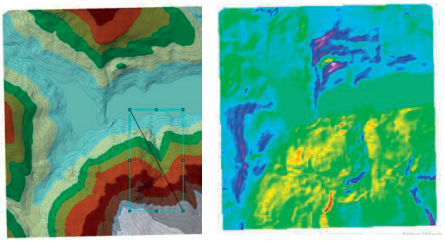

Figure 13. Hypsometric map and hills map

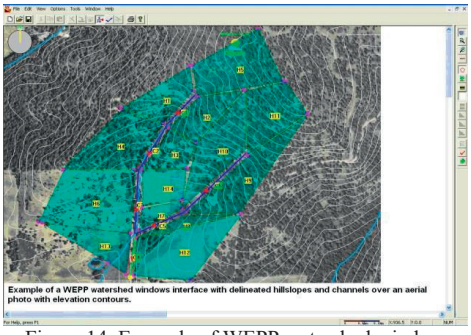

Figure 14. Example of WEPP watershed window

CONCLUSIONS

Compared to previous models, we are carrying out a statistical analysis on a limited number of data but WEPP is based on process analysis. The most significant advantage consists in the ability of temporal and spatial estimation of water and soil losses on the slopes used in agriculture. In other words, the model simulates in very much detail the entire chain of processes defining soil erosion and namely: dislocation, transportation and deposit of sediments.

An important advantage of the WEPP model is that the simulation results may be represented graphically and analytically. We may choose the graphic display of the evolution in time of parameters or the representation in cross-section of the areas with processes of sediment dislocation and deposit. Also, the data can be rendered synthetically under multiple forms of daily, monthly or annual reports.

The high complexity of the mathematical models in soil erosion at the same time represents a disadvantage due to the great number of parameters requested for input. This makes the data input procedure in a difficult activity and many times this is not easily accessible for less experienced users. In Romania, the chance of capitalizing the WEPP model or other similar models according with the projected performances is closely related by the use of GIS.

Testing the WEPP model for the natural conditions of Ghilavesti Inferior hydrographic basin rendered good and very good results. Therefore, the analysis of solid and liquid drainages for the 177 calculation elements recorded shows a close connection (R = 0.604) between the simulated and measured elements on experimental parcels. A slight oversize of the simulated values was observed.

With the help of this model, several long-term forecasts were made regarding the surface erosion and its influence on the soil productivity. The results of simulation were highlighted corresponding to the scenarios of a greater importance for agricultural practices in the conditions of Berheci catchment area.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

USE OF THE DRAINED LAND POTENTIAL IN UKRAINE

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Abstract

The distribution of the drained lands of Ukraine over the land used areas is investigated, among which the highest economic value is agricultural land. It was found that there are a number of local factors that impede the effective sustainable use of drained land. Among the main factors in the short-term are a short list of crops and non-specialized short crop rotations, and in the long-term - inappropriate use of drained land. The result of such decisions was the reduction of yield potential on drained lands for almost all major crops. In order to eliminate the socio-economic and environmental obstacles to the effective use of drained land for crop production, the following areas of land use in Ukraine have been substantiated: a) cultivation of agricultural crops, traditional for the area where drainage amelioration is conducted, in premise the flax; b) increasing the share of renewable energy sources in the energy balance at both regional and national levels in terms of biomass, bio fuels and waste.

Key words*: agricultural land, climate change, drained land, energy resources, sustainable development.*

INTRODUCTION

The Land Fund of Ukraine is one of the biggest in Europe; combined with favourable climatic conditions it provides a potentially high level of agricultural production. However, facing the global humankind problems, namely: climate change, land degradation, reduction of areas suitable for growing crops, while increasing the world's population, the task of the world community is to maximize the rational and effective use of its agricultural lands resource potential.

According to the Food and Agriculture Organization of the United Nations (FAO), agricultural production needs to be increased by at least 1.5 times in the coming decades to meet the food needs of the world's population. At the same time, FAO notes that irrational methods of using or agricultural soil cultivation can cause the release of soil carbon into the atmosphere in the form of carbon dioxide, which in turn can be a factor in climate change. For example, it has been found that changes in land use and organic soil drainage with purpose of land cultivation is the cause for about 10% of all greenhouse gas emissions (FAO, 2015).

On December 12, 2015, at the 21st session of the UN Climate Summit (COP21), it was agreed on a new climate framework document - the Paris Agreement, to the UN Framework Convention on Climate Change (UNFCCC). The agreement noted the need to stimulate the development of renewable energy sources (UNFCCC, 2015).

Ukraine, in line with its commitments under the Energy Community and in line with the Energy Strategy of Ukraine by 2035, should increase the share of renewable energy sources, including biomass, bio fuels and waste up to 11% (today, the share of such sources in the energy balance is about 2%). Agriculture has significant biomass potential as one of the most promising renewable energy sources.

MATERIALS AND METHODS

The research material is based domestic and foreign on scientific publications related to solving global problems of sustainable development, namely climate change, land degradation, reduction of areas suitable for cultivation of crops and tasks for maximum

rationalization and efficient use of the potential of land resources.

The statistical data bases of the study are the official materials and reports of FAO, the State Statistics Service of Ukraine and the State Service of Ukraine for Geodesy, Cartography and Cadastre.

RESULTS AND DISCUSSIONS

Agricultural land occupies 68.8% (41,511.7 thousand hectares) of the total area of Ukraine. The total area of drained land in Ukraine is 3.3 million hectares, or 5.5% of the total area of the country, where the main area of drained land is located in Polissya and in the western regions of Ukraine. Table 1 summarizes the distribution of Ukraine's drained land, where farmland is of the greatest economic value, of which the area of drained agricultural land was about 3 million hectares (2,954.8 thousand hectares) or 7.1% of the total area of agricultural land and 89.4% of all drained land.

Table 1. Distribution of the drained lands of Ukraine as on 01.01.2015

Kind of land	Area of drained land		
	thousand hectares	% to the total area of drained land	% to the total area of land in Ukraine
Agricultural soils, including:	2,994.5	90.6	*7.0*
Agricultural land, including:	*2,954.8*	*89.4*	*7.1*
tilled area	*1,851.1*	*56.0*	*5.7*
long-fallow land	*18.7*	*0.6*	*4.6*
perennial plantings	*9.8*	*0.3*	*1.1*
hay lands	*562.6*	*17.0*	*23.3*
Pastures	*512.6*	*15.5*	*9.3*
Lands under ameliorative improvement and fertility restoration	*0.7*	*0.0*	*1.3*
Other lands	*39.0*	*1.2*	*3.4*
Forests and other wooded areas	192.7	5.8	4.3
Building land	9.7	0.3	0.4
Other lands	110.0	3.3	10.6
Total area of drained land	**3,306.9**	**100.0**	**5.5**

Source: According to the data of the 6-зем form of the State Service of Ukraine for Geodesy, Cartography and Cadastre.

An analysis of the dynamics of agricultural production in the world shows that the greatest success has been achieved in those countries where large-scale national programs for the creation of irrigation and drainage systems have been implemented. According to Delian E., Chira A., Badea M. L., and Chira L. (2019) the future of conservation agriculture will be different, in different parts of Europe because of geographic, climatic, ecological, cultural, local traditions and policy impact, as well as the EU agenda (Delian, Chira, Badea & Chira, 2019).

Today, however, there are a number of factors in Ukraine that hold back the ecological, economic and social efficiency of agricultural use of drained land. Researchers note such causation, in particular:

- transition period of the country's economy;
- parcelled and fragmentation of land, in turn, the destruction of integral land melioration complexes and a decrease in the level of efficiency of functioning of domestic economic networks of hydrotechnical constructions;
- weakening of human resources in the area of land improvement, especially at the level of agricultural producers and land users, and
- insufficient funds from commodity producers for agrotechnical provision of crop production and proper maintenance of melioration systems.

The factors that impede the ecological, economic and social efficiency of agricultural use of drained lands can be seen in the fragment of the land use plan in the territory of the Zabolotskaya village council of the Volodymyretsky district of Rivne region of Ukraine (Figures 1 and 2), where part of the Zabolotivskaya drainage system was constructed in 1963-1967. From the Figure 2 you can see that the majority (almost 80%) of the drained land is owned by the citizens-land parcels owners and the peasant farms which are cultivated independently.

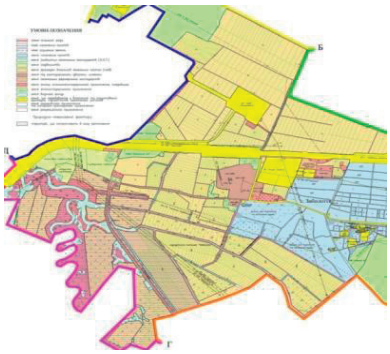

Figure 1. Fragment of the land use plan in the territory of Zabolotskaya village council of Vladimir district of Rivne region, Ukraine (Archive of Zabolotsk village council of Vladimir district of Rivne region)

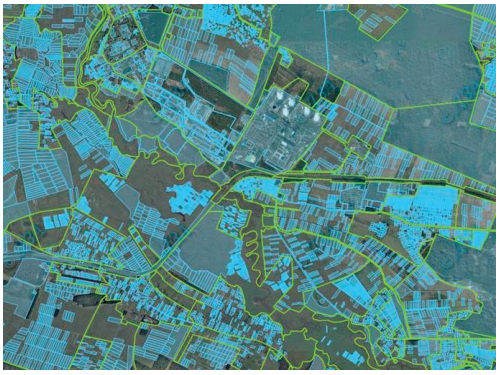

Figure 2. Extract from the Public cadastral map of the territory of the Zabolotsk village council of the Vladimir district of Rivne region (A fragment taken from the Public cadastral map of the State Service of Ukraine for Geodesy, Cartography and Cadastre)

It is well-known that the most important feature of the quality of agricultural land is the fertility of soils, and the main task of land amelioration systems is to ensure maximum yields, while maintaining high soil fertility.

However, in the process of land reform in Ukraine, most of the drained land was converted into individual use by citizens. As a result, the efficiency of the use of these lands has decreased, as the organization of small land areas causes a decrease in crop production and the transition to non-specialized short-rotation crop rotations, and subsequently - to land misuse. In addition, the current market conditions lead to the cultivation of foremost, energy crops, which often lead to neglect of crop rotations, especially in case of growing sunflower.

According to the official statistics of the State Statistics Service of Ukraine, the yield on the drained lands of almost all major crops is not much higher than the yield of crops in Ukraine in general, and in some cases - generally lower (Table 2).

Thus, the functioning of agricultural enterprises with small land areas lead to a mass disturbance of crop rotation, which is one of the reasons for the decrease in soil fertility, as well as the cultivation of monocultures, saturation of crop rotation with energy-intensive crops, which lead to depletion of soil and deterioration of its physical properties and other negative consequences.

Accordingly, we propose to consider priority areas for the use of drained lands in Ukraine.

The proposed directions are considered in the context of Ukraine's compliance with international obligations under the provisions of the Paris Agreement within the UNFCCC on the regulation of measures to reduce carbon dioxide emissions from 2020, as well as increasing the share of renewable energy in the energy balance up 11% by 2035.

Table 2. Yields of basic crops in agricultural enterprises by years, centner per hectare

Main crops	Years					
	2004	2006	2008	2010	2012	2014
On drained lands						
Cereals and legumes, including:	24.1	19.5	24.0	27.4	43.0	56.2
wheat	28.9	21.8	24.5	25.2	36.4	46.4
rye	19.0	11.6	12.5	12.5	18.1	20.7
barley	23.4	19.0	20.9	20.5	31.9	44.8
Sugar beet (factory)	254.7	300.8	384.2	299.2	411.5	470.7
Sunflower	8.7	11.6	15.6	14.6	17.6	22.2
in Ukraine						
Cereals and legumes, including:	28.3	24.1	34.6	26.9	31.2	43.7
wheat	31.7	25.3	36.7	26.8	28.0	40.1
rye	22.2	16.2	22.9	16.7	22.7	25.8
barley	24.6	21.7	30.3	19.7	21.1	30.1
Sugar beet (factory)	238.3	284.7	356.2	279.5	410.8	476.5
Sunflower	8.9	13.6	15.3	15.0	16.5	19.4

Source: According to the State Statistics Service of Ukraine.

Directions for the use of drained lands in Ukraine:

1. Growing and processing traditional crops for the drainage zone.
2. Improving energy efficiency at both regional and national levels in terms of increasing the share of renewable energy in the energy balance.

Given the large areas of drained land, Ukraine has the potential to expand the production of traditional best crops, in particular flax, because the climatic conditions are favourable for this.

The creation of flax plantations on drained lands is fully consistent with the development trends of the domestic economy and the growth of global demand for flax production.

Flax is one of the common multifunctional industrial crops, the popularity of which has increased significantly in recent years around the world.

This is evidenced by the significant increase in acreage under flax in many countries of the world and the constant expansion of the range

and increase in production of various kinds of environmentally friendly household and technical goods.

According to FAO estimates, in 2013, the total area of flax plantations in the world was 2.3 million hectares (Table 3) (SaskFlax, 2015).

Table 3. Characteristics of World Flax Production (fragment) (SaskFlax, 2015)

Country	Crop area, ha		Yield, t/ha		Volume of production, t	
	2013	average over 2009-2013	2013	average over 2009-2013	2013	average over 2009-2013
Canada	412,000	404,360	1.73	1.42	712,000	584,480
Russia	410,000	238,940	0.79	1.29	325,756	289,370
Kazakhstan	384,300	269,440	0.77	0.66	295,020	173,648
India	338,000	371,542	0.43	0.42	147,000	153,780
China	330,000	332,686	1.00	1.03	330,000	341,918
Ethiopia	105,722	112,927	0.99	0.97	104,948	111,165
USA	56,960	111,836	1.50	1.29	85,242	144,214
Ukraine	38,000	50,560	0.66	0.79	25,000	40,240
UK	34,000	34,000	1.50	1.71	51,000	58,000
Belarus	29,024	41,906	0.24	0.24	7,005	9,849
Total	2,270.353	2,150.745	0.99	0.97	2,238.938	2,087.600

As can be seen from the analysis of the table data, in terms of flax sowing areas, Ukraine lags significantly behind many economically developed countries of Europe. 80% of global flax fibre production comes from Europe (Figure 3).

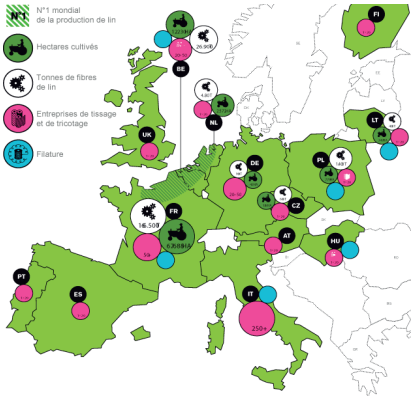

Figure 3. EU flax growing (CELC, 2015)

EU producers consider waste less at all stages of flax fibre production to be the main incentive in growing flax. Flax growing as an actively developing EU agro-industry contributes to economic and social development in rural areas, preventing labour migration. Flax growing and processing requires considerable amount labour and skilled labourers, thus providing a high level of employment in rural areas (five times higher than for growing cereals) (CELC, 2015).

Since 2000, the EU Council has decided to provide the financial support to flax growers through the support system for producers of certain agricultural crops.

The unique biochemical composition of flax seeds makes it a valuable raw material for the creation of functional foods and dietary supplements. In addition, in our opinion, flax cultivation is particularly relevant in the context of increasing the share of renewable energy sources in the energy balance in Ukraine.

The Energy Strategy of Ukraine for the Period up to 2035 "Security, Energy Efficiency, Competitiveness" defines the forecast structure of the total primary energy supply (TPES) (Table 4) (Cabinet of Ministers of Ukraine, 2017).

Table 4. Estimated structure of total primary energy supply (TPES) (million tons of oil equivalent) (fragment) (Cabinet of Ministers of Ukraine, 2017)

Source of primary energy supply	2010	2015	Forecast			
			2020	2025	2030	2035
Biomass, biofuels and waste	1.5	2.1	4.0	6.0	8.0	11.0
Solar and wind energy	0	0.1	1.0	2.0	5.0	10.0
Hydro energy	1.1	0.5	1.0	1.0	1.0	1.0
Thermal energy	-	0.5	0.5	1.0	1.5	2.0
Share of renewable resources	-	4.0	8.0	12.0	17.0	25.0

There is sufficient biomass available for energy production in Ukraine to meet this target - more than 27 million t/year is estimated: the primary components of the potential are primary agricultural waste (straw, corn and sunflower) and energy crops, cultivation of them on an industrial scale has been actively developing in the country in recent years (Geletukha, Zheliezna, Kramar & Kucheruk, 2015).

At present, only about 10% of the total biomass potential is used for energy needs in Ukraine - 2.7 million t/year. It is mainly wood biomass in the form of firewood, wood chips, pellets / briquettes (generally 86% of the total annual use of biomass), and sunflower hulls (8%). The least actively used is the plants waste - 94 thousand tonnes of straw per year, which is less than 1% of the economic potential of straw in Ukraine (Geletukha, Zheliezna, Kramar & Kucheruk, 2015).

Given the above, it can be argued that the demand for bio fuels will grow. This, in turn, indicates a high potential for growing agricultural crops on drained land with the aim, in addition to ensuring food security, also meeting the demand for bio fuels from agricultural waste and growing on plantations the energy crops, in particular, growing flax.

Mechanisms for stimulating the development of the renewable energy sector, the use of renewable energy sources and alternative fuels in Ukraine include such instruments (Cabinet of Ministers of Ukraine, 2014):

- reduction of land tax for renewable energy companies;
- tax reduction for farmers, households, etc. who are engaged in growing flax;
- tax exemption:
  - profits from the core business of energy companies producing electricity from renewable sources;
  - profits of bio fuel producers from the sale of bio fuels;
  - profits of enterprises obtained from activities for the simultaneous production of electric and thermal energy and / or production of thermal energy using biological fuels;
  - profits of manufacturers of machinery and equipment for the manufacture and reconstruction of machinery and vehicles consuming biological fuels.
- exemption from value added tax on operations involving the import into the customs territory of Ukraine of equipment that operates on renewable energy sources, equipment and materials for the production of alternative fuels or for the production of energy from renewable energy sources, as well as exemption from import duties on mentioned equipment and materials;
- the Law of Ukraine “On the Electric Energy Market” dated 04.13.2017 No. 2019-VIII provides for the stimulation of the production of electric energy from alternative energy sources by establishing a “green” tariff for electric energy produced from alternative energy sources, as well as a differentiated premium to the “green” tariff for the use of Ukrainian-made equipment at a level of 30% or more, but less than 50%, or 50% or more.

CONCLUSIONS

Ukraine has significant potential for increasing flax production on drained lands, in addition to the fact that flax production on drained lands creates a range of benefits. In particular, drained lands will be involved in circulation, in particular parcels that are not used today and abandoned, or are occupied with other crops that have worse agri-biological and technical and economic characteristics.

Recommendations on the minimum sown area of flax for one farm is at least 50 ha, which is economically feasible and allows more efficient use of harvesting and other special equipment (Goloborodko, Loginov & Sitnik, 2006), determines the creation of small farms, households specializing in the cultivation of this particular crop.

The high profitability of flax production increases the investment attractiveness of the rural region. The development of flax growing on the drained lands will also stimulate the employment rate of the rural population.

Summarizing, it should be noted that in the context of the formation of financial and investment prerequisites for increasing the level of socio-economic development of the drainage melioration zone, the question arises of choosing the optimal managerial decision on the use of each individual land plot. We believe

that such a tool as comparing the costs and benefits of land use alternatives will make it possible to adopt and implement the best management decisions available:

- to restore the traditional specialization of the administrative areas of the drainage zone;
- to grow bio energy crops to enhance Ukraine's energy efficiency potential;
- to conduct or institutionalize the re-naturalization of drained lands.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

RECOVERY OF LOSSES FOR INAPPROPRIATE USE OF LAND

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Abstract

The article justifies theoretically-methodological principles of economic mechanism to ensure environmental security of land-use, based on use of economic methods and levers and their interaction with the legal framework. The aim of the paper is a clear definition of damage, caused to the state due to non-compliance of norms of sustainable land management. The main tasks are to develop economic instruments of determination of sanctions for violation of norms of sustainable land management. The State and the territorial communities are losing considerable resources from non-payment of land fees at various levels, through unauthorized and misappropriation of land, degradation of the quality of the fertile soil, etc. Inappropriate use of land plot violates the principle of the targeted use of land and causes losses, which are defined as, firstly, the loss of income that a person might have earned from the use of the land and, secondly, the improper generation of additional income from unauthorized actual use of the land; that doesn't meet its target. Compensation for damages caused by a violation of the land law does not relieve the offender(s) of the need to compensate real damages, i.e., to carry out, at his own expense, measures to eliminate the consequences of the violations in the shortest period of time, Including demolition of buildings, houses and structures, as well as site restoration. Such principles of land law should be taken into account when justifying the harm caused by the diversion of land, as priority of agricultural land use; purpose-oriented land use; stability of land use; principle of rational land use. The basis for determining the amount of damage caused by the inappropriate use of land is the sum of relevant loss of the normative average annual income from the targeted use of land and the excess annual average income from actual functional use of land, which does not meet its target.

Key words*: environmental security, economic mechanism, economic methods, purpose of land-use, state control.*

INTRODUCTION

Current state and use of land comes to be the root cause of many negative phenomena of both ecological and economic nature.

As a result of these offences the state and territorial communities lose significant funding because of lack in budget of different levels of payment for land as a consequence of its unauthorized misuse, degradation of fertile layer of soil.

In particular, resolution of Cabinet of Ministers of Ukraine from July, 25 2007 № 963 "Determination of loss amount, caused by unauthorized occupation of a land plot, inappropriate use of land plots, removal of the ground cover(fertile layer) without special permit" methodology approved.

This Methodology aimed at determining the extent of damage, caused to the state, territorial communities, legal and natural persons, on all categories of land in a consequence of unauthorized occupation of land plot, inappropriate use of land plot removal of the ground cover (fertile layer) without special permit.

The loss amount is determined apart in each offence.

The aim of the paper is clear definition of damage, caused to the state due to non-compliance of norms of sustainable land management.

The main tasks are to develop economic instruments of determination of sanctions for violation of norms of sustainable land management.

MATERIALS AND METHODS

The important task in the process of state control of land use and protection is a clear definition of damage, caused to the state as a consequence of:

- failure to comply with the conditions of removal, saving and coating a fertile layer of ground;
- failure to comply or poor-quality compliance of compulsory event, that approved by project documents in accordance with the law for removal, saving and coating of fertile layer of ground, that caused it's damage or destroying;
- non-use of land plot or its actual use, that does not respond its purpose, established for transfer of land to ownership or land allotment, or rent, and failure to comply with regime for the use of land plot or it's part in case of restrictions (enhancement) (Martyn, 2007; Martyn, 2008);
- unauthorized occupation of a land plot by a guilty person and it's use without legal basis, that is without established right to property or another right to land under current law, for example, lease for a land.

Sometimes unauthorized occupation of land is supposed to be its owning for violation of established land allotment, without land allotment in nature (in a location) and without obtaining a document certifying the right to private ownership of land - excerpt from the State Register of Real Property Rights.

Unauthorized occupation of land plots, inappropriate use of land plots, and removal of ground (fertile layer) without a special permit are considered to be offences, which damage to legal landowners, territorial communities and the state.

Thus, owing to unauthorized occupation of land plots their owners or users lose legal right to use the land plot to manufacture certain products or receiving certain economic benefits. An intruder of the land law, that committed unauthorized occupation of a land plot, in turn, illegally profits from use of its useful profits.

Therefore, a landowner of a land plot or land user, according to the civil law, should obtain compensation of lost profit - profit, which could be received from that land plot under normal conditions, but it should be understood, that this compensation must not be less, than profit, received by the intruder.

It means, that in fact the following must be compensated: a) losses caused by not using the land for the intended purpose; b) additional income, which was received illegally as a result of land plot use not according to the stated purpose, in comparison with the one, that is typical for targeted use of land.

The right to compensation of losses, caused by unauthorized occupation of land, belongs to persons, whose right to use land has been violated – landowners and land users. State and territorial communities become the subjects of law in case of unauthorized occupation of land, that is state and communal property (The Code of Administrative Offences of Ukraine, 1984). When land is not used for the intended purpose, and removal of ground (fertile layer of ground) without special permit, that was complied with land users (including persons, who committed illegal seizure of land plot), relevant losses should be compensated to the state and local councils, which, in accordance with the law, dispose of land on behalf of the Ukrainian people and territorial communities.

It should be noted, that the described kinds of damage, owing to unauthorized occupation of land plots, inappropriate use of land plots, and removal of ground (fertile layer of ground) without special permit do not include the costs for converting land plots to suitable state for the intended use, because such costs are specific for each particular offence and their cost cannot be rationed.

State regulation of land management is a system of measurements, established to ensure the rational and efficient use of land, it's protection, recreating and increasing of soil fertility, preserving and establishment of a favourable environment, right to protection of property rights, ownership and use of land, ownership and use of land through the implementation of a set of organizational, legal, economic actions.

The right for a land plot, under article 111 Land Code of Ukraine, may be restricted by law or agreement by setting (Land Code of Ukraine, 2002):

1) Prohibition on the sale or other seizure by certain persons within a specified period of time;
2) Prohibition on leasing (subleasing);
3) Right to an overwhelming purchase if it's sold;
4) Condition of inheritance, determined by a beneficiary only;
5) Condition to start and finish development of land plot within specified period of time;
6) Prohibition on certain activities;
7) Prohibition on a change of targeted use of land, landscape and exterior of real estate;
8) Condition to implement construction, repair or maintenance of a road or a section of a road;
9) Condition for compliance of environmental requirements or performance of certain work;
10) Condition to give a right for hunting, fishing, gathering of wild plants on one's own land plot within prescribed time and in accordance with the established procedure;
11) Other duties, restrictions or conditions.

Consequently, the restrictions for land use, that were defined by law can be clearly divided into the ones, that concern land management as real estate and the ones, that determine a special regime for land plot use or it's part as a valuable nature object, or location of a building, which demand a special attitude.

Deep ground degradation was caused by regional approach to land use, lack of awareness in its global framing and social role, deficiency of state policy about land protection (Leonets, 2001).

In exercising legal protection of land, the State has four main functions: regulatory, promotional, monitoring and punitive functions.

The regulatory function of legal protection of land is to establish rules for the management of land resources.

The promotional function of legal protection of land is to provide economic incentives for rational land management and protection.

The control function of the legal protection of land is the exercise by the relevant State and local government bodies of State control over the use and protection of land (Dyptan, 2009; Dyptan, 2008).

The punitive function of legal protection of land is in the imposition of sanctions for infringement of the rules of rational use and protection of land and their attachment to violators of land legislation.

The system of economic regulators of land relations under condition of transition to a market economy includes: land tax; rental charge for land; land market price; bond land price; compensation payments for land seizure; compensation payments while land conservation; payment for improved land quality; penalties for environmental damage; civil land taxation; payment for the right to lease etc. (Budziak, 2008; Dobriak and Babmindra, 2006).

Economic mechanism of regulation of land relations should respond the following demands: ensuring equal start for the reproductive process for all land subjects; use of land rents as a basis for the formation of a system of economic regulators, interaction of rent regulators with other economic instruments (prices, interest charge, income tax etc.); taking into account the interests and equal rights of different social groups for the realization of land ownership rights and different forms of land use; promotion of rational location and specialization of agricultural manufacture; strengthening environmental protection of land (Budziak, 2008; Dobriak and Babmindra, 2006).

It should be also noted, that on the basis of indicators of normative land valuation it is possible to determine rented income from a land parcel for a specific purpose, rather than income at all (Dobriak and Vitvytska, 2009). Rate of return should be used to move from rented income to total income, in particular – Assumption that the cost of generating a certain income (economic benefit) is offset by that income with a certain excess, which is the rent. It means, that according to a coefficient of rate of return (ratio of income to costs) where 1.35, which is used for standard costing, total income from land can be determined by formula (1):

$$I = R/1.35 \quad (1)$$

where:
I - total income from used land, UAH/ha;
R - rental from used land, UAH/ha.

Excess average annual income from actual land use, which does not respond their purpose, describes excess average annual income as a consequence of actual functional use of land over the ones, which respond their purpose.

Functional use of land plots are specifications of environmental and socio-economic functions of land plots according to their purpose, that are determined by certain part of landholdings and kinds of economic activities, according to the data of the quantitative land register in the State land cadastre under the Order of the State Statistical Committee of Ukraine of№ 377 "Approval of forms for State statistical reporting from land resources and instructions for the completion of State statistical reporting on land accounting (forms №№ 6-land, 6a-land, 6б-land, 2-land)" (registered in Ministry of Justice of Ukraine 14.12.1998 № 788/3228) (Official Gazette of Ukraine, 2002).

RESULTS AND DISCUSSIONS

Actual functional use of land plots for the purpose of unambiguous diagnosis while verifying compliance with the requirements of law should be carried out in such directions:

1) Agricultural production (planting of crops, including perennial grasses and pure fallow lands, greenhouses and perennial plantings);
2) Current construction work, exploration, prospecting and other activities;
3) Constructing of industrial facilities, roads;
4) Development of residential buildings, boarding houses, commercial and trade objects, sports facilities, camping, camp sites, guesthouses, rest houses, garden and country houses with economic buildings and yards;
5) Open mines, quarries, mines and related facilities;
6) Landfill sites of all kinds.

The noted directions of functional use of land plots or their parts can be clearly qualified by state control inspector after use and protection of land in nature (in a location), it is also possible to determine their consistency with the intended purpose of land, established on the basis of relevant decisions of State and local government bodies .

Calculation of the excess annual average income resulting from the actual functional use of land that does not meet its intended purpose is considered to be the difference between the average annual income from actual functional use of land and normative annual average income from land use of this category on the main purpose.

Actual calculation is based on formula 2:

$$EAInt = NAInt - NAIt \quad (2)$$

where:

EAInt - excessive average annual income resulting from the actual functional use of land from non-targeted use of land, UAH/ha;

NAInt - normative average annual income from actual functional use of land plots, which fit targeted use, UAH/ha;

NAIt - normative average annual income from targeted use of land, UAH/ha.

The methodological problem of such approach is calculating of excess average annual income as a result of actual use of land plots for agricultural needs, as calculating of average annual income from their use is less, than normative average annual income from all other categories of land, and excess normative income, respectively, should have negative value. It is obvious, that in this case, the technique used in the current regulatory framework should be applied, which is used in the current normative basis, in particular, for evaluating of forested land in steppe area, where the responding rent has negative value, and the income is equal to a known rate – cost for cultivation of forest. It means, that in our case it may be considered possible to equalize excess average annual income to known rate - normative average annual income (Ievsiukov and Openko, 2014; Martynet et al., 2019).

Estimated average annual income from land development by industry, roads is accepted as equal to normative average annual income from industrial land, transport, communication, power industry, defence and other purposes.

Estimated average annual income for other categories of land is taken with the application of a procedure coefficient of normative monetary evaluation of non-agricultural land (except land in built-up areas), that was approved by State Geocadaster (State Land Committee of Ukraine), Ministry of Agrarian Policy and Food of Ukraine, Ministry of

Construction, architecture and housing and communal services of Ukraine, State Forest Resources Agency of Ukraine, State Agency of Water Resources of Ukraine, National Academy of Agrarian Sciences of Ukraine of 27.01.2006 № 19/16/22/11/17/12, such as:

- commercial and another highly profitable use - 2.5;
- current constructing, minerals research – 0.5;
- open development, carriers, mines and related buildings - 1.2;
- landfills and waste dumps - 0.65.

Excessive income as a result of actual functional use of land appointed for industry, transport, communication, power industry, defence and others for unauthorized building development of industries, taken for the used approach, must be zero, it is appropriate to adopt half of the normative average annual income in this category.

In determining the extra-normative income, regional differences should also be taken into account in its formation, since the above figures are averages for Ukraine, and in certain regions there may be significant differences in the persistence of the land, compared to the national average.

Such differences must be taken into account according to the relevant coefficient (Table 1).

According to Land Code of Ukraine (2002) such territories with special regime are allocated:

- protective zones around valuable natural sites;
- protective zones around objects of cultural heritage;
- protective zones around hydro meteorological stations;
- special valuable agricultural land;
- around sanitary (mountain-sanitary) protection, on territories of areas of health resorts and spas;
- coastal protection strips along rivers, around reservoirs and on islands;
- coastal protection strips along seas, bays and lakes, estuaries and other reservoirs, and on islands in inland waters;
- water protection zones along seas, around lakes, reservoirs and other bodies of water ;
- protection zones of surface, above-ground and underground pipelines;
- protective zones along air and underground cable lines, which pass outside built-up areas, as well as around broadcasting facilities and radio relay lines;
- protective zone along air and underground cable of power lines;
- defensive, protective and other zones with special conditions use around military and other defensive objects;
- exclusion and unconditional (compulsory) removal zones, which have been exposed to radioactive contamination as a result of the Chernobyl disaster;
- a sanitary protection zone around facilities with underground and open water supply sources, water and wastewater treatment plants, water and sanitation facilities;
- sanitary protection zones around objects which are sources of harmful substances, odors, elevated noise levels, vibrations, ultrasonic and electromagnetic waves, electronic fields, ionizing radiation etc.;
- frontier line along the State border of Ukraine;
- territories without particular use of land.

The main aim of setting up such territories is protection and defence of valuable natural and other objects from adverse, anthropogenic influence or opposite - protection of land from objects, causing adverse effect on the environment (Table 1).

For the coefficient, that takes account of the restrictions (encumbrances), which determine the particular use of the land (Co), it is appropriate to base an expert assessment of the severity of the damage, caused by inappropriate use of land (Table. 2).

Table 1. Calculation of coefficients that take into account regional differences in the generation of excess annual average income resulting from the actual functional use of land that does not meet its intended purpose

№	Administrative-territorial entities	Index area of land (except housing and public land), thousand ha	Approximate normative average annual income (excluding housing and public land), thousand UAH	Approximate normative average annual income (excluding housing and public land), UAH/ha	Ratio of the estimated normative average annual income by oblast to the average for Ukraine
1	Autonomous Republic of Crimea	2541.8	6905972.9	2716.96	1.26
2	Vinnytska	2556.9	4990765.4	1951.89	0.90
3	Volynska	2016.7	4971674.9	2465.25	1.14
4	Dnipropetrovska	3067.2	6839934.5	2230.03	1.03
5	Donetska	2521.2	6905579.8	2739.00	1.27
6	Zhytomyrska	2891.6	6296532.0	2177.53	1.01
7	Zakarpatska	1374.9	3389939.8	2465.59	1.14
8	Zaporizka	2687.2	5407956.9	2012.49	0.93
9	Ivano-Frankivska	1587.2	4403686.3	2774.50	1.28
10	Kyivska	2705.1	5932685.1	2193.15	1.01
11	Kirovohradska	2396.1	4648680.8	1940.10	0.90
12	Luhanska	2454.7	5438944.4	2215.73	1.02
13	Lvivska	2199.6	4874531.5	2216.10	1.02
14	Mykolayivska	2390.8	4399580.8	1840.21	0.85
15	Odeska	3249.1	6381475.0	1964.08	0.91
16	Poltavska	2825.0	5942269.5	2103.46	0.97
17	Rivnenska	2019.4	4400116.3	2178.93	1.01
18	Sumska	2418.6	4402692.6	1820.35	0.84
19	Ternopilska	1437.7	2849319.5	1981.86	0.92
20	Kharkivska	3059.4	6269290.0	2049.19	0.95
21	Khersonska	2805.2	5401843.9	1925.65	0.89
22	Khmelnytska	2273.7	3935535.0	1730.90	0.80
23	Cherkaska	2028.4	4395002.9	2166.74	1.00
24	Chernivetska	837.7	1386442.5	1655.06	0.76
25	Chernihivska	3224.8	6052724.0	1876.93	0.87
26	Kyiv	94.6	1637047.1	17304.94	7.99
27	Sevastopil	107.8	935052.5	8673.96	4.01
Total (average)		59772.4	129395275.5	2164.80	1.00

Source: own calculations.

Table 2. The coefficient, that considers the limitations (strains), which define a special regime of land use

Territories with special regime of land use	The severity of harm, caused by inappropriate use of land	Expert value of coefficients that take account of restrictions (encumbrances) that determine the particular use of the land (Co)
Sanitary protection zone around facilities with underground and open water supply sources, water and wastewater treatment plants, water and sanitation facilities	Extreme damage: there is a risk of deterioration of drinking water sources, irreversible loss of water facilities	6
Coastal protection strips along seas, bays and estuaries and islands in inland waters		5
Coastal protection strips along rivers, around reservoirs and on islands		4.5
Protection zone around objects of cultural heritage	Substantial harm: a risk to	4

Around sanitary (mountain-sanitary) protection, on territories of areas of health resorts and spas	lose valuable natural objects , endangering the country's sovereignty	4
Protection zone around valuable nature objects		3.5
Frontier line along the State border of Ukraine		3
Especially valuable agricultural land	Moderate harm: there is a risk of loss of particularly productive soils, accidents, disruption of the State observation system and radiation safety	2.5
Protection zones of surface, above-ground and underground pipelines		2.5
Protective zones around hydro meteorological stations		2
Exclusion and unconditional (compulsory) removal zones, which have been exposed to radioactive contamination as a result of the Chernobyl disaster		2
Water protection zones along seas, around lakes, reservoirs and other bodies of water	Low damage: there is a risk of deterioration of water bodies, deterioration of health of people who are regularly on land plots, tasks of harm to national security	1.5
Protective zones along air and underground cable lines, which pass outside built-up areas, as well as around broadcasting facilities and radio relay lines		1.5
Protective zone along air and underground cable of power lines		1.5
Defensive, protective and other zones with special conditions use around military and other defensive objects		1.5
Sanitary protection zones around objects which are sources of harmful substances, odors, elevated noise levels, vibrations, ultrasonic and electromagnetic waves, electronic fields, ionizing radiation, etc.		1.5
Territories without particular use of land	No particular damage	1

Source: own suggestions.

Thus, extent of the damage, caused by inappropriate use of land plot, is determined by formula (3), (Openko et al., 2019; Openko et al., 2020):

$$DIU = Siu \times 0.33 \times (NAIAU + EAIAU \times Kr) \times Krp \times Ki \quad (3)$$

where:
DIU - damage extent, caused by inappropriate use of land plot, UAH;
Siu - area, where land plot was identified to be used inappropriately, ha;
0.33 - coefficient, which takes into account the part of the normative average annual income that is redistributed through the State and local budgets.
NAIAU - normative average annual income from appropriate use of land, UAH/ha;
EAIAU - excessive average annual income due to the actual functional use of land that does not meet its intended purpose, UAH/ha;
Kr - coefficient that takes into account regional differences in the generation of excess average annual income resulting from the actual functional use of land that does not meet its intended purpose;
Krp - coefficient that takes into account restrictions (encumbrances), that determine the particular use of the land;
Ki - indexation factor of the normative monetary valuation of land.

CONCLUSIONS

As a result of these offences, the State and the territorial communities are losing considerable resources from non-payment of land fees at various levels, through unauthorized and misappropriation of land, degradation of the quality of the fertile soil, etc. Inappropriate use of land plot violates the principle of the targeted use of land and causes losses, which are defined as, firstly, the loss of income that a person might have earned from the use of the land and, secondly, the improper generation of additional income from unauthorized actual use of the land; that doesn't meet its target.
Citizens and legal entities are subject to civil, administrative or criminal liability in accordance with the law for failure to comply with the requirements concerning the targeted use of land. Under article 56 of the Law of Ukraine "On the Protection of Land", damage

caused by a violation of the legislation of Ukraine on the protection of land is subject to full reparation.

Compensation for damages caused by a violation of the land law does not relieve the offender(s) of the need to compensate real damages, i.e., to carry out, at his own expense, measures to eliminate the consequences of the violations in the shortest period of time, Including demolition of buildings, houses and structures, as well as site restoration.

Such principles of land law should be taken into account when justifying the harm caused by the diversion of land, as priority of agricultural land use; purpose-oriented land use; stability of land use; principle of rational land use.

The basis for determining the amount of damage caused by the inappropriate use of land is the sum of relevant loss of the normative average annual income from the targeted use of land and the excess annual average income from actual functional use of land, which does not meet its target.

ACKNOWLEDGMENTS

This paper was supported by the project "The Newest Concept of Creating a Digital Atlas of Land Value in Ukraine - An Instrument for Regulation of Market Land Relations and Spatial Development" funded from the Ministry of Education and Science of Ukraine 2018-2020, State registration code and number 00493706 No. 0118U000291.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

BIODEGRADATION OF BLACK AND REMAZOL RED TEXTILE DYES BY BACTERIAL STRAINS ISOLATED FROM RIVER CONTAMINATED TEXTILE DYES EFFLUENT

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Abstract

Research on biodegradation of black and red Remazol dyes in textile wastewater containing black and red Remazol dyes in concentrations of 500 ppm, 1000 ppm and 1500 ppm was carried out for 14 days in singly and consortium. Strains isolated from effluent containing Remazol black and red dyes. Selected isolates were identified using the API test and known as Bacillus subtilis, Bacillus licheniformis, Bacillus coagulans, and Bacillus cereus. Biodegradation in a consortium can reduce respectively; decolorization reached were 64.18%, 60.11% and 54.27% in Remazol black, and reached 65.46%, 62.92% and 55.90% in Remazol red. COD 77.63-72.92%, BOD 77.31-75.46%, TSS 67,68-52.72%, ammonia 62.85-53.69%. Biodegradation of textile wastewater containing red Remazol decreased respectively, COD 78.6-72.8%, BOD of 78.07-76.33%, TSS 70.14-58.72%, and ammonia 68.51-55.47%. Biodegradation of red Remazol textile dyes results in a greater reduction in concentration than in black Remazol. Also, biodegradation in a consortium results in a greater decrease in dye concentration than singly.

Key words*: biodegradation, consortium, decolorization, textile dyes, wastewater.*

INTRODUCTION

The textile factory produces dominant liquid waste containing dyes caused by the dyeing process to increase the commercial value of the fabric. Textile waste water, in general, has a very high concentration of organic matter such as protein, lipids, and cellulose so that COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand) become high. Decreased river water quality occurs because the waste that enters the body of water contains various organic materials, heavy metals, fats, and minerals.

Textile waste treatment needs to be done to minimize pollution by wastewater by providing effective and efficient wastewater treatment technologies that are environmentally friendly. The processing of liquid waste is carried out biologically, which is expected to reduce the cost of treatment, and the results of waste biodegradation become safer (Srinivasan et al., 2014). Indonesia is a country that has the potential for creative industries, namely the batik industry, which is also found in all regions and it is part of economic activities that can improve the welfare of the community. In Indonesia, pollution of water bodies such as rivers is caused by textile effluent and the textile home industry were discharged into water bodies without being treated.

The batik industry effluent has large volume, concentrated colour, pungent odour and temperature, acidity (pH), and high in some parameter such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS).

Dyeing effluents have become a vital source of water pollution. Due to the xenobiotic properties and toxicity to all life forms including humans, removal of undesirable colour and associated toxicity is crucial (Yaseen and Scholz, 2018).

Various pollutants contained in textile wastes mainly are recalcitrant organics, colours, toxicants, and surfactants, chlorinated compounds, pH, and salts. Especially azo dyes (N = N group), which is a large group of synthetic dyes with a variety of colour and structure. Azo dyes are estimated to be around 60-70% of all dyes used in food and textile manufactures, and nearly 2-50% of these dyes

are lost and enter waste discharges (Uday et al., 2016). Remazol black has a diazo structure and Remazol red has a mono azo structure were reactive azo dyes (Benkhaya Rabet and El Harfi, 2020). The characteristic chemical structure (such as ─C═C─, ─N═N─ and ─C≡N─) of azo dyes makes them recalcitrant to biological break down (Singh and Singh, 2015).

The batik industry uses a lot of Remazol dyes because it is faster in the process and more economical than dyes naphthol or indigo sol in batik colouring, Remazol dyes are used, because Remazol dyes are faster in processing and are more economical than naphthol or indigo sol dyes. The advantage of Remazol dye is that the dye is strongly bonded to the fabric, gives good colour, and does not fade easily it is used mainly for dyeing cellulose, cotton, rayon and wool fibres (Dewi et al., 2018).

The toxicity of azo reactive dyes according to EU criteria for hazardous substances is relatively low. However, a very small amount (10-50 mg/l^{-1}) of dye is visible in water, decreasing the transparency of the water, inhibit the solubility of gases, thus interfer the activity of photosynthesis of microalgae (Chequer et al., 2013). Also, azo dyes have a negative impact due to biotransformation products such as aromatic amines show carcinogenic and mutagenic effects, and toxic (Brüschweiler and Merlo, 2017). Bioremediation refers to cost-effective and environment-friendly method for converting the toxic, recalcitrant pollutants into environmentally benign products through the action of various biological treatments or their metabolite. Bacteria, fungi, and yeast are known to decolorize dyes; these microorganisms develop a system of enzyme decolorization and mineralization of azo dyes (Deshmuk et al., 2016).

Biological decolorization has been employed under either aerobic or anaerobic environment. This usually involves tolerating bacteria or other microbes that can be genetically engineered to provide degrading potential strains and they are working singly or in consortia. Some strains, such as *Bacillus cereus, Pseudomonas putida, Pseudomonas fluorescence, Pseudomonas desmolyticum and Bacillus* sp. have been used in the biodegradation of azo dyes. These microbial consortia were recommended for environmental remediation to degrade variety of pollutants (Telke et al., 2014).

Microorganisms developed enzyme systems for the decolorization and mineralization of azo dyes under certain conditions and involving azo reductases and laccases. Laccases have been shown to decolorize a wide range of industrial colours Dyes that have complex aromatic molecular structures are more stable and difficult to biodegrade (Kannan et al., 2013). Species *Bacillus coagulans, Bacillus pumilus, Nitrosomonas* sp.*, Pseudomonas* sp.*, Bacillus licheniformis, Bacillus strearothermophyllus, Bacillus brevis, Enterobacter aerogenes* and *Cellulomonas* also can degrade textile waste. Some bacterial species that are used to degrade textile waste containing dyes include the consortium of *Pseudomonas aeruginosa* and *Bacillus subtilis.*

Bacteria can produce extracellular enzymes such as proteases, lipases, amylases, and cellulases. The enzyme can break down complex organic compounds into simpler compounds (Telke et al., 2014). Due to the chemical complexity of dyes, it is necessary to develop more efficient microbial processes for decolorization. Some of reports suggest that the average decolorization rate of the bacterial consortium was significantly higher than that observed for individual bacterial cultures (Sghaier et al., 2019).

Therefore, the purpose of this study was to evaluate the ability of strain was isolated from mixed wastewater effluent with Remazol black and Remazol red.

The isolate were *Bacillus subtilis*, *Bacillus licheniformis* and *Bacillus coagulans* in consortia and singly to decolorize and to degrade of dye-effluent generated by the local textile industry that contaminated with Remazol black and Remazol red.

MATERIALS AND METHODS

The study was carried out experimentally in a laboratory to evaluate the ability of bacterial isolates from textile effluent to decolorize and to degrade of Remazol black red and. Research and data analysis using a completely randomized design (CRD) factorial AxB pattern with three replications.

The factor I is the type of bacteria (A) consisting of: *Bacillus subtilis, Bacillus licheniformis, B. coagulans*, and a consortium of three species of bacteria.
Factor II namely (B0): 100% textile waste, (B1): Textile waste + 500 ppm black remazol, (B2): Textile waste + 1000 ppm black remazol, (B3): Textile waste + 1500 ppm black remazol, (B4): Textile waste + 500 ppm red remazol, (B5): Textile waste + 1000 ppm red remazol, (B6): Textile waste + 1500 ppm red remazol. Remazol black and remazol Red dyes, obtained from the home industry batik company Trusmi, Cirebon. Decolorization analysis was measured with a spectrophotometer (SHIMADZU-1700, Japan) at 597 nm. The decolorization was expressed as percent (%) decolorization and estimated as (Ai - At)/Ai x 100, where Ai is the initial of absorbance of the dye solution and At is absorbance at cultivation time.
Data analysis was performed using the Variance Analysis (ANOVA) test to determine the effect of treatment on the measured parameters and it is followed by Duncan's multiple range test with a level of 5%.
The parameters measured in this study are the population of bacteria (Total Plate Count), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), Do (Dissolved Oxygen), TSS (Total Suspended Solid), degrees of acidity, temperature, and ammonia. Decolorization efficiency analysis using visible spectrophotometric method.

RESULTS AND DISCUSSIONS

Microbial selection tolerant of black and red Remazol dyes isolated from river water mixed with textile waste

Strains selected that are tolerant to black and red Remazol dyes at concentrations of 500 ppm, 1000 ppm and 1500 ppm (Tabel 1).

Tabel 1. Tolerance of isolates to Remazol black and red dyes at different of concentrations.

		Black Remazol concentration (mg/l)			Red Remazol concentration (mg/l)		
No	Strain	500	1000	1500	500	1000	1500
1	*B. subtilis*	+	+	+	+	+	+
2	*B. licheniformis*	+	+	+	+	+	+
3	*B. coagulans*	+	+	-	+	+	-

The Tabel 1 showed that *Bacillus subtilis, Bacillus licheniformis* and *Bacillus coagulans* can grow on dyes, which means that the three bacterial isolates can degrade black Remazol dyes and red and can use carbon and nitrogen as their energy sources. *B subtilis, P. putida, B. coagulans* and *B. licheniformis* are found in textile effluent.
These three strains are known to produce enzymes azo reductase and also produce several extracellular proteins such as amylase, aminopeptidase, metal protease, lactamase, endo-N-acetyl glucose amidase, and lipase. Bacillus licheniformis also contributes to the nutritional cycle and has antifungal activity. Bacillus licheniformis secretes extracellular amylase, β-glucanase, and protease enzymes, while *Bacillus subtilis* produces protease enzymes *B. coagulans, B. subtilis, B. licheniformis, B. amyloliquifaciens, B. cereus, B. megaterium, B. caldolyticus, B. polymyxa, B. pumilus, B. circulans, B. firmus, B. brevis, B. macerans, B. stearothermophilus* produce various enzymes such as a-Amylase, b-Amylase, Arabinase, Cellulase, Chitinase, Chitosanase, Dextranase, Galactanase.
Bacillus coagulans are known to be able to degrade lipids and tolerate acids (Elshaghabee et al., 2017). The ability of the strain to tolerate, decolorize azo dyes at high concentration gives it an advantage for treatment of textile industry.

Bio-decolorization of Remazol black and red dyes by three isolates selected singly and consortium

Biodegradation can be interpreted as a process decomposition of substance by activities microbes, which result in the transformation of the structure of a compound such that changes in molecular integrity or breakdown of materials that occur when microorganisms use an organic substance as a source of carbon and energy.
One of the main physical features of textile waste water is colour and must be removed before being discharged into nature.
Azo reactive dyes are one of the synthetic dyes that are very commonly used in the textile dyeing industry.
A significant proportion of these dyes were entering into the surrounding environment in the form of wastewater. Black and red Remazol dyes are one of the substances that colour and contained in the textile waste water.

In this study, the biodegradation of Remazol black and Remazol red dyes by three isolates carried out singly and consortium and showed that all strains were able to use Remazol black and Remazol red textile dyes contained in wastewater at concentrations of 500 ppm, 1000 ppm and 1500 ppm (Tabel 2).

Tabel 2. Bio-decolorization of Remazol black and Remazol red dyes (% reduction) by *Bacillus subtilis, Bacillus licheniformis, Bacillus coagulans* singly and consortium

Treatment	Remazol black (%) reduction	Remazol red (%) reduction
Control 500 ppm	0	0
Control 1000 ppm	0	0
Control 1500 ppm	0	0
B. subtilis 500 ppm	60.26	62.04
B. subtilis 1000 ppm	57.37	58.23
B. subtilis 1500 ppm	52.67	53.53
B. licheniformis 500 ppm	55.03	57.21
B. licheniformis 1000 ppm	52.55	54.31
B. licheniformis 1500 ppm	48.45	50.86
B. coagulans 500 ppm	58.70	60.75
B. coagulans 1000 ppm	54.37	56.24
B. coagulans 1500 ppm	51.13	51.96
Consortium 500 ppm	64.18	65.46
Consortium 1000 ppm	60.11	62.92
Consortium 1500 ppm	54.27	55.90

The treatment of Remazol black and Remazol red dyes by the consortium of bacteria *Bacillus subtilis, Bacillus licheniformis,* and *Bacillus coagulans* at concentrations of 500 mg/l, 1000 mg/l and 1500 mg/l, percentage of decolorization reached were 64.18%, 60.11% and 54.27% in Remazol black, and reached 65.46%, 62.92% and 55.90% in Remazol red. These results indicate that the decolorization of dyes by the consortium is higher than individual isolates.

The consortium can decolorize at a higher rate compared to the individual bacterial. This high decolorization is due to the synergistic effect. Individual strains can attack dye molecules at various positions or can use decomposition products produced by other strains, and this is synchronization in AZO dye decolorization (Shah et al., 2014; Karim et al., 2018). Biodegradation by the consortium is considered more effective in decomposing organic matter such as cellulose, lipids, and protein. Because the consortium is a combination of several strains that carry out biodegradation activities synergistically, isolates carry out metabolic activities together and complement each other (Thakur et al*.,* 2012). Decolorization by pure as well as mixed cultures have required complex organic carbon sources, such as, yeast extract, peptone, or a combination of complex organic source and carbohydrate (Telke et al., 2014). Some bacteria can utilize these dyes as a source of nutrients in the form of a single carbon, while other bacteria only break down the azo with the azo reductase enzyme. Azo bonds (N = N) present in these compounds are resistant to break, with the potential for the persistence and accumulation in the environment. Bacteria are precious biodegradation agents for the decolorization of textile dyes that pollute the environment. Bacterial genera, such as *Pseudomonas, Bacillus, Rhodococcus*, are reported to be bacteria that rapid decolorize of azo dyes. The azo dye decolorization by bacteria has been associated with the production of oxidoreductive enzymes, such as lignin peroxidase, laccase, azo-reductase and other non-specific reductases. Some review suggested that azo dye decolorization was associated with reductive cleavage of the azo bond by reductase (Telke et al., 2014.)

Consortium of *B. coagulans, B. pumilus, B. subtilis and Nitrosomonas* sp. very effective in decomposing Remazol blue dyes in industrial effluent (Amniati, 2013). The result also shows that the higher the concentration of blue Remazol dye, the smaller the degradation efficiency. This consortium can decipher industrial waste with a maximum concentration of Remazol blue dye of 2500 mg/l produced decolorization 84.9%, decreased on BOD levels by 57.9%, decreased on COD by 37.7%; and a decrease in TSS by 52%. Mixed bacterial consisted of five bacterial strains as *B. vallismortis, B. pumilus, B. cereus, B. subtilis* and *B. megaterium* exhibited excellent potential (43-71%) in aerobic decolorization of azo dyes (Lade et al., 2015).

Bacterial strains are able to decipher azo dyes by aerobics and use these dyes as a source of

carbon and nitrogen (Coughlin et al., 2002; Sudha, 2014). The content of dyes in the waste water of 1 mg/L has caused water to appear coloured, while the dye content in textile waste generally ranges between 20-200 mg/l. Decolorization ability is different for each type of azo dyes. Azo-reductase is reported to be the critical enzyme expressed in bacterial azo dyes degrading and catalyses the reductive cleavage of the azo bond resulted in aromatic amines are metabolized under aerobic conditions and subsequently simpler compounds, then leading to the removal of colour (Telke et al., 2014). The basic step in the decolorization and degradation of azo dyes is breakdown of azo bonds, leading to removal of colour. Azo dyes are known to undergo reductive cleavage whereas the resultant aromatic amines are metabolized under aerobic conditions (Kumari et al., 2016). Microorganisms degrade a wide range of mono-azo, di-azo, tri-azo, and poly-azo textile dyes used in dyeing and printing industries (Sudha et al., 2014). Azo-reductase is reported to be the key enzyme expressed in bacterial azo dyes degrading and catalyses the reductive cleavage of the azo bond. Azo-reductase activity had been identified in a number of bacterial species recently, such as *Staphylococcus aureus, Shewanella putrefaciens, Shewanella* and *Pseudomonas* spp. (Shah et al., 2014).

Ammonia levels in textile waste biodegradation

High ammonia levels are an indication of organic material pollution from domestic, industrial, and agricultural wastes. The elimination of nitrogen is achieved with the means of a two-step process: nitrification followed by heterotrophic denitrification. The first one converts ammonia into nitrates (NO_3^-) under anoxic condition while the second one converts the resulting NO_3^- (electron acceptor) into nitrogen gas (N_2) with the presence of organic carbon (electron donor) (Benneouala et al., 2017).

Unionized ammonia is toxic because nitrification microorganisms are needed to oxidize ammonia to nitrite and nitrate. Ammonia in water can be in the form of NH_3 molecules (non-dissociation/unionization) and the form of ammonia ions (dissociation) in the form of NH_4^+. Both forms of ammonia are very dependent on pH conditions and water temperature. Cell walls cannot be penetrated by ammonia ions (NH_4^+), but ammonia NH_3 will easily diffuse through the network if the concentration is high and potentially toxic to fish. The results of biodegradation of dyes in textile effluent showed that the consortium of *Bacillus subtilis, Bacillus licheniformis and Bacillus coagulans* on Remazol black at a concentration of 500, 1000 and 1500 mg/l for 14 days can reduce ammonia levels were 62.85%, 56.44%, 53.69% respectively. While on Remazol red can reduce ammonia levels was 68.51%, 54.76%, 70.72% respectively. This result shows that biodegradation by consortium can reduce ammonia higher than singly, also can be seen that the decrease in ammonia levels in Remazol red is more considerable than Remazol black (Table 3).

Tabel 3. Ammonia levels on biodegradation of black and red Remazol dyes (%) by three strains in a consortium and individually

Treatment	Remazol black ammonia (%) reduction	Remazol red ammonia (%) reduction
Control 500 ppm	1.36	2.05
Control 1000 ppm	0.15	1.51
Control 1500 ppm	0.14	73.43
B. subtilis 500 ppm	55.89	62;18
B. subtilis 1000 ppm	52.08	36.3
B. subtilis 1500 ppm	51.53	65.12
B. licheniformis 500 ppm	52.13	46.25
B. licheniformis 1000 ppm	50.48	55.86
B. licheniformis 1500 ppm	50.28	71.27
B. coagulans 500 ppm	61.55	62.25
B. coagulans 1000 ppm	55.09	59.13
B. coagulans 1500 ppm	51.52	47;20
Consortium 500 ppm	62.86	68.51
Consortium 1000 ppm	56.44	54.76
Consortium 1500 ppm	53.69	70.72

Decreasing ammonia levels will reduce ammonia toxicity and improve wastewater quality. Referring to Government Regulation of the Republic of Indonesia No. 82 of 2001 concerning Management of Water Quality and Water Pollution Control, the quality standard of COD class III parameters is 0.5 mg/l, it can be

concluded that biodegradation products of textiles effluent that contain black and red Remazol have not met the quality standard but have been able to reduce ammonia levels. Lowering the toxicity of ammonium in textile effluent, nitrification by nitrifying microorganisms is an attempt to eliminate ammonium biologically. In nitrification, ammonia will be oxidized to nitrite and then to nitrate, and nitrifying bacteria used the organic compounds in textile effluent as a source of nutrition.

Biological Oxygen Demand (BOD) levels in textile effluent biodegradation

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed by aerobic microorganisms to oxidize organic matter to carbon dioxide (CO_2) and water (H_2O). The higher the BOD concentration of water, shows the concentration of organic matter in water is high, which is an indicator that the waters have been polluted.

Tabel 4. BOD levels (mg/l) on biodegradation of Remazol black and red dyes (%) by three strains in a consortium and individually

Treatment (ppm)	Remazol black BOD % reduction	Remazol red BOD % reduction
Control 500 ppm	7.73	1.57
Control 1000 ppm	4.94	0.02
Control 1500 ppm	1.05	0.02
B. subtilis 500 ppm	73.58	74.10
B. subtilis 1000 ppm	71.85	72.10
B. subtilis 1500 ppm	71.81	71.92
B. licheniformis 500 ppm	72.90	72.63
B. licheniformis 1000 ppm	71.62	71.64
B. licheniformis 1500 ppm	69.31	70.55
B. coagulans 500 ppm	75.06	75.32
B. coagulans 1000 ppm	7278	73.90
B. coagulans 1500 ppm	72.53	72.03
Consortium 500 ppm	77.31	78.06
Consortium 1000 ppm	76.59	76.70
Consortium 1500 ppm	75.45	76.33

Table 4 shows that the biodegradation of Remazol black and red Remazol in textile wastewater by a consortium and individual *Bacillus subtilis, Bacillus licheniformis,* and *Bacillus coagulants* with a concentration of 500 ppm, 100 ppm, and 1500 ppm obtained BOD levels in black Remazol, respectively 77.31%, 76.59%, 75.45% while BOD levels in red Remazol BOD levels were 78.06%, 76.7% and 76.33%, respectively. The removal of organic matter and nutrients from the wastewater is an important aspect of biological treatment.

A decrease in BOD levels around 70 percent shows the consortium, and individuals can degrade dyes up to 1000 mg/l. A significant reduction in the BOD value indicates that organic matter in waste acts as a substrate for the metabolism of aerobic microorganisms. The decrease in BOD levels in the consortium is more significant than the reduction of BOD levels individually. Decreased levels of BOD might be due to their synergistic effect on pollutant removal. bacterial consortium proved as efficient organic biodegradation than that of the monocultures.

The developed bacterial consortium was more efficient in biodegradation pure dye solutions as well as mixture of all dyes, which indicates that microbial consortium is more powerful agent to treat dying wastewater than single bacterial inoculums, and all the isolates used showed compatibility with each other. Various microorganisms including, yeasts *Proteus* sp*., Enterococcus* sp*., Streptococcus* sp*., Bacillus subtillis* and *Streptococcus* sp., can degrade azo compounds, and after the bacterial degradation, they were also found less toxic than original dye (Singh and Singh, 2015).

The developed bacterial consortium was much more efficient in biodegradation and decolorizing single dyes as well as mixture of dyes than monocultures indicating the potential of mixed microbial consortium as potent bioremediation agent for cost effective removal of diverse dyes from dying effluent. The dye effluents are high in colour, pH, suspended solids (SS), chemical oxygen demand (COD), biochemical oxygen demand (BOD) and metals, temperature and salts. Therefore, during the treatment processes, it is important to monitor and compare these parameters with the standard concentrations before discharging the corresponding effluent to the receiving water body (Karim et al., 2018).

Chemical Oxygen Demand (COD) levels in biodegradation of textile effluent

The effluents from textile industries are varied in composition, which may not be biodegradable. The level of COD is a critically important factor in evaluating the extent of organic pollution in textile wastewater. Chemical Oxygen Demand (COD) is the amount of oxygen needed to oxidize organic compounds chemically. COD is a test conducted to determine the content of biodegradable (easily decomposed) and non-biodegradable (non-biodegradable) organic compounds (Myszograj et al., 2017). In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the number of organic compounds in water, making COD a useful measure of water quality. It is expressed in milligrams per litter (mg/l), which affects the mass of oxygen consumed per litter of solution (Kosseva et al., 2013). COD is always indicated as pollution loads resulting from each processing operation of various raw materials. Therefore, COD removal is needed with more effective microorganisms for treatment. High levels of COD depend on the type of fibre, dyes, additives, and various textile operations that are routinely carried out.

Tabel 5. COD levels (mg/l) on biodegradation of three strains in a consortium and individually

Treatment (ppm)	Remazol black COD % reduction	Remazol red COD % reduction
Control 500 ppm	0.65	0.24
Control 1000 ppm	0.19	0.04
Control 1500 ppm	0.00	0.03
B. subtilis 500 ppm	69.53	70.3
B. subtilis 1000 ppm	67.66	69.08
B. subtilis 1500 ppm	66.68	67.19
B. licheniformis 500 ppm	65.96	67.92
B. licheniformis 1000 ppm	62.72	63.06
B. licheniformis 1500 ppm	61.78	61.88
B. coagulans 500 ppm	68.70	69.52
B. coagulans 1000 ppm	67.98	68.95
B. coagulans 1500 ppm	65.91	66.49
Consortium 500 ppm	73.91	73.77
Consortium 1000 ppm	71.74	71.29
Consortium 1500 ppm	68.91	71.00

Biodegradation of Remazol black and Remazol red dyes by a bacterial consortium of *Bacillus subtilis, Bacillus licheniformis* and *Bacillus coagulans* at concentrations of 500 ppm, 1000 and 1500 ppm COD levels obtained, respectively 73.91%, 71.74%, 68.91%, 73.77%, 71.29%, 70.00% (Table 5). The decrease in COD value indicates the degradation of dyes and organic matter in the waste by microorganisms. Biodegradation reaches up to 70% because microorganisms decompose finely dispersed materials, colloids, and solutes through metabolism.

Although pure culture is reported to be effective in treating textile wastewater, a mixed culture or consortium would probably be more effective in degrading toxic compounds in the textile wastewater. A mixed culture can adapt better to changing conditions during growth. For example, anaerobic, facultative species will grow after aerobic species, and facultative species will survive with or without oxygen.

Bacillus sp*., Pseudomonas* sp*., and Pseudomonas luteola* are widely used in industrial waste management and can reduce levels of dissolved COD by 57.5%, which is carried out for 12 days (Dwipayana, 2010).

Bacillus sp. can integrate the components of cellulose, tolerant to acids, and can break down urea into ammonia, carbon dioxide, and water to reduce the levels of BOD and COD of industrial liquid waste. The genus *Bacillus* has interesting physiological properties because each type has different abilities, including (1) able to degrade organic compounds such as protein, starch, cellulose, hydrocarbons, and dyes, (2) able to produce antibiotics, (3) plays a role in nitrification and denitrification, (4) nitrogen-fixing, (5) oxidizing selenium, (6) oxidizing and reducing manganese (Mn). Some genera of Bacillus differ in their growth properties, some of which are mesophilic, namely *Bacillus subtilis*, facultative thermophilic, for example *Bacillus coagulans*, thermophilic for example *Bacillus thermophilus*. It also has different enzymatic abilities in producing enzymes, including in producing amylase, protease, and lipase enzymes such as *Bacillus licheniformis, Bacillus cereus, Bacillus subtilis, Bacillus coagulans, Bacillus pumilus, Bacillus samithi, Bacillus brevis.* These bacteria can decompose

dyes, such as Remazol, indigo sol, and naphtol. Microbial consortia were recommended for environmental remediation to degrade a variety of pollutants. The different conditions of textile wastewater after certain times may affect the growth of the consortia.

Industrial wastewater has a very high content of organic matter, one of which is cellulose content. The process of decomposition of the waste requires the help of cellulase enzymes that can break the glycosidic bonds. *Bacillus subtilis* and *Bacillus coagulans* are known to be the Bacillus class, which are capable of producing high amounts of cellulase enzymes. The reduced BOD and COD levels indicate the reduction of the toxic substances in the effluent. The mechanism of decolorization may be through two steps, either through adsorption and other enzymatically.

Different enzyme systems are known to exist in individual bacteria that are responsible for degradation. A consortium of the bacterium gives a synergistic effect both enzymatically as well as the availability of surface areas, which may be liable for the enhanced rate of decolorization.

***Total Suspended Solid* (TSS) levels in biodegradation of textile effluent**

Total Suspended Solids (TSS) is the portion of fine particulate matter that remains in suspension in water.

TSS are particles that are larger than 2 microns found in the water column. Anything smaller than this is called a dissolved solid.

The majority of suspended solids are made up of inorganic materials, although bacteria and algae can contribute to total solid levels.

These solids include anything floating through the water such as gravel, silt, sand or clay. TSS is the term used to refer to the solid particles suspended in water. It is defined as the total amount of solid material, suspended in water, that is retained by a filter.

The decrease in TSS percentage (%) produced by biodegradation of Remazol black and red Remazol dyes by *Bacillus subtilis*, *Bacillus licheniformis* and *Bacillus coagulans* in a consortium at various concentrations of each 67.5%, 66.83%, 52.71%, 70.13%, 60.93% and 58.72%.

Tabel 6. The TSS levels (mg/l) on biodegradation of Remazol black and Remazol red dyes (%) by three Isolates in a consortium and individually

Treatment (ppm)	Remazol black TSS % Reduction	Remazol red TSS % reduction
Control 500 ppm	0.73	0.185
Control 1000 ppm	0.13	0.13
Control 1500 ppm	0	0.03
B. subtilis 500 ppm	57.27	57,57
B. subtilis 1000 ppm	55.49	56.11
B. subtilis 1500 ppm	55.33	55.59
B. licheniformis 500 ppm	55.88	57.05
B. licheniformis 1000 ppm	53.48	55.16
B. licheniformis 1500 ppm	52.94	53.82
B. coagulans 500 ppm	56.75	57.45
B. coagulans 1000 ppm	55.95	55.26
B. coagulans 1500 ppm	50.53	54.79
Consortium 500 ppm	67.5	70.13
Consortium 1000 ppm	66.83	60.93
Consortium 1500 ppm	52.71	58.72

The results show that the biodegradation with mixed bacteria showed more significant than individual.

A decrease in TSS levels indicates that the synergistic effect of bacterial combination brings about enhanced performance for effective biodegradation. The decrease in TSS level an occur because the organic materials contained in the waste have been broken down by waste degrading bacteria and produce compounds that can be used for bacterial growth.

As in this study, showed that bacteria from different genera can work together in an environment and survive through the interaction of the metabolite because a mixed culture has more competence and has a higher tolerance to toxic metabolites.

Some strains, such as *Bacillus cereus, Pseudomonas putida, Pseudomonas fluorescence, Pseudomonas desmolyticum* and *Bacillus* sp. have been used in the biodegradation of azo dyes.

These microbial consortia were recommended for environmental remediation to degrade variety of pollutants (Kumari et al., 2016). *Bacillus subtilis* and *Bacillus coagulans* have high cellulolytic ability, therefore dissolved solids of cellulose can be decomposed. Also, *B.*

subtilis and *B. coagulans* belong to a group of *Bacillus* genus bacteria that can decompose crude fibres and lignin that are difficult to decompose through the process of delignify-cation and hydrolysis of cellulose.

CONCLUSIONS

B. subtilis, B. licheniformis and *B. coagulans* isolated from the river were contaminated from textile effluent, can grow, and tolerate Remazol black and red Remazol dyes up to 1500 mg/l. A consortium of these species can decolorize black Remazol and red Remazol up to 1000 mg/l, with a reduction percentage ranging from 50-60%. Bio-decolorosation by the consortium is more effective than monoculture. Also, the consortium can reduce levels of BOD, TSS, BOD and ammonia > 70% at concentrations of Remazol black and red Remazol up to 1000 mg/l.

ACKNOWLEDGEMENTS

This study was supported by the Academic Leadership Grant, an internal from the University of Padjadjaran with the title: "Isolation, Identification, Characterization of The Potential and Application of Microor-ganism to Processing Industrial and Domestic Waste" supervised by professor dr. Jetty Nurhayati.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

CONSOLIDATION OF TENANTS' LAND - THE PRACTICAL APPROACH IN BULGARIA

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Abstract

Land consolidation allows rational organization of farm works, proper use of agricultural machinery, land reclamation, soil conservation, and environmental protection. There are texts in Bulgarian normative framework that regulate land consolidation concerning land-use. An out-of-leases redistribution of the rights on land use into large massifs is legalized by an Agreement for Use of Land Massifs. Since the number of Participants in the Agreement can be quite large, further consolidation of the massifs is possible. The objective of the paper is to present an approach to consolidation of massifs that are under the Agreement. It is suitable for the Participants who suffer from economic and geographical compelling circumstances for cultivating their land, to manage it efficiently by cooperating with neighbour participants. The idea emerged from a sociological study through a questionnaire survey on the available machinery park and possibilities of land cultivation. This facilitates the structural design of the agricultural area under cooperation. The Law permits the participant to cooperate for joint land processing. The legal rights for establishing this cooperation are revealed. The idea is illustrated by maps of a draft land consolidation project.

Key words*: cooperation, land consolidation, legislation, questionnaire survey.*

INTRODUCTION

The small-sized and fragmented structure of land ownership is characteristic for the countries in transition to the market economy. Their establishment is based on historical factors but also by the legislation in force. The historical precondition in Bulgaria is that the land ownership was small-sized and fragmented still before the socialist collectivization began. This was written down in the documents for landownership, which were used for its restoration by the Agrarian Reform. After the completion of the Agrarian Reform, 26 million owners had property rights on more than over 12 mil. plots which average area was 0.4-0.5 ha. Average land ownership of 2 ha consisted of four to five plots (Rembolt, 2003). Rapid division of property rights between the heirs followed. Today the average size of landed property is 0.608 ha and varies from 0.27 to 2.03 ha (Moteva et al., 2015). Nowadays the Law still allows landed property division and the average size and fragmentation go to the worse.

While the Agrarian Reform was implemented, partial land consolidation per locality was accomplished. Every owner had to acquire a maximum of two landed properties in a locality. When an owner possessed more than two parcels, they had to be consolidated (Newcast No. 6, 1994). Since that time, no efficient legislation against division with the consequence for the plot's area and fragmentation has been invented. The Inheritance Act (prom SG 22 of 29 Jan 1949, last am SG 47 of 23 Jun 2009) permits the actual size of a plot to fall to a minimum of 0.3 ha for the arable lands, 0.2 ha for the pastures and meadows, 0.1 ha for the perennial plantations (Art. 72). These sizes are spatially restricting with regard to operation with the land. The small-size of landed properties and fragmentation of land ownership have undesirable consequences for land use: no proper mechanization can be applied for cultivation, no meliorations can be carried out and no land protective measures can be applied. Without adequate and optimized spatial conditions the economic growth of farms is hindered because of big costs and insufficient income from agricultural production, hence agricultural sector development and social development are slowed down. As a result,

landed properties are not attractive to private investments too.

With the establishment of the land market, most of the agricultural lands are being leased and cultivated in consolidated land massifs. A small number of very large farms occurred > 50 ha each. They are 2% of all the farms but occupy 84% of the arable land in the country. This predetermines the strong polarizing of the structure of the production units. On the other pole are 67% of the farms of < 0-1 ha each and they cultivate 10% of the arable land. They are mainly subsistent and semi-subsistent farms (National Census, 2010)

A priority prerequisite for effective land management and one of the main factors for rationalizing of the agricultural production is land consolidation. Land consolidation gives the farms the possibility of structuring their space so that they can have the best conditions for the highly technological processing of the land. Land consolidation also aims at enlarging the space for production so that proper treatment and conservation of soil can be ensured, also land reclamation and environmental protection to be applied.

Nowadays, land consolidation is actively applied in the sphere of land use, rather than land ownership. In order to carry out large-scale agricultural activities, Agricultural Land Ownership and Use Act (ALOUA) (prom SG, No. 17 of 1 March 1991, last am. and suppl. SG, No. 77 of 18 September 2018) by its Art. 37в gives the bearers of the tenure rights: owners and tenants in a settlement, the chance to establish "land massifs for use". Land tenants and landowners voluntarily sign an "Agreement for Land Massifs for Use". The leased land is formally consolidated in massifs and the latter are distributed among the participants of the Agreement at their request. The Agreement contains information about the participants, the acquired by them massifs and the rent due. An integral part of the agreement is the "Map for the Land Massifs for Use" that indicate their allocation. This agreement is being signed for the territory of the arable land and the territory of the perennial plantations. Analogous Agreement can be signed for pastures and meadows too.

The state and the municipalities also have the right to participate in this Agreement. The State participates in the Agreement (Art. 24a, ALOUA, 1991) with the objective to contribute to partially overcome the small size and fragmentation of the cultivated lands. By land exchange, it supports the initiatives of the private entrepreneurs and the legal entities on land consolidation. The Municipality distributes the abandoned unclaimed or undeclared for cultivation lands between those who have signed the "Agreement for Land Massifs for Use". The income from those lands is stored in case any owner will be looking for it. If a part of it remains unclaimed, it is used for public works.

The objective of the paper is to suggest a practical approach to further consolidation of the land massifs under the regulated by Art. 37в ALOUA, 1991 "Agreement for Land Massifs for Use" for establishing economically more efficient farms and for rationalizing land operation.

MATERIALS AND METHODS

Firstly, interviewing, analytical and synthesizing methods were used to study the processes in cooperation between the agricultural producers. A questionnaire survey of two focus groups - professionals and producers in agriculture was conducted. The data was collected from 250 respondents - 50% of professionals in agricultural land management and 50% of agricultural producers.

The questions for the professionals were divided into two thematic groups: (i) Land legislation - what is the current legal and regulatory context governing land use and are there any potential changes in the laws and regulations currently governing land consolidation?; (ii) Planning of the agricultural land use and land consolidation - is it important for solving the contemporary environmental and economic issues and for obtaining EU and national subsidies for agricultural production?

The groups of questions for the agricultural producers were: (i) Land consolidation - is there a benefit or opportunity for land consolidation planning and how would it be funded? (ii) Sustainable land use - what is important for maintaining high productivity of lands?

The data obtained were systematically recorded, organized, compiled, tabulated, computerized, and analysed in accordance with the objectives of the study. A variety of statistical analysis such as frequency, range, mean, percentage, distribution, standard deviation, categories, etc. was used to describe, represent, and explain the relationships between the variables. The data was personally collected in 2015 through face-to-face visits with all selected interviewees.
The development of the newly suggested approach to Land Consolidation is based on the knowledge of the legal regulation of land consolidation and the association of producers.
The idea is illustrated by maps of a draft land consolidation project.

RESULTS AND DISCUSSIONS

The results of the questionnaire survey definitely show that Land Consolidation Planning is essential to the creation of favorable territory conditions for farm growth and sustainable land use. Furthermore, planning should be regulated by the state. The main results are shown in Tables 1 and 2. They show that:

- Land Consolidation in the conditions of dynamic land relationships and market-regulated income is vitally needed. This is confirmed by both professionals and farmers.
- The legislation for spatial planning and land consolidation is insufficient. The prevailing assessment of the actual land legislation by the professional respondents (50% of them) is as positive as negative. A Law on Land Consolidation would provide for overcoming the inconveniences, proceeding from the existing land legislation.
- Sustainable land use is possible only if the agricultural territory is properly planned. If this is guaranteed and regulated by the state, it will help to obtain EU financial support.
- The farmers believe that the expenses paid for a land consolidation project will be compensated by the revenue of the optimized production process.

Table 1. Distribution of the opinions on main problematic questions on land consolidation among the professionals (%)

Question	yes	as yes as no	no
Is Land Legislation sufficient for land management in Bulgaria?	14	50	29
Does Land Legislation need changes?	85		8
Does Land Consolidation contribute for improvement of land productivity?	71		29
Does land ownership in Bulgaria need land consolidation?	64		21
Does Land Consolidation contribute to sustainable development?	86		14
Does Land Consolidation contribute to obtaining EU subsidies?	53	14	23
Is it appropriate to put limitations to the maximum size of land ownership?	71		23

What must the maximum size (ha) of land ownership?	1000	500	300	100	50
	14	14	14	44	14

Table 2. Distribution of the opinions on main problematic questions on land consolidation among the agricultural producers (%)

Question	yes	as yes as no	no
Do you suffer from deficiency of funds?	92		8
Is the procedure of adoption of EU fund difficult?	58		42
Do you cope with the territorial organization of the farm?	67		33
Does Land Consolidation contribute to the increase of your income?	67		33
Will the costs of a Land Consolidation Project be reimbursed because of improved land use and production?	50	30	20
Is it important to apply antierosion measures?	50		50
Is it important to apply other measures for improvement of soil fertility?	100		

- The interviewees believe that land consolidation will contributes to the following: increase of the arable land, compact arrangement of the crop rotations, the irrigation for vegetable and fodder crops, minimum lost area for field roads, anti-erosion disposition of the field roads,

minimum transportation expenses, proper sizes and configuration of the fields, applying measures against wind and water erosion etc.

- The opinions in favour of the maximum size of land ownership and the land-use area in the country pool around 100 ha. The range, though, is quite wide - from 50 to 1,000 ha. The major factor for its size is the specialization of the farm..

The expected restructuring of the small-sized and fragmented landed property with the means of the land market didn't take place and nowadays reality does not cover the expectation of the Transition. Implementation Land Massifs for Use (Art. 37в ALOUA, 1991) is a good practical solution for making possible mechanized and large-scale cultivation of land and for applying good practices.

Regardless that this is a positive step, such redistribution cannot be enough efficient when there is a great number of Participants in the Agreement for Land Massifs for Use. In some big settlements, there are more than a hundred of them. Then the average size of a massif that is included in the Agreement can be small and the massifs of one Participant can be dispersed in many locations, which is actually the general case. Assuming that a Participant in the Agreement has more than 5-6 massifs, then fragmentation can be considered great (Ejek et al., 2014). This is a precondition for the inefficiency of farm production. The fundamentals of this approach are that the tenants/bearers of tenure rights perform a voluntary consolidation - they agree among themselves on the location of the massifs they will cultivate (use). This approach is very approximate regarding the principles of land consolidation. The first problem is that in this exchange, they evaluate the quality of the land in the massifs approximately. No one calculates the equivalent of the exchanged landed properties. Their idea of land quality is based on their practical experience. This undoubtedly harms the efficiency of agricultural production for some or for all of them. The second one is that this step towards consolidation improves but still does not guarantee the potential of the agricultural production efficiency. At this stage, overcoming the fragmentation and dispersal of leased agricultural land is achieved but there is still potential for its improvement. The territorial criteria for highly efficient organization of farm work, the use of the machine and tractor fleet and the implementation of environmental measures for the production zone are far from being met. There is a need for further development of land consolidation, continuing the process of consolidating the massifs of some participants in the Agreement.

The need for consolidation between Participants after the signing of the Agreement arises both because of the lack of agricultural equipment in many of them, as well as because their homes can be far from the rented land. The association of Participants allows the rational use of the available equipment of some of them, as well as to assist the smaller tenants in cultivating soil, growing crops and harvesting. We discussed these ideas with real tenants in the country. It turned out that our views are correct. This is their practice. The Constitution of Bulgaria (prom SG 56 of 13 Jul 1991), Art. 19, para 4 gives the full right "for cooperatives and other forms of association of citizens and legal entities to achieve economic and social progress". And the Land-Lease Act (prom SG 82 of 27 Sept 1996, last amend and suppl SG 55 of 3 Jul 2018) Art. 11, para 1 noted that if it is agreed in the contract, a Participant has the right to re-lease a part of or the entire object of the contract but he is not exempt from his obligations to the lessor.

In the process of land surveys, we drew attention on the map of the Land Massifs for Use of several settlements to the fact that the same group of Participants in the Agreement for Land Massifs for Use have selected neighbouring massifs. This repeated for several locations in the village area and for several groups of Participants. Even such grouped massifs in a locality represent parts of bigger massifs with natural borders on the field. So the idea of consolidating massifs of groups of Participants logically arose. In this way, the size of the cultivated area increases and also the natural terrain conditions for land cultivation are used. If creating groups of massifs of one and the same group of Participants in different localities, all of them together can be considered a farm. This farm can have massifs of only one method of permanent use, i.g.

arable land or can be of different methods of permanent use, such as arable land, orchards, vineyards, pastures, and meadows. The farm may include the whole or a part of the leased land of the Participants in the Agreement: those which are suitable for land consolidation. If the terrain conditions allow, on the newly consolidated massifs a crop rotation (s) or/and a joint orchard or/and rotational grazing can be implemented. The income of the affiliated farm will be distributed among the affiliated farmers in accordance with the percentage of their lands of a certain quality.

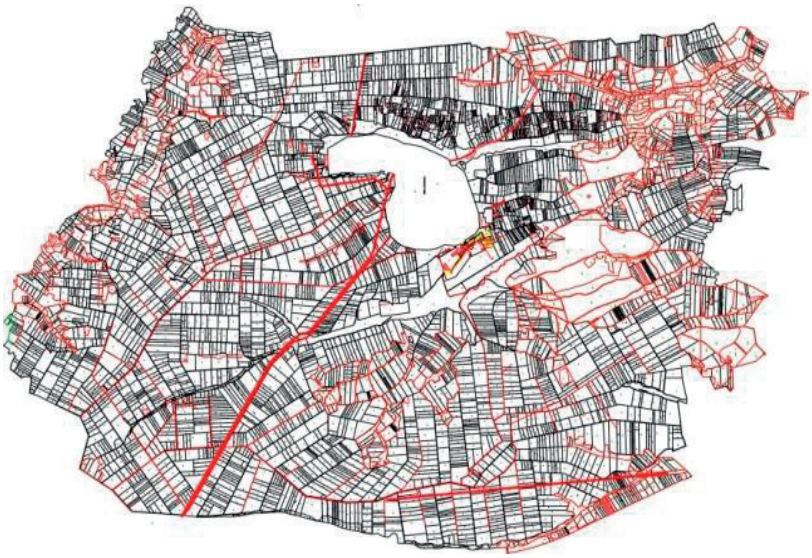

Figure 1. Map of land ownership in the village of Tsar Petrovo, the city of Vidin (Source: Vidin Municipality database)

Figure 2. Additional consolidation of land massifs of three Participants (coloured in red, blue or green, respectively) in the Agreement for Land Massifs for Use (Art. 37в ALOUA, 1991) (Source: own study)

In Figure 1 a map of the landed properties in the village of Tsar Petrovo, the city of Vidin is presented.
In Figure 2 the map of the massifs of three participants after land consolidation, subsequent the Agreement of Landed Massifs for Use, is presented. The massifs are apparently located nearby in every locality of the village area. Thus, instead of 31 landed massifs with a total area of 684.928 ha, 14 massifs with nearly the same area - 680.410 ha were formed. As a result of this land consolidation, 4.518 ha of agricultural roads were added to the arable land and the average area of one massif increased from 22.904 ha to 48.601 ha. This consolidation can be legally issued, it can also be a result of mutual understanding, but in all cases, it leads to the more rational use of the agricultural land - the application of crop rotations and other measures that are subsidized by the European Union. Thus, the farmers get an additional opportunity to financially support their activities.

CONCLUSIONS

Land consolidation is essential for ensuring proper territorial conditions for sustainable social and individual development. The idea of developing land consolidation after signing the Agreement for Land Massifs for Use (Art. 37в of Agricultural Land Ownership and Use Act, 1991) is useful for creating better conditions for rational space use, protection of land natural properties, efficient use of the agricultural machinery, economic growth of the farms. Cooperation of the Participants in the Agreement is regulated by Bulgarian legislation. It is actually applied in practice because of hindering circumstances for some of the land tenure bearers for cultivating their land. By a questionnaire survey was established that amendments and supplements of the normative frame work is needed to support the process of land consolidation in the country.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Education and Science, Bulgaria and also was financed from Project BN 209/18 of Research, Consultancy and design Centre at University of Architecture, Civil Engineering and Geodesy.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

GIS - BASED MAPPING OF GRASSLANDS AND OILSEED RAPES FOR ECOLOGICAL DATA MANAGEMENT - CASE IN BULGARIA

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Abstract

The purpose of STACCATO project (SusTaining AgriCultural ChAnge Through ecological engineering and Optimal use of natural resources) is to investigate the interactions between annual crops and surrounding landscapes in the light of ecological engineering as a tool for eco-functional intensification. Geographical Information system (GIS) was used in this study to map habitat types of indicator species according of the project protocol around semi-natural grasslands and oilseed rapes in Bulgaria target field sites. Recording system of habitats and the database is performed as outlined and reclassified the available areas and objects in polygon, linear and point elements. The permanent land use categories or type of vegetation has been recorded by EUNIS habitat classification or redefined in accordance with the proposed method.

Key words*: ecological management, GIS, grassland, habitat mapping, oilseed rape.*

INTRODUCTION

In order to advance long-term sustainable development of land use systems, against risks arising from multiple aspects of global change, STACCATO project (SusTaining AgriCultural ChAnge Through ecological engineering and Optimal use of natural resources) aims to quantify the dependence of ecosystem functions (ESF) and the services (ESS) they generate on environmental pressures in representative agriculturally dominated landscapes in Europe. The focus is on local and regional land use intensity (including the socio-economic background) and biodiversity, and the potential impacts of future climate and land use change.

Action 5 of the EU Biodiversity Strategy to 2020 called Member States to map and assess the state of ecosystems and their services in their national territory with the assistance of the European Commission. The results of this mapping and assessment should support the maintenance and restoration of ecosystems and their services (Maes, J. et al., 2013).

The field site network (FSN) was established, based on the selection of paired sites with different land use intensity (crop dominated vs. high shares of semi-natural sites) across Europe.

Case study regions for the assessment of the interactions between annual crops and semi-natural grasslands and surrounding landscapes for ecological engineering are from the participating countries: Germany (Saxony), Switzerland, Sweden (Uppsala), Romania (Transylvania), Bulgaria (South Bulgaria).

Design of field site network

In each country, the field site network was identified of 10 **F**ield **S**ites (FS). Each site consists in pair of one semi-natural grassland field (grazed or mown, depending on what is most common in the region) and one field with autumn-sown oilseed rape. Project team defined semi-natural grasslands as grasslands that are permanently (minimum estimated age 30 years) not fertilized, not tilled and not improved by sowing. The grasslands can have a more or less dense cover of shrubs and trees. The maximum distance between the grassland and the oilseed rape field should be 500 m and the minimum distance should be 100 m.

The 10 sites are situated along a gradient from low (0%) to high (~20%) semi-natural habitats in the surrounding landscape, here defined as a buffer of 500 m from the edge of the focal grasslands and crop field. The minimum distance between sites should be 2 km (Figure 1).

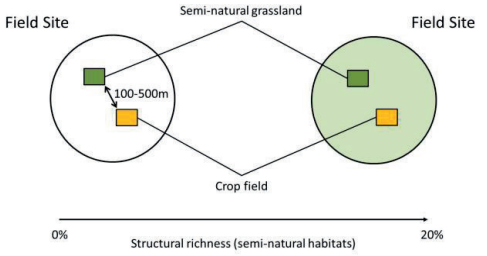

Figure 1. Design of field sites network

General characterisation of the FSN:

Abiotic parameters

FS: Landscape structure: based upon aerial photography and/or remote sensing data, both contemporary and historical, to assess urbanisation and soil loss trends; Data collection about geology, relief, climate and soils from available sources; Small-scale climate data: based upon statistical downscaling methods.

TF: Landscape structure: 50-200 m radius around TF; field mapping of crops (i.e. recording what crops are actually grown within certain radii around the TF).

Questionnaires on socio-economic frame conditions

FS: Household/family/production structure, yields, agricultural inputs and outputs including pesticide and fertiliser use, land ownership/use rights structure, competing/complementary land uses, market integration, income sources and level, land use intensity, landscape value criteria

TF: Income sources and expenditures, agricultural input expenditures, income structure and level, spending priorities, dominant sources of information, aspirations/priorities for change and for conservation, decision driving forces (tradition, state regulation, religion, gender roles), future development plans (some elements are repeated in FS and TF as more general data on the FS level can be used as basis for the information on the surrounding conditions) (http://staccato-project.net/).

The purpose of this study's to present habitat types selection and mapping according of project protocol around grassland and oilseed rape in Bulgaria by Geographical Information system (GIS).

MATERIALS AND METHODS

Study area

According to the field protocol, ten field sites were selected in 2 regions (Plovdiv and Haskovo) from South Bulgaria - Dobrich, Kostievo, Malak Cherdak, Momino selo, Radinovo, Stalevo, Stryama and Zelenikovo (Figure 2)

These sites represent the semi-natural grassland gradient in surrounding landscape.

For the purposes of this study, the timing of the habitat mapping is not linked to growth stages of oilseed rape. The data for land cover (LC) and land use (LU) are generated from land classification according to Bulgarian cadastral register and filed identification.

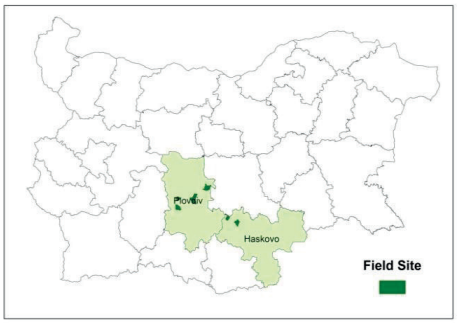

Figure 2. Selected field sites in Bulgaria

For the field database recording were used GNSS Trimble JUNOSB with a portable version ArcPad 10.0 and ArcGIS 10.0.

The sites data layer was overlaid into the Web-based satellite ArcGIS World Imagery by ESRI.(ESRI World Imagery)

Techniques for generating a land classification from raw data bottom-up approach can draw on existing methods used in geographical disciplines and allow flexibility in adapting the land classification to the specific research question (Hahs & McDonnell, 2006; Owen et al., 2006; Samuelson & Leadbeater, 2018).

The protocol involves manual generation of a land cover map based on visual inspection and using existing data layers to increase flexibility in selecting resolution, allow later combination with ground survey data.

Cadastral maps of the selected regions and field sites regions were used.

It was used European Terrestrial Reference System 1989 (ETRS89, EPSG:4258) as coordinate system following the "INSPIRE Data Specification on Population Distribution - TechnicalGuidelinesguideline" (http://spatialreference.org/), (http://inspire.ec.europa.eu/id/document/tg/pd).

Habitat mapping and Land Cover (LC)

The mapping protocol was inspired by the guidelines for habitat mapping and recording developed by the "European Biodiversity Observation Network" (EBONE) but it was simplified and adjusted for the needs of the project (Bunce R.G.H. et al., 2011).

The key concept is as follows:

• The habitats of the surrounding and connecting landscape of pair the oil-seed rape field and the grassland are mapped in a buffer of 500 m surrounding the oilseed rape and the grassland (Figure 3).

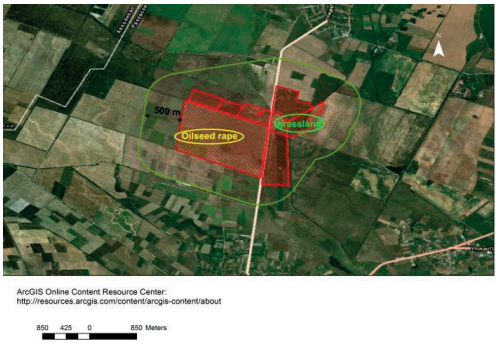

Figure 3. Illustration the steps of land cover for 500 m radii around the field sites

• In order to have a consistent vegetation classification, it should be follow the classification of habitats from the European Nature Information System (EUNIS) down to the third level of classification (EEA Habitat types, EEA, 2017).

• LU classification system and type of vegetation in Bulgaria, which can be used at the recording state as long as each local vegetation type can be assigned a EUNIS habitat.

Record the habitat type of:

Areal elements with an area > 400 m^2 with a minimum dimensions of 5 x 80 m (elements that smaller in extent, and/or are less than 5 m wide are recorded as linear or point elements);

Linear elements longer than 30 m and wider than 1 m according to the predefined list:

- lines of trees (LTR);
- hedges (HED);
- species Rich Hedge (SRH);
- lines of scrub (LSC);
- dry stone wall (DSW);
- water edges (WAT);
- herbaceous strips (HST);
- grass strips (GST);
- annual strip (ANN);
- walls (WAL);
- banks (BAN);
- tracks (TRA);
- roads, sealed compared to tracks (ROA);
- lines of sparse vegetation (LSV).

Point elements if landscape elements do not fulfil the areal or linear requirement (i.e., are smaller than 400 m^2, shorter than 30 m, or less than 1 m wide) following the EUNIS habitat types and the list of linear elements.

The protocol to map habitat types consists of three phases (Figure 4).

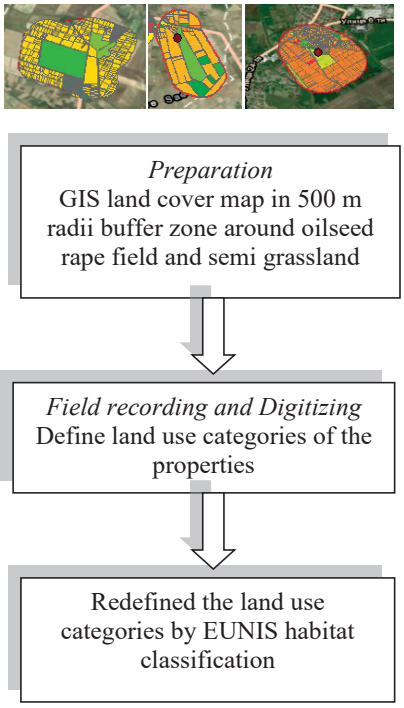

Figure 4. Phases of habitat mapping

RESULTS AND DISCUSSIONS

Selecting of the research field sites

The start of data acquisition from Bulgarian field sites started in Spring 2018.The reason was that in Bulgaria, autumn 2016 and spring 2017 were exceptionally dry, which hampered the successful establishment of oilseed rape plants.

New surveys have been made with cooperation the Municipal agricultural services in South Bulgaria to selected other study field sites like a pair - crop field (oilseed rapes) and semi-natural grasslands. Unfortunately, it was impossible to locate all of the research fields according to proposed methodology. The reason was the poor communication and information of the local agricultural services with landowners.

Table 1. Field sites in South Bulgaria

FS	LU	Villages	Coordinates	Gradient
1	grassland	Kostievo	N 42°10'28.6" E 24°36' 49.7"	5%
	rape	Kostievo	N 42°10'19.0" E 24°36' 48.3"	
2	grassland	Zelenikovo	N 42°22'50.1" E 25°04' 43.4"	5%
	rape	Zelenikovo	N 42°22'44.8" E 25°04' 48.1"	
3	garssland	Dobrich	N 42°01'09.3" E 25°32' 08.1"	5%
	rape	Dobrich	N 42°01'24.3" E 25°32' 08.2"	
4	grassland	Stryma	N 42°14'56.6" E 24°51' 02.3"	10%
	rape	Stryma	N 42°15'14.8" E 24°50' 53.5"	
5	garssland	Zelenikovo	N 42°23'49.4" E 25°03'08.7"	10%
	rape	Zelenikovo	N 42°23'47.0" E 25°02' 57.5"	
6	garssland	Momino Selo	N 42°17'39.7" E 24°52' 59.3"	20%
	rape	Momino Selo	N 42°17'30.8" E 24°52' 50.8"	
7	grassland	Malak chardak	N 42°16'53.2" E 24°37' 52.8"	20%
	rape	Malak chardak	N 42°16'47.1" E 24°37' 31.9"	
8	garssland	Stalevo	N 42°03'22.7" E 25°23' 25.5"	20%
	rape	Stalevo	N 42°03'15.2" E 25°23' 28.9"	
9	grassland	Radinovo	N 42°11'12.7" E 24°38' 22.4"	100%
10	Rape	Malak chardak	N 42°16'45.4" E 24°38' 47.4"	0%

Eight of the new field sites were selected to meet the requirements of the protocol and to be situated along a gradient from low (0%) to high (~20%) semi-natural habitats in the surrounding landscape (Table 1).

For the purpose of the project Bulgarian team selected two new field sites, only one TF with a gradient 0% (oilseed rape) and 100% grassland. Table 1 shows the name of villages, gradient and focal coordinates of the target fields.

Habitat mapping

In this study are indicated some of investigating field sites which are more specific and representative.

Region village Radinovo

Habitat mapping in this buffer zone is only determined by the presence of semi-natural grassland. One of main characteristic is proximity to two settlements - Radinovo and Kostievo. Total area for mapping is 160.3 ha. The area of the target grassland site is 11.2 ha.

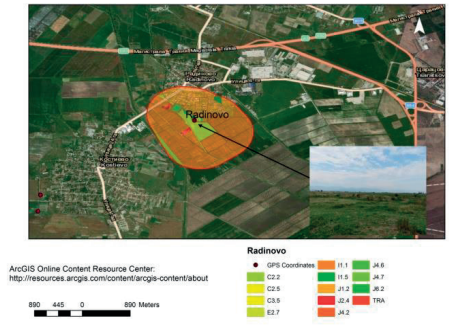

Figure 5. Map of habitats around field site villages Radinovo

Redefined land use and vegetation by EUNIS classification in the buffer zone (Figure5):

C2.2: Permanent non-tidal, fast, turbulent water courses;

C2.5: Temporary running waters;

C3.5: Periodically inundated shores with pioneer and ephemeral vegetations;

E2.7: Unmanaged mesic grassland;

I1.1: Intensive unmixed crops;

I1.5: Bare tilled, fallow or recently abandoned arable land;

J1.2: Residential buildings of villages and urban peripheries;

J2.4: Agricultural constructions;

J4.2: Road networks;

J4.6: Pavements and recreation areas;

J4.7: Constructed parts of cemeteries;
J6.2: Household waste and landfill sites;
TRA: Tracks.
As a result of classification 61% of total area is Intensive unmixed crops and 17.7% - Residential buildings of villages and urban peripheries.
Land surrounding the grassland sites in this buffer was dominated by arable agricultural fields and residential buildings in the immediate vicinity of the research area within a rural landscape.
Region village Kostievo
Habitat mapping in this buffer zone is determined by the presence of oil-seed rape and grassland with a gradient of 5%.
The target fields are very close to the village Kostievo. The area of grassland and oil-seed rape are respectively 24.5 ha and 21.3 ha. Total area for mapping is 367.8 ha.

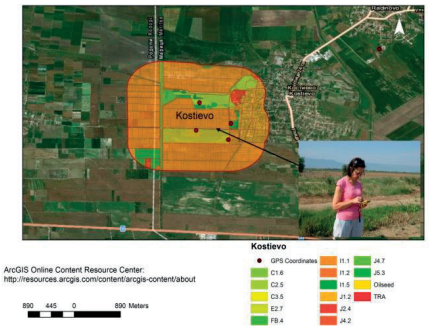

Figure 6. Map of habitats around field sites villages Kostievo

Redefined land use and vegetation by EUNIS classification (Figure 6):
C1.6: Temporary lakes, ponds and pools;
C2.5: Temporary running waters;
C3.5: Periodically inundated shores with pioneer ephemeral vegetations;
E2.7: Unmanaged mesic grassland;
FB.4: Vineyards;
I1.1: Intensive unmixed crops;
I1.2: Mixed crops of market gardens and horticulture;
I1.5: Bare tilled, fallow or recently abandoned arable land;
J1.2: Residential buildings of villages and urban peripheries;
J2.4: Agricultural constructions;
J4.2: Road networks;
J4.7: Constructed parts of cemeteries;
J5.3: Highly artificial non-saline standing waters;
TRA- Tracks.
Similar to the mapping in the previous field site in Radinovo, the largest percentage of the area was occupied of Intensive unmixed crops - 60.6%, Residential buildings of villages and urban peripheriesare 8.6% (Figure 7).
Region villages Momino selo

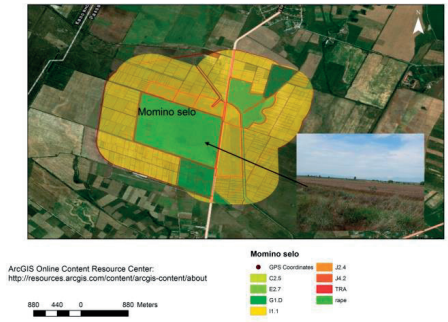

Figure 7. Map of habitats around field sites villages Momino selo

C2.5: Temporary running waters;
E2.7: Unmanaged mesic grassland;
G1.D: Fruit and nut tree orchards;
I1.1: Intensive unmixed crops;
J2.4: Agricultural constructions;
J4.2: Road networks;
Rape: oil-seed rape;
TRA: Tracks.
The region is characterised irrigated arable land and cereals crops.
Region villages Zelenikovo
In this region are selected two field sites. The area is a very interesting and specific with regard to vegetation and land use.
The village of Zelenikovo is located on the Southern slopes of the highest part of the Eastern Sredna Gora Mountain. It is part of Brezovo municipality. The terrain of the regions from flat to mountain. Total habitat mapping area for two researched fields sites are respectively 337.4 ha and 247.4 ha.
The following habitats were mapped and identified in the two regions (Figure 8):

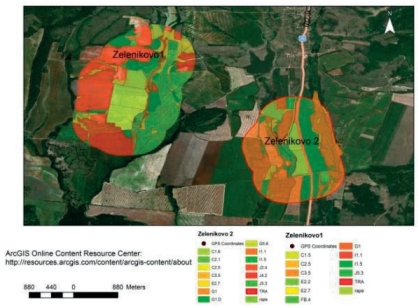

Figure 8. Map of habitats around field sites villages Zelenikovo

C2.1: Springs, spring brooks and geysers;
C2.5: Temporary running waters;
C3.5: Periodically inundated shores with pioneer and ephemeral vegetations;
E2.2: Low and medium altitude hay meadows;
E2.7: Unmanaged mesic grassland;
FB.4: Vineyards;
G1: Broad leaved deciduous woodland;
G1.D: Fruit and nut tree orchards;
G5.6: Early-stage natural and semi natural woodlands and regions;
I1.1: Intensive unmixed crops;
I1.5: Bare tilled, fallow or recently abandoned arable land;
J5.3: Highly artificial non-saline standing waters;
TRA: Tracks.

The analysis of the habitats in the two sites in Zelenikovo village presents a wide variety of vegetation and permanent land use. This is due to the proximity of the mountains to the field sites and the availability of forest vegetation.

The percent of the forest and perennials vegetation are 26.5% and 12.5% in the two zones. At the same time the percent of abandoned lands and early stage natural and semi natural vegetation are high.

This has a very positive impact on the habitats of indicator species.

CONCLUSIONS

Climate change and drought in the period from the start of the project adversely affect the development of the selected oil see drape, which has hampered the project work.

In 2018, 10 new field sites were selected in South Bulgaria. Analysis was performed for 5 of the selected field sites with specific and representative habitats.

The results of this mapping and evaluation should support the maintenance and restoration of ecosystems and their services for environmental management. This will help to analyze the dominant agricultural landscape and the potential impacts of future changes and land use.

ACKNOWLEDGEMENTS

This research work was supported by the Project STACCATO: SusTaining AgriCultural ChAnge Through ecological engineering and Optimal use of natural resources (BiodivERsA-FACCE2014-47) funded by the National Science Fund of Bulgaria under the contract number D002/2.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

ASSESSMENT OF ENVIRONMENTAL RESOURCES FOR VINEYARDS MICROZONING BY GIS

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Abstract

Nowadays making decisions quickly and selecting the best alternative are very important for location of agricultural crops to gain competitive advantage in a complex environment. In this research, multi-criteria decision analysis with pair wise comparison weighting method was utilized to determine the suitable locations for vineyard plantation in Karlovo region, Bulgaria. Soil maps, meteorological measurements, slope, aspect, elevation maps were used as input to conduct spatial analysis. AHP method is compared with previous investigation and the pair wise comparison research is identified as a better one for the spatial analysis by GIS. In this study GIS multi-criteria evaluation for zoning and exploration sites presents the potential vineyard location in the research area.

Key words*: AHP, GIS, microzoning, multi-criteria analysis, vineyards.*

INTRODUCTION

Vineyards are wildly spread farming systems, combines different and comprehensive conditions of natural resources to achieve a high-quality production. Grapes and wine are natural products whose special characteristics depend on environmental conditions. Viticulture has a strong association of place and time. Many factors and complex relationships of variables influence to the final results for different regions.

The uniqueness of the great wine terroirs of the world has been built up on the basis of right combination of climate, soil and terrain in general. Viticulture zoning and site selection for potential vineyards are becoming important in the context of growing wine markets and emerging wine producing regions in Bulgaria beyond the limit defined by certain vine requirements (Bramley et al., 1999).

Most researchers believe the same reasons are behind the secret of French wine (Willson, 1998) and best wine *terroirs* of the world (Fanet, 2004; Winkler, 1962), because grape quality and yield highly depend on the micro-, meso- and macro climatic conditions formed by the surrounding environment (Jackson, 2008) and the soil characteristics (White, 2003). Site selection for the expansion or the establishment of new vineyards is one of key aspect of viticulture zoning (Vaudour et al., 2005).

The quality of wine depends on the quality of the grapes and it is determined by their environmental and growing conditions, referred to as '*terroir*' by the French (Wilson, 1998). A broader meaning (of *terroir*) includes a combination of vineyard location, soils, climate, and other environmental factors, as well as choice of grape varieties, viticulture practices, and the strategies of the producers – natural as well as human characteristics (Moran, 2001; Deloire et al., 2005). Location or spatial references are important to many of these factors. Results are determined by environmental effects, and by the analyses, decisions and actions of the grower. Vineyards cultivation takes advantage of natural factors - such as soils, climate, altitude, slope, aspect, by selecting suitable sites for particular vine varieties. They control or manipulate other factors through management procedures (Smith, 2002).

The quality of available information is an important factor determining the quality of decisions made and, therefore, the quality and profitability of results. Much of the information and processes relate to location, so spatial (geographical) relevance is a significant aspect of vineyard data. Physical conditions vary across landscapes at all scales (Voltz, 1997). As the success of agricultural production depends on these conditions, analyses of the associated information and understanding of their

variability, using spatial information systems to support decisions and management responses to them, offers opportunities to improve results (Smith, 2002).

Site selection requires a system that gathers and makes accessible the types and ranges of information that a viticulturist will use in decisions, to optimise the selection of sites. It needs to correlate and compare the factors & constraints that are significant to vineyard development and performance, especially the factors that vary spatially (Tonietto et al., 2004). It will be a system to integrate spatially based information from a variety of sources, to allow selection, combination and analysis of important factors, in an integrated manner (Badcock, 1998; Malczewski, 1999).

Precision agriculture and site-specific farm management have demonstrated the successful tools of spatial information systems and related technologies in primary production - crops from the land, and the management and use of resources (Hall et al., 2002). The selection and establishment of a suitable site is probably the most important, fundamental, irreversible decision in the life of a vineyard (Gladstones, 1992; Pool, 2001; Roberts, 1999). It is speculated that this process will be enhanced systems along with multi-criteria analyses, decision support and management systems.

The using of GIS database in vineyards management will help to increase the knowledge of the vine farming relating with the selection of areas, selection of suitable productions direction and varieties and applying of good agricultural practices for sustainable vine production sector. The future perspective tools like GIS gives us opportunity to modelling with a huge amount of different king of information. It contains interdisciplinary information that involves integration of criteria from different branches of science. Some case studies in the references cited also discuss potential uses for GIS in site selection and they do point out potential benefits (Badcock, 1998; Kirkby et al., 1996).

MATERIALS AND METHODS

This paper proposes that the process of vineyards site selection will be achieved and the probability of success improved, by the use of spatial information systems combine with multi-criteria analyses, decision support and management systems. The processes will need to include criteria and factors that are important in selecting a site and establishing the vineyards.

In this research, multi-criteria decision analysis with pair wise comparison weighting method was utilized to determine the suitable locations for vineyard plantation in Karlovo region of Bulgaria. Soil maps, meteorological measurements - temperature, irrigation, topographic components- slope, aspect and elevation were used as input to conduct spatial analysis.

The methodology is based on a Geographic Information System (GIS) analysis of the most important ecological parameters, representative of the topography, climate and soils in the continental climate vineyards. Weighted decision-making analyses by using suitable coefficients of each criteria present relative importance of particular environmental factors or constraints (Malczewski, 1999).

The necessary information is gathered by different sources as the soil distribution maps, elevations models, temperature distributions, depends on the vine crops requirements about the land use for suitable vineyards zoning. All data is transformed and realized by using spatial analysis and systems in GIS platforms.

The results are done by complex combination of the Analytic Hierarchy Process (AHP), GIS tools and spatial distribution of different parameters and vineyards management for multi environmental assessment of suitability sites and profitable future results.

The Analytic Hierarchy Process (AHP) is a well-known multi-criteria decision-making method, proposed by Saaty in 1980 (Saaty, 1980; 1996; 2001). The method provides a theory of relative measurement of various criteria for decision analysis (Saaty, 1990; 2005). The Analytic Hierarchy Process consists of the decomposition of the decision problem into simpler components or levels and the definition of a hierarchy framework by pair wise comparison between the levels.

The top level of the hierarchy is the goal of the decision problem- environmental assessment of vineyards zoning. The next level consists of the main criteria and sub-criteria used to assess the

alternatives, which in turn, form the bottom level of the hierarchy. AHP uses pair wise comparisons to assign weights to the individual elements of each level, by measuring their relative importance using Saaty´s 1-9 scale, and then calculates the overall priority for the alternatives of the decision process (Saaty, 2008). The method also calculates a consistency ratio associated with each matrix of pair wise comparisons to verify the consistency. The mathematical foundations of the method can be found in Saaty (1977; 1994).

RESULTS AND DISCUSSIONS

Selection of potential sites for a new vineyard for wine production is a complicated and important decision as several factors have influenced on it. This research paper deals with a methodological approach based on GIS multi-criteria evaluation for zoning and exploration of potential vineyard sites in the Karlovo region, Bulgaria. Among several indicators proposed in the methodology, environmental factors are calculated to show implementation of the AHP methodology for zoning and to assess the prospective outcomes of the viticulture research.

Nowadays making decisions quickly and selecting the best alternative are very important for vineyard farming to gain competitive advantage in a complex environment. Therefore, the suitable vineyard location selection is considered in this paper. Because this selection affects the quality of wine as the grape quality affects the wine quality directly. Selection of vineyard location is a specific multi-criteria decision problem and the conventional methods for resolve suitable vineyard site location problems are deficient for dealing with the insufficient or unclear nature parameters of environmental assessments. This paper attempts to solve the vineyard location selection problem by adopting the method of analytic hierarchy process (AHP) and multi-criteria decision making (MCDM) method into GIS platforms. After determining the criteria and alternatives that affect the vineyard location decisions, these methods are used to solve the problem and results are presented by the thematic suitability map.

The study region Karlovo is being analysed in some past researches (Arnaudova et al., 2010; 2011; Popov et al., 2010; 2011) and illustrated vineyard microzonig for determination of three branches of wine production - red wine, white wine and dessert grape. The articles show the suitable territories analysed with distribution of some initially parameters of natural resources-temperature, relief and soil characteristics (Arnaudova, 2008; Popov, 1997; 1998). The used method is based on eliminated the insufficient territories to vine growing requirements. Implementation of AHP method to achieve the viticulture suitable locations enable to the combination of different and complex interdisciplinary factors. The importance of each analyzed parameters are realized by pair wise comparison. As a result different methods were compared and pair wise comparison method is identified as the most appropriate method of weighting for vineyard spatial analysis.

Using AHP models for vineyard environmental assessment combine diverse natural resources as well as climate characteristics, soil parameters and topography factors, which influence on vineyard location for realizing profitable wines.

Some of the most spread and studied parameters influenced on vineyards site selection is the topography of the investigated territory. The topography factors are used to define and describe physical features of the land (natural and built) and related characteristics that are significant to site selection. Topography of a certain region can mainly be described by altitude (both relative and absolute), slope and aspect. Information types can include - mapped spatial features, images, attributes. Raster data will be used for continuous information such as slope and aspect. Vector data will be used for point, linear or polygonal features such as water races or buildings. Landform can be represented by a digital elevation model (DEM), obtained by acquiring data from existing sources of land information, from topography maps, or by direct survey (Eastman, 2009). Contours, slopes and aspects are all generated from the basic elevation model. Comparative heights or elevations are also important, maybe more so than actual altitudes, for example relative

height above a valley floor can affect cold air drainage, or fall from a main water source may provide gravity supply. Annual average temperature is a function of altitude i.e. decreases 0.5°C for every100 m, and which leads moderately cool climate and good temperature conditions in certain heights or frost in higher mountains, limiting the cultivation. Site aspect, defined as the compass direction of slope, relatively influences the local climate (Jackson, 2008; Jones et al., 2002; Wolf et al., 2003). So, it is essentially to combine all topography characteristics in one spatial analysis by using AHP to determine suitable vineyard sites location. Implementation of all relief parameters into AHP method and the results are presented by the next table (Table 1).

Table 1. Weights of topography parameters

Factors	Elevation	Slope	Aspect	SUM	AVERAGE	CONSISTANCY MEASURE
Elevation	0.16	0.38	0.14	0.67	0.22	3.16
Slope	0.05	0.13	0.17	0.35	0.12	3.05
Aspect	0.79	0.50	0.69	1.98	0.66	3.40
SUM	1.00	1.00	1.00	3.00	1.00	
					CI	0.10
					RI	0.58
					CR	0.18

Accordingly, to the resulted weights (average value) done by pair wise comparison of each researched factors, the most importance topography parameters for vineyard site selection is the aspect with its 0.66 value. Next influence place is for the elevation (0.22) and finally the slope impact (0.12). So, it is the most essentially for vineyards territories to be on south aspect, then elevation not to be more than 600m for all Bulgarian regions. Slope is less important, because vineyards can be cultivated from 1 up to 20° and the land can be transformed by terracing.

Geology and soil also control the vine quality indirectly through influence on soil composition, geomorphology, and capability of retention of water (Huggett, 2006). Soil properties affect vine performance which is mainly described by survival and growth, root function and fruit quality and management (Lanyon et al., 2004). Several years may elapse before observing significant alternation to, or its interactions with the grape vine. Relatively uniform, mild-climate soils were considered in the above analysis of land suitability for viticulture together with four soil properties: depth, organic matter, pH and texture were identified with descending importance respectively. Parallel studies on site selection had also referred to internal water drainage as a driver of root growth and steady water supply (Kurtural, 2002). Organic matter content of the soil is an important parameter related to soil fertility. Soil pH is considered as an indicator of fertility, nutrient balance and toxicity (Jones et al., 2004) while soil moisture is an indicator of many factors such as vegetation growth, drought stress, rate of internal water drainage and water holding capacity. Other authors (Wolf et al., 2003) further extended the significance of soil properties including soil depth, bulk density, soil fertility, organic matter, soil texture, soil biology, and origin of soil and surface characteristics for vineyard site selection.

So, the study presents the importance of soil parameters, calculated by AHP analyses and it contains soils profiles, including the surface or topsoil, and the deeper soil or subsoil profiles (where vine roots penetrate and seek water and nutrients), and relevant geological information. Soils are the most commonly described components of '*terroir*' (Wilson, 1998) and are given high priority in the search for suitable sites. Therefore, soil characteristics can be considered as holding one of the most important sets of site selection criteria and data, and be weighted accordingly by AHP. Soils data may be acquired from existing maps, probably in raster format scanned from soil maps, zoned for various categories. If this is insufficient in detail or scale or extent then further survey work may be required, perhaps from scanned images or plotted by survey. Using pair wise comparison methodology to analyse the most important soil factors are presented by the Table 2.

To achieve profitable vineyards location in Karlovo region, Bulgaria the high importance among all analysed soil parameters come down to the soil depth. The minimum depth of topsoil level is between 3-5 m.

Table 2. Weights of soil parameters

Factors	Soil depth	Soil reaction (pH, H_2O)	Soil texture	Organic matter content	Sum	Average	Consistency measure
Soil depth	0.60	0.66	0.54	0.41	2.21	0.55	4.30
Soil reaction (pH, H_2O)	0.20	0.22	0.32	0.29	1.04	0.26	4.30
Soil texture	0.12	0.07	0.11	0.24	0.54	0.13	4.07
Organic matter content	0.09	0.04	0.03	0.06	0.22	0.05	4.06
SUM	1.00	1.00	1.00	1.00	4.00	1.00	
						CI	0.07
						RI	0.9
						CR	0.08

Soil depth distribution presented the opinion of vine roots to grow into deep soil layers and to provide all necessary components. Next importance is to the soil reaction (pH) with its 0.26 points, followed by soil texture (0.13) and organic matter content (0.05). The last one can be modified and increase by additionally fertilization, so it can be changed according to the vine sorts by human actions. About 30% of vineyards location depends on soil reaction. The territories with acidic soils are not suitable for vine cultivation. For profitable yields of grape growth and long-lived vineyards cultivation, the soil reaction is good to be amount between 6.6-7.5 values. Accordingly, to the soil texture, the vine developing is high reached on sandy clay soils, with clay content around 30%. To gather the most suitable vineyards microzoning it is essentially to know the adequate soil depth and the soil reaction in the studied area.

One of the most critical and important components of vineyards location is the climate of the studied region (Jones et al., 2000). Among all climatic variable's temperature is of predominant importance (Jackson, 2008) as a measure of heat sum (Winkler et al., 1962) which is calculated as the base of 100C below which almost no shoot can grow general. Extreme values of temperature throughout the viticulture cycle such as frost occurrences in spring and fall, limiting factors on photosynthesis and respiration in maturing, ripening and harvesting periods, as cold or winter injuries (as opposed to the winter hardiness) when becomes negative values (Jackson, 2008; Jones et al., 2004; Kurtural et al., 2002). General climate is determined simply by country or latitude band, on abroad scale. Macroclimate is in regionally typical climate zones and characteristics. These may fluctuate or change an important consideration in long-term suitability of sites (Smith, 2002). Weather and ongoing need for monitoring events & patterns for vineyard management can be incorporated here. There are some categories included in: temperature, annual precipitation, minimum temperature in the coldest month and maximum temperature in the warmest month, mountain/river influence. All these parameters are pair wise compared by AHP method and the results are presented by the next table (Table 3).

The suitability of vineyards areas highly depends on total vegetation temperature, so in the AHP analyses it takes the first place of importance with weight of 0.39 points. It is almost 40% major influence on the vine cultivation. The vineyards are going well grow between 3500-400°C total vegetation temperatures.

If the temperatures are under these values, the studied regions are not suitable for viticulture. The next level of substantial is presented by annual precipitation - 0.32 points of weight. It presents the cumulative amounts through seasons, patterns of rainfall, events and timing. This factor can be moderate and improved by some kind of irrigation.

Minimum temperature in the coldest month and maximum temperature in the warmest month are critically significant parameters accordingly to the different sorts of vine and the final production of wine. Theirs influence is calculated to the 0.13 and 0.12 value of weight, compared to other parameters. The minimum temperature in the researched area has to be more than 10°C and the maximum temperature has not to be more than 28°C about the Bulgarian climatic zones.

In these critical values on temperature the vine stopping its growing and it reflects on the grape quality and the wine taste. Influence of nearly located mountains and rivers or sea is arranged to the last position (0.04 points), because it is associated with land structure and act on average daily temperatures.

Table 3. Weights of climate parameters

Factors	Total vegetation temperature	Annual precipitation	Minimum temperature in the coldest month	Maximum temperature in the warmest month	Mountain/river influence	SUM	AVERAGE	CONSISTANCY MEASURE
Total vegetation temperature	0.44	0.55	0.41	0.27	0.29	1.96	0.39	5.52
Annual precipitation	0.22	0.27	0.41	0.45	0.24	1.59	0.32	5.77
Minimum temperature in the coldest month	0.11	0.07	0.10	0.18	0.19	0.65	0.13	5.50
Maximum temperature in the warmest month	0.15	0.05	0.05	0.09	0.24	0.58	0.12	5.12
Mountain/river influence	0.07	0.05	0.03	0.02	0.05	0.22	0.04	5.20
SUM	1.00	1.00	1.00	1.00	1.00	5.00	1.00	
							CI	0.11
							RI	1.12
							CR	0.09

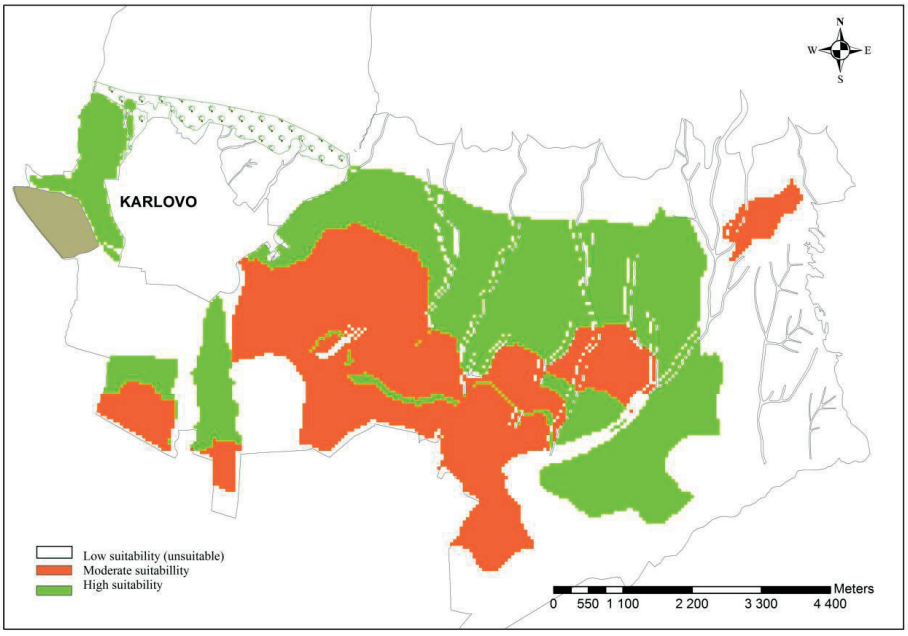

Figure 1. Assessment thematic map of soil resources of Karlovo region, Bulgaria

Land, soil and climatic parameters of given area has variability in certain range. Fluctuation of this range could cause change in growth and development of vegetable crops effecting is final yield.

Parameters are categorised in potential ranges according to needs of the crops (Arnaudova et al., 2010; 2011). The variety of data is collected by different sources and implemented in GIS platform. The results of Karlovo region about the soil analysis are presented on the assessment soil thematic map (Figure 1).

The distribution of soil resource characteristics is performed by suitability located areas for profitable viticulture. Current vineyard areas were determined using AHP method and their spatial distribution compared with the resulting suitability map to determine the current

suitability. Comparison showed vineyards were mostly established in locations where suitability soil map expresses high capability.

CONCLUSIONS

In order to characterize the viticulture potential, it is necessary to assess the suitability of all environmental and ecological factors that influence the quality of the grapes and wines. Climate, topographical and soil suitability determines environmental assessment of the viticulture potential and suitability assessment.
In this paper the AHP method is used to help an investor to select the location of a vineyard for the production of high-quality wine. The method has the advantage of being able to systematically and reliably analyse multiple environmental criteria. The problem relating to the case study is of great conceptual complexity due to the large number of criteria which had to be taken into account by the AHP. According to the studied region of Karlovo, Bulgaria, the most suitable territory for viticulture is 78% and it is presented by assessment thematic map about distribution of soil vine requirements for white wine production. All area is analysed by AHP method and the sites are suitable for cultivation of vineyards for profitable white wines.
The combination of various and complicated technologies - GIS tools, AHP method and well-established techniques- soil mapping, climate studies, topographic parameters, increases the range and types of data available for analyses of vineyard sites.
This paper explores the aspects of site selection or vineyards zooning that are distinctive to viticulture and can be implemented into complex rated methods for suitability assessment.
Issues that are addressed include significance of location, natural and manipulated factors that affect production and quality, important information to support from spatial systems and the probability of success improved, by the use of spatial information for profitable viticulture practices and management.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Agricultural University-Plovdiv, Bulgaria and Centre of research, technology transfer and protection of intellectual property rights and also was financed from Project 17-12.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE USE OF AERIAL PHOTOGRAPHY DATA AND INSTRUMENTAL DATA IN ADAPTIVE FARMING

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Abstract

This article reveals the practical experience of using aerial photography by drone in combination with analytical methods of chemical analysis of soil samples for solving problems of adaptive agriculture (application of nitrogen fertilizers) for winter wheat by equipment without precision sowing and GPS. In order to solve this problem, aerial photography was conducted according to the phases of winter wheat growth with simultaneous soil sampling and subsequent agrochemical analysis. Based on the obtained information, thematic maps were created in the GIS package ArcGis and flow charts for the application of nitrogen fertilizers. Additional soil samples were sampled in soil contours where winter wheat was lagging behind in growth, as well as additional general soil analysis and the reasons for the lag of wheat growth were identified. Recommendations on the further use of similar methodological approaches in the territory of Ukraine are given.

Key words*: adaptive farming, digital soil mapping (DSM), drone, GIS mapping, soil samples.*

INTRODUCTION

In recent years, due to the increase in the cost of mineral fertilizers, it has become important to decreasing it consumption on farm fields It is logical that the spatial distribution of mineral fertilizers on the field depends on the terrain (microrelief) and land productivity.

Therefore, identification of this relief on the field and continuous monitoring using any systems and methods (ground, remote, contact) comes to the fore. In general, this set of methods has received the name - precision farming.

For practical verification and implementation of the latest research methods (aerial monitoring and it data processing) and instrumental research methods (wet chemistry), a number of industrial experiments were carried out, that results were used as an example in the article.

The aim of the research was to verify the operation of monitoring methods on an industrial scale in a single farm. Adaptive agriculture was understood as the use of simple agricultural implements (without precise sowing and GPS) and the latest monitoring methods.

Simultaneous measurement by contact methods of soil samples was carried out, continuous monitoring with the help of a drone, obtaining orthophotomaps of test fields and their analysis, achieving results on productivity in test fields. A check was also carried out on the economic component of adaptive agriculture.

Tasks:

- laying a network of points for sampling by the "envelope" method and their subsequent optimization using the results of aerial photography;
- soil samples analysis and phyto-indication on test fields;
- development of recommendations for the mineral fertilizer's application, only on soil contours with oppressed vegetation;
- economic efficiency calculation of the results applying complex methods after harvesting.

The experiment processes

For a full-fledged experiment with adaptive farming elements in industrial conditions, at the customer's request, the maximum loading of

their technical capacities was used. We are talking about using an unmanned aerial vehicle of the customer, such as a drone, controlled by operator.

A transfer of source information (aerial photographs) was organized through the web links of information array on special exchange servers to ensure fast processing of data received from the drone on the customer's fields.

Due to this, the total time consumption for survey, processing ("stitching", channel analysis) was reduced to 40 minutes per field. The customer (agronomist) got completely ready cluster graphic file for decision-making throughout for two hours.

MATERIALS AND METHODS

The field stage included the departure on area and soil samples collecting both by the "envelope" method and method based on the results of aerial photography (Solokha M.O., 2019).

Obtaining the aerial photographyresults and orthophotomap creation (Solokha M.O., 2014) were organized via the web-service.

The cameral stage included: channels analysis of the RGB model, systematization of channel indicators for each research object, statistical processing and obtaining dependencies between remote sensing data and laboratory analysis data (Solokha M.A., 2018).

The channels model analysis algorithm of the RGB model sequentially reproduced the stages of obtaining the result of vegetation analysis based on aerial photography.

Using the software ErdasImage 91 allowed obtaining the processed orthophotomap of the study object.

After loading the image into the ErdasImage environment, the following image processing sequence was performed (Figure 1).

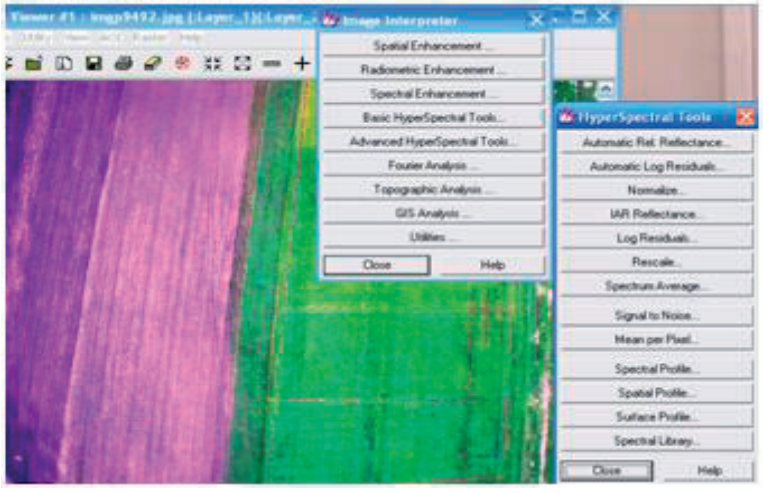


Figure 1 Image processing sequence in ErdasImage

1. At the first stage, RGB processing in ErdasImage was done Sequence Used: Image Interpreter: Basic Hyper Spectral Tools - Automatic Rel Reflectivity, which is due to RGB, which allows you to minimize the impact of negative meteorological factors.

2. The second stage of the processing of the orthophotomap was the gain of each of the channels of the RGB models, which dominate in each pixel. Doing this, we used the Auto Internal Average Relative Reflection menu, which allows obtaining the weighted average reflection coefficient of all three image channels (Figure 2).

A processed orthophotomap in this way allowed carrying out analysis to obtain digital values of each channel for further mathematical processing (Figure 3).

The image located on the right, enhanced after processing, allows us to differentiate visually

from the translucent crop (winter wheat), which is clearly distinguished and can be mathematically processed using tools in ErdasImage software.

3. Obtaining digital numbers (DN) in the image, was selected in the Profile Tabular Data menu of the Statistics menu, where all statistical sampling parameters for the channel were. It allows statistically processing either one channel or a single set, or variants of sets.

As a result, we obtained: a sample for statistical calculations (Figure 4), statistical error, the total sample size and number of values in the calculation, the min-max and average values This allowed us to move on to the mathematical component of the analysis or quantitative analysis of aerial photography and also create a new model for the analysis of research objects, based on the use of ternary or three-dimensional graphs.

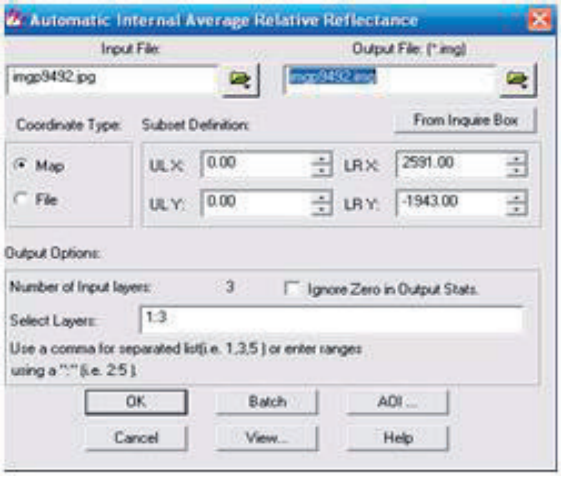


Figure 2. Relative average reflection coefficient analysis menu (based on all channels)

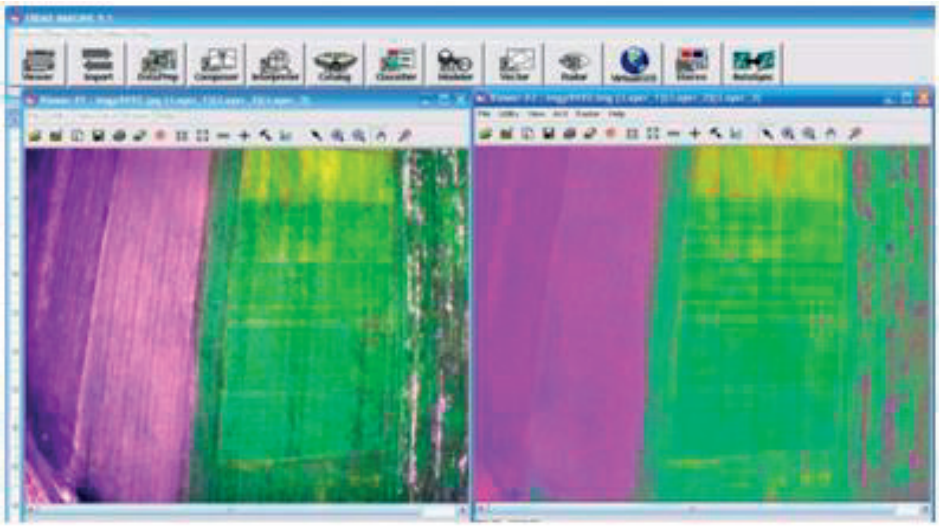


Figure 3. Aerial image before (left) and after processing (right)

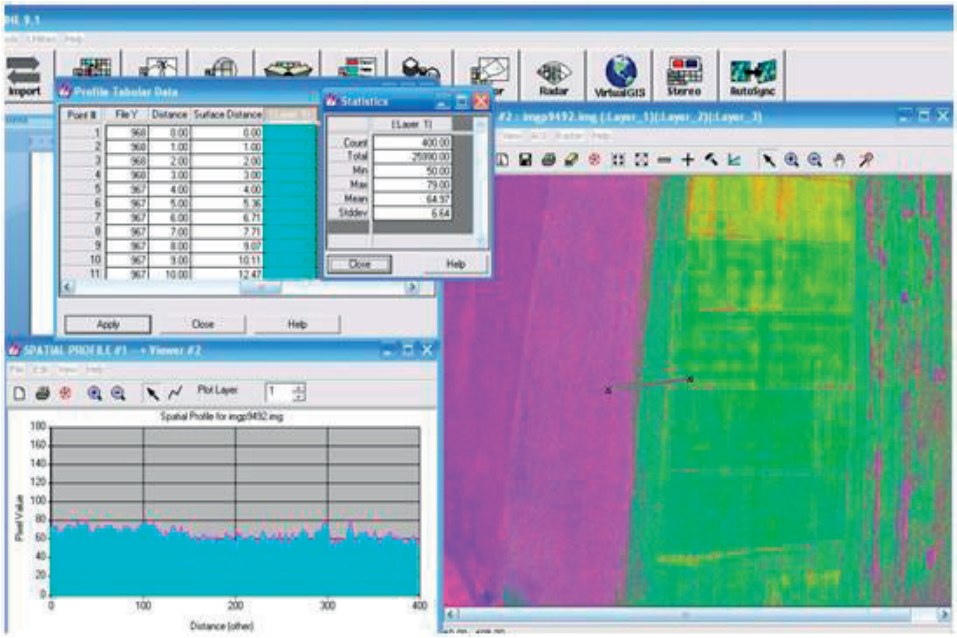


Figure 4. Calculation of R-channel statistics in an aerial photograph

4. The data obtained were entered either in the corresponding software "Statistica" or "Microsoft Excel" and calculated in the form of ternary graphs (in the form of a triangle), or three-dimensional graphs used to study the correlation between several variables Methodical approach developed by (ShMDavis, DMLandgrebe, TLPhillips 1983), is based on spectral responses of measurements of natural objects, was used basis They invent own methodological approach using all three channels of the RGB model, in the form of three-dimensional (ternary) graphs (Figure 5).

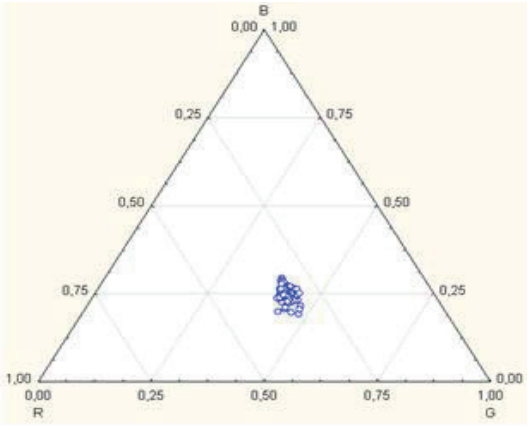


Figure 5. Ternary channel graph of the RGB model

To determine the crops classes or the crop state on the field, which was shown in aerial photographs a mathematical analysis of ternary graphs was carried out. During changing the value of all RGB model channels determinate, is the value optimal for the culture (based on many years of experience) or not. After that an appropriate managerial decision is make.

The points shown in Figure 5 are located on the ternary plot depending on the factors of influence (wheat sort and the influence of the microrelief), which indicates whether the crop is in the optimal growth or not.

Mapping

Office work was carried out using methods of analysis, synthesis and digital soil mapping (DSM) using GIS technologies.

Cartographic work was performed in the ArcGIS 105 software product. On the basis of aerial photographs and analytical information on the physical and chemical parameters of the soil using GIS, agrochemical maps have been built. To solve issues, the most important information is the presence of trace elements and the amount of organic carbon (humus) in the soil. Maps were constructed for four key indicators: phosphorus (mg/kg), nitrogen (mg/kg), potassium (mg/kg), humus (%).

The construction of maps was carried out by interpolation by aninverse distance weighted (IDW) technique (Watson D.F., Philip G.M., 1985). The output value for the cell, calculated using the IDW method, is limited to the range of values used for interpolation. Since the IDW method finds the average based on the weighted distance to the reference points, the average cannot exceed the highest input value and cannot be less than the lowest value. For the best qualitative and proportional distribution of spatial information, using the most optimal values for this territory. The output cell size is 238. Degree, i.e. the significance of points located in the vicinity of the interpolated value equal to 2. The search radius is variable. The number of nearest input control points is used by default.

RESULTS AND DISCUSSIONS

On the test fields before the season of winter wheat top dressing (Shestopalovka sort), samples were taken according to DSTU 4287: 2004 (DSTU 4287: 2004). Location of soil sampling points on the Izyum city cluster - Lipchanivka village is shown in Figure 6 using field № 21 as an example.

Note:

point 1: X = 37387676, Y = 49329106;
point 2: X = 37391143, Y = 49331970;
point 3: X =3 7392325, Y = 49334545;
point 4: X = 37397743, Y = 49332000;
point 5: X = 37392530, Y = 49328729

The following data were obtained, as a result of chemical analysis (Table 1)

Figure 6. Coordinates of field № 21 sampling points

Table 1. The results of the agrochemical analysis of soil samples taken in field № 21

№	Field number - the first two figures, sample's number - the last figure	Ammonium and nitrate nitrogen DSTU 4729:2007		Phosphorus and potassium by Chiricov method DSTU 4115-2002		Organic carbon DSTU 4289:2004		pH of a water extract DSTU 8346:2015
		$N\text{-}NO_3$ mg/kg	$N\text{-}NH_4$ mg/kg	P_2O_5 mg/kg	K_2O mg/kg	C %	Humus %	pH units
1	211	6.70	4.56	14.66	224.13	3.10	5.3	7.85
2	211	9.60	5.67	25.65	238.59	3.08	5.3	7.60
3	213	4.50	3.97	18.55	180.75	2.92	5.0	6.90
4	214	6.60	6.51	21.07	231.36	2.68	4.6	8.15
5	215	3.40	5.11	11.91	209.67	2.68	4.6	8.14

According to the conditions of the experiment, it was not planned to measure soil quality indicators, except for agrochemical and pH. The result of constructing maps - distribution of macronutrients over field № 21 (Figure 7a-d).

The humus content in the soil on field № 21 at points 1 and 2 is very high; 3, 4 and 5 - high. According to pH value, the soil of point 3 of is neutral; points 1 and 2 - slightly alkaline and points 4 and 5 - medium alkaline. The content of mineral nitrogen in the soil of points 1, 2 and 4 is low, the remaining points of all fields are lowest (less than 10 mg/kg with a fluctuation in the range of 69-97 mg/kg). This shows expediency top dressing by nitrogen in spring.

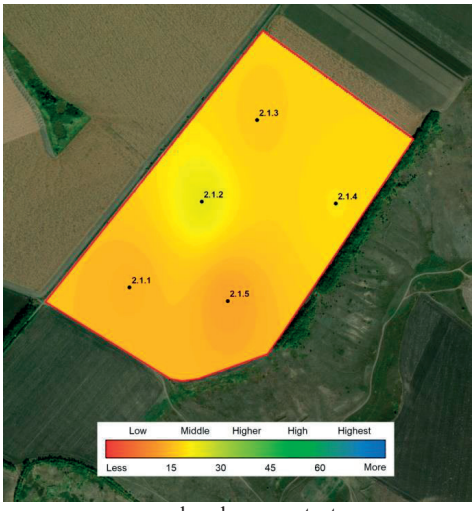
Based on the results of the analysis, doses of nitrogen fertilizer application were developed to Lipchanivka village in 2019 an example for the field № 21 given below.

Recommended doses of nitrogen fertilizers in kilograms of active substance per hectare, according to the analysis on the field № 21, are: Point 211 - N45, point 212 - N40, point 213 - N70, point 214 - N40, point 215 - N70.

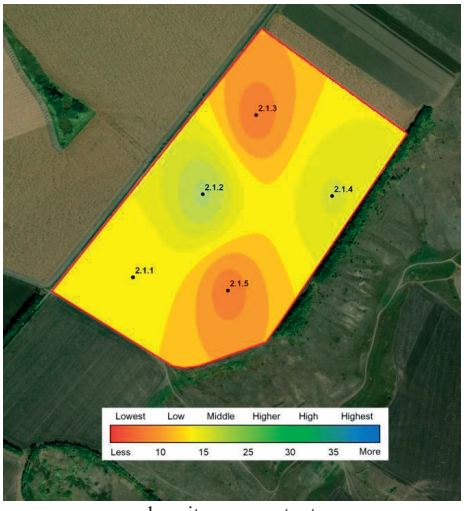
Given doses to prevent nitrogen loss, it is advisable to applicate in 2 doses – half on frost-thawed soil, half – after the resumption of plant vegetation.

Since the soil of field 21 is characterized by a low and medium content of mobile phosphorus, it is advisable to applicate ammophos or nitroammophos in it.

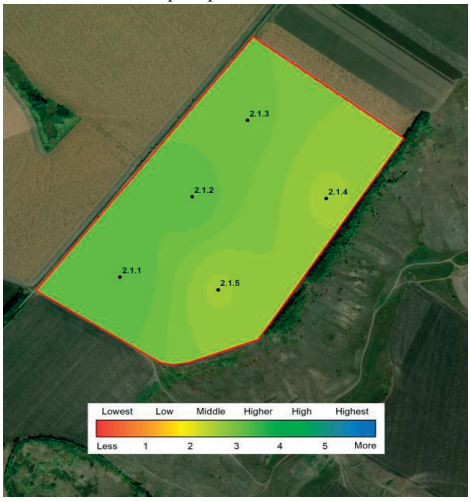
After obtaining data on the state of macro-indicators on the field using GIS tools, routes were developed for the differential application of mineral fertilizers using ordinary agricultural equipment (MTZ, etc). Figure 8 Several rounds of aerial photography from a drone were carried out after making the planned fertilizers in the fields. The main goal is to assess the state of agricultural vegetation in these fields (monitoring) Figure 9 (a-d).



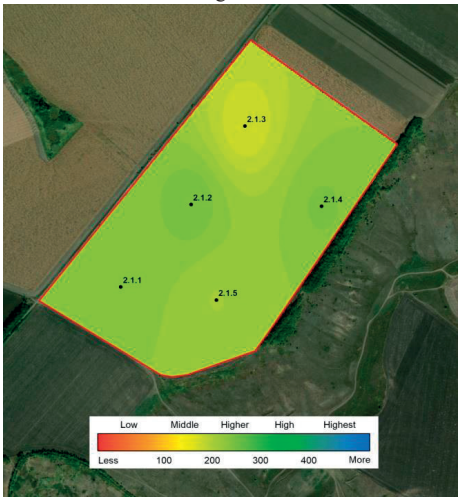
a – phosphorus content



b - nitrogen content



c - humus content



d - potassium content

Figure 7. Distribution of humus and macronutrients in the field № 21 (a-d)

Figure 8. Estimated routes of agricultural machinery in the field № 21

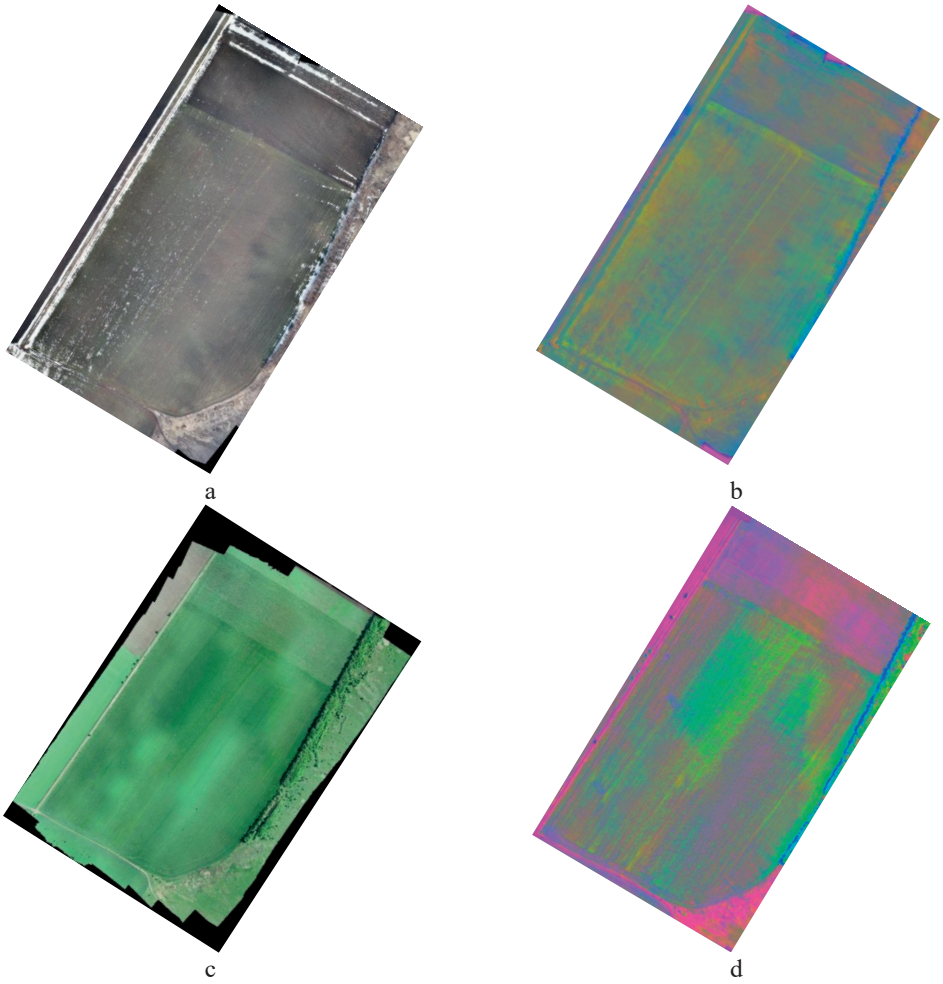


Figure 9. Field № 21 Image obtained in March (a), spectrally processed image (b) of the same date, image obtained in May (c), spectrally processed image (d) of the same date

According to the results of the flight, the dynamics of growth of winter wheat in the field № 21 was watched It has been established that since April, the lag in the growth of culture was observed in the eastern part of the field (a, b), and in the south of the field. The overflights in May showed (c, d) that the culture continues to be stunted and will not be able to produce the planned crop. Therefore, an additional survey of field № 21 was carried out on agrochemical indicators (Tables 2, 3, 4) and an added soil sample was taken in the south part of the field.

Table 2. Hydrolytic acidity and exchangeable cations on the field № 21

№, depth of selection	Hydrolytic acidity DSTU 7537:2014 cmolc kg^{-1}	Exchangeable cations ДСТУ 7861:2015 Number of equivalents of exchangeable cations cmolc kg^{-1}				
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	∑
10-30 cm	1.86	16.70	2.58	0.09	0.37	19.74
230-60 cm	1.06	16.12	1.94	0.09	0.28	18.43

Table 3. Cationic-anionic composition of the soil sample from field 21

Laboratory number	pH	Cl^{-}		SO_4^{2-}		Ca^{2+}		Mg^{2+}		Na^{+}		K^{+}		∑ equiv of cations, cmolc kg^{-1}
		Number of equiv cmolc kg^{-1}	Mass fraction, %	Number of equiv cmolc kg^{-1}	Mass fraction, %	Number of equiv cmolc kg^{-1}	Mass fraction, %	Number of equiv cmolc kg^{-1}	Mass fraction, %	Number of equiv cmolc kg^{-1}	Mass fraction, %	Number of equiv cmolc kg^{-1}	Mass fraction, %	
1	6.29	0.09	0.003	0.26	0.012	0.18	0.004	0.22	0.003	0.03	0.001	0.02	0.0008	0.45
2	6.30	0.09	0.003	0.18	0.009	0.18	0.004	0.17	0.002	0.03	0.001	0.02	0.0008	0.40

Table 4. Granulometric composition of the soil sample from field 21

DSTU 4730: 2007, №	Granulometric fraction content, %						
	1-0.25 mm	0.25-0.05 mm	0.05-0.01 mm	0.01-0.005 mm	0.005-0.001 mm	< 0.001 mm	Sum of fractions < 0.01
1	9.7	24.90	26.57	6.38	6.02	26.16	38.56
2	10.79	32.46	21.32	5.66	7.21	22.56	35.43

The analysis of soil samples showed that the sum of salts in the 0-30 cm layer is 19.74 cmolc kg^{-1}, in the 30-60 cm layer – 18.43 cmolc kg^{-1} of soil, which indicates that no salinization in the field №21 (Table 3), the capacity of the absorbed bases is small (Table 2) and the content of physical clay is quite high (Table 4).

Table 5 The results of the bunkering of winter wheat grain sort "Shestopalovka" on the field № 21

Field №	Area, ha	Ammonium nitrate, t/ha	Grinding, centners	Yield, centners/ha
2/01 (test part)	38	67	121 660	32
2/1 (part of the field where conventional technology was used)	34	5	108 620	319
Total	3435	595	1365 950	

The economic effect of an adaptive farming experiment

The results of the economic effect of the adaptive farming experiment are given in Table 5.

According to the data of Table 5 in the field (test plot under adaptive farming) № 2/01 with an area of 38 ha with the addition of ammonium nitrate of 67 t/ha, with a grinding of 121660 centners, the yield was 32 centners/ha. On the field № 2/1 with an area of 34 ha, with fertilizer application of 5 t/ha, with grinding of 108 620 centners, the yield was 319 centner/ha. In general, on an area of 343.5 ha and an ammonium nitrate application of 59.5 t/ha, the grinding made up 1 365 950 centners, while the economic effect amounted to 344 604.17 UAH.

CONCLUSIONS

1. Before conducting research and sowing crops, it is necessary to analyze the soil of the studying area for the granulometric composition as well as the content of absorbed bases.
2. After receiving the results of soil analysis for the content of absorbed bases and the granulometric composition, it is necessary put in order the technological map of soil contours processing into the field (if, as a result of the analysis, the granulometric composition is lightweight - top dressing should be done according to the sheet, if not, in the traditional way).
3. It is imperative to orient the passes of equipment for the soil cultivating and fertilizing plants based on the identified soil contours and contours of agricultural vegetation with different colors in aerial photographs.
4. The approach with sending operational monitoring information (aerial photography) via the web has completely paid off, which has reduced the time for analyzing information to several hours and seriously reduced errors in creating orthophotomaps.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

REMOTE SENSING TENDENCIES IN THE ASSESSMENT OF AREAS DAMAGED BY ARMED CONFLICTS

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Abstract

War and armed conflicts have been shown to contribute directly to decreased landscape values and environmental degradation, especially in developing and tropical countries. This paper presents a methodic review approach designed to analyze the relationship between drivers and remote sensing methods in areas affected by armed conflicts. The document seeks beyond showing and comparing a series of cases where the various remote sensing methods have been used, seeks to find trends, patterns of repetition or non-repetition, points of convergence and divergence taking into account variables such as area, scale, satellite sensors used, and geographic conditions to determine the relationship between causes and consequences of the conflict with the remote sensing methods. We collected data from international peer-reviewed journals that are indexed using scientific search engines as Scopus and Science Direct. We analyzed 43 research papers from 1998 to 2019 time-lapse that used satellite imagery and aerial photos in 21 countries of 4 continents to assess environmental effects caused by armed conflicts. Quantitative analysis of the trends identified within these areas contributed to an understanding of the reasons behind these conflicts.

Key words*: armed conflict, deforestation, forest cover, land use change, remote sensing.*

INTRODUCTION

Principles for remote sensing of violent conflict

The utilization of remote-sensing analysis to study violent conflict has increased considerably over the last 10 years and the trend shows that is going to keep growing steadily (Witmer, 2015). This recent increase has been driven, in part, by the conflicts in the Sub-Saharan region, Latin-American region and the higher availability of ultra-fine resolution satellite imagery (Butsic et al., 2015; Leiterera et al., 2018; Gorsevski et al., 2012; Rincon-Ruiz et al., 2013; Potapov et al., 2012; Sanchez-Cuervo & Aide, 2013; Murad and Pearse, 2018).

Originally remote sensing methods including aerial photos analysis in armed conflict areas were used for military purposes because the military field has been for a long-time source of innovation and has had enough financial resources to invest in remote sensing technology researching (Corson and Palka, 2004). Improvements in the remote sensing technology and satellite imagery have increased the effectiveness of armies and the accuracy of military operations (Witmer, 2015).

The difficulty of access to an area during wartime combined with no clear spatial or temporal definition for the extent of conflict makes an accurate and timely assessment of the impacts extremely challenging (Butsic et al., 2015).

Because of these limitations, information derived from satellite remote sensing data can provide insight into how conflict directly affects the physical environment during wartime and indirectly leads to changes in human populations and land use activity that drive the observed land cover modifications.

The impacts of armed conflicts on ecosystems are complex and difficult to assess due to restricted access to affected areas during the war, making satellite remote sensing a useful tool for studying the direct and indirect effects of conflicts on the landscape (Murad & Pearse, 2018; Hoffmann et al., 2018). Since World War II, 80% of armed conflicts occurred directly at biodiversity hotspots, most of which are tropical forest regions (Hanson et al., 2009). Due to this high spatial correlation and the need for increased conservation efforts, the

relationship between war and the environment needs to be further examined (Ordway, 2015).

Sensors and Satellite Imagery.

Remote sensing technology is based on the detection of electromagnetic energy reflected or emitted from a surface without making physical contact with it.

There are two types of remote sensing approaches; passive is based on solar radiation reflected or emitted from a surface, while active remote sensing generates radiation impulses and detects the reflected signal. Most conflict-related research uses passive technology mounted on a satellite platform (Witmer, 2015).

There are also two types of images available; the free online images (e.g. Google Earth), these images have the disadvantage that they only provide information in the visible range, without multispectral data in the infrared range. These images can be very useful, for example, as ground reference data used to confirm conflict-related land abandonment and to corroborate the effects of war.

Resolution is a key consideration in the use of remote sensing. Spatial, spectral and temporal resolutions are perhaps the most relevant, but radiometric resolution also affects what can be detected.

Table 1 lists the sensors commonly used to study the effects of violent conflict. The sensors are grouped by spatial resolution using the category jumps found in the SAGE Remote Sensing Manual (Warner, Nellis and Foody, 2009), where the very fine spatial resolution images are ≤ 1 m, fine 1-10 m, moderate 10-250 m, and coarse > 250 m (Table 1).

Direct and Indirect Drivers

Armed conflict and post-conflict development may interact with land use and land cover activities to influence the modification of the landscape and severity of forest deterioration. Land use has contributed to the recent overwhelming decline in biodiversity through habitat fragmentation, modification and loss, leading to degradation of ecosystems and environmental services (Ordway, 2015; Nackoney et al., 2014; Qamer 2012 et al., 2005; van Etten et al., 2008). The growing body of literature addressing various direct and indirect impacts of armed conflict on the environment has raised a number of hypotheses (Black, 1994; Jarret, 2003; Machlis and Hanson, 2008; McNeely, 2003; Omar et al., 2009).

Table 1. Characteristics of commonly used sensors (Source: Witmer, 2015)

Sensor	Spatial resolution (m)	Swath width (km)	Spectral bands	No. Studies
Very fine spatial resolution (≤ 1 m)				
QuickBird	0.6	30	Pan	3
World View	0.5	18	Pan	2
IKONOS	0.8	11	Pan	3
GeoEye	0.5	10	Pan	1
Fine spatial resolution (1-10 m)				
GeoEye	1.6	10	4	1
QuickBird	2.4	30	4	3
SPOT	2.5	60	Pan	4
IKONOS	3.2	11	4	3
IRS LISS 4	6	25.70	5	0
Moderate spatial resolution (10-250 m)				
SPOT	10, 20	60	4	4
IRS LISS 3	6, 23, 70	70,140	5	1
Landsat 8 OLI	15, 30		11	6
Landsat 6-7 ETM +	15, 30		8	19
Landsat 4-5 TM	30	185	7	20
Landsat 1-5 MSS	60, 120		4	3
Coarse spatial resolution (> 250 m)				
MODIS	250, 500, 1000	2330	36	4
AVHRR	1100, 4400	2500	5.6	1
DMSP-OLS	2700	3000	2	

Studies have shown that conflict and war can drive deforestation or promote forest recovery (Alvarez, 2003; Biswas and Tortajadaquiroz, 1996; Dávalos, 2001; Hecht and Saatchi, 2007; Lodhi et al., 1998; McNeely, 2003) (Figure 1).

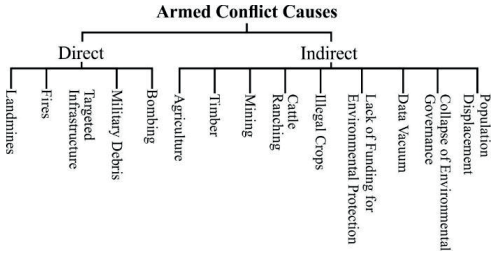

Figure 1. Causes on environment based on Jha, 2014

Direct impacts are all events that are physically related to direct military action of confrontation and that frequently arise in the immediate or short term (bombings, direct armed confrontations, military structure), while indirect impacts are those that are generally linked to many factors not necessarily military triggered by the armed conflict and only manifest themselves completely in the medium or long term (Jha, 2014; Partow, 2008). Some examples of direct impacts include the deliberate destruction of natural resources, environmental pollution from the bombing of industrial sites and military debris and demolition wastes from military infrastructure.
On the other hand, indirect effects include the environmental footprint of displaced populations, deforestation due to new colonization areas, the possible creation of illegal crops and illegal mining, the collapse in the implementation of environmental regulations and the information vacuum, as well as the lack of funds for environmental protection. Another additional problem is that any war destroys buildings and infrastructure that must be rebuilt and consume large resources and increase extensions (Jha, 2014; Solomon et al., 2018) (Figure 2).

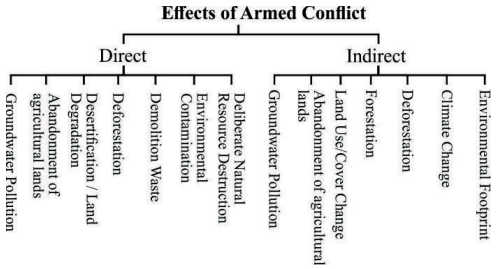

Figure 2. Effects of conflict on environment based on Jha, 2014

Besides and complementing the aforementioned Witmer states that the effects can be categorized into four groups, sorted by the time for which each effect normally requires to be visible. For example, physical damage induced by bomb or fire detonations is often a very immediate impact, which occurs in minutes or hours. Other effects such as environmental damage (hours to days), population forced and unforced movement (days to months) and changing land cover/use (months to years) take more time to materialize. Although there is some overlap between the different effects of the conflict between direct and indirect, this categorization generates a useful way of approaching research (Figure 3).

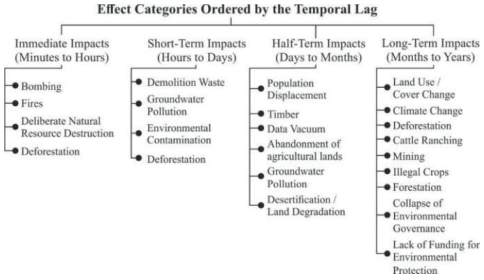

Figure 3. Effects ordered by temporal lag (Source: Witmer, 2015)

Aim

The aim of this paper is to offer an overview of the most important trends in the usage of remote sensing methods as a media of environment affectations assessment in conflict areas. Our study aims to demonstrate the specific correlation between armed conflicts (causes) and environment (consequences) using state-of-the-art remote sensing technology to provide conditioned geo-spatial environmental information. More specifically, this paper presents an integrative and transferable approach for the quantification, systematic comparison, and an evaluation of the remote sensing methods used in areas affected by armed conflicts.
Therefore, this approach not only produces a spatial delimitation and prioritization of armed conflict based on context-specific landscape values, but it also characterizes the underlying drivers of conflict based on the qualitative understanding of affectation indicators. We demonstrate the utility of satellite-based remote sensing techniques for monitoring difficult hard access zones and examining the different links during wartime and post-conflict periods observing modification, repetition and difference patterns in the environment.
The questions motivating this review are:
- How is the relationship between armed conflict causes (indirect and direct drivers) and environmental consequences using remote sensing analysis?

- Which are the direct and indirect consequences that can be analyzed by remote sensing methods?
- Which is the connection between the drivers and satellite imagery sensors and spatial resolution?
- What might the future hold for the remote sensing of armed conflict?

MATERIALS AND METHODS

We reviewed papers published in international peer-reviewed journals that are indexed using Scientific Search Engines as Scopus and Science Direct from 1998 to 2019 (Figure 4).

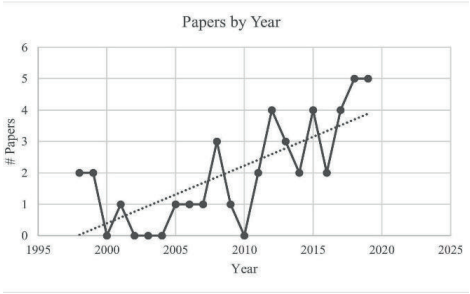

Figure 4. Papers by year

We searched the terms “Remote sensing + Armed Conflict”, “Land Use Changes + Armed Conflict” and “Deforestation + Armed Conflict”, finding 2554 papers related, after we made a filtered search based on the parameters of indicators (Sensors, Scale, Causes, Consequences, etc.) we depured and analyzed 114 papers deeper, after the second review, we chose 43 documents that fulfilled with all or almost all the information required for the review. The documents retrieved from the various searches were read, evaluated and synthesized in the write-up.

We collected data from 43 research papers that used satellite imagery and aerial photos. We searched data of study area size, armed conflict causes and consequences, types of causes (direct or indirect), forest cover affectation (increase or decrease), time-lapse, data set source (satellite sensor), spatial resolution, conflict period and site focus.

Quantitative analysis of the parameters identified within these areas contributed to an understanding of the reasons behind these affectations and their correlations. The resulting inventory mapping comprises statistics charts, patterns, trends, and findings on the remote sensing and its relationship with armed conflict.

The target of this paper is to review the environmental impacts of armed conflict in the world and where have been studied using remote sensing methods. We found that at least in 21 countries of 4 continents this methods have been used (Afghanistan, Belgium, Bosnia & Herzegovina, Cambodia, Colombia, El Salvador, Kuwait, Liberia, Myanmar, Nicaragua, Pakistan, Republic Democratic of Congo, Rwanda, Sierra Leona, South Sudan, Sri Lanka, Syria, Thailand, Turkey, Uganda, Zambia) (Figures 5 and 6). This was done in the context of a comprehensive review, the process of collecting, appraising, and then synthesizing data from a large number of sources.

The main method for selecting the literature was cumulating research findings across different studies on the same issue which, in our case, was “remote sensing of environmental impacts of armed conflict”.

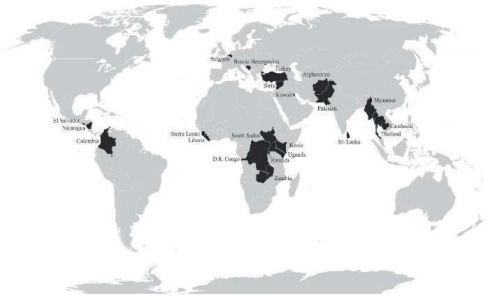

Figure 5. Papers location by country

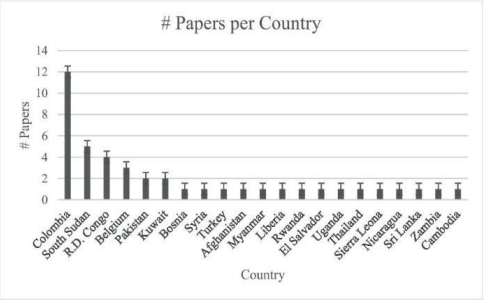

Figure 6. Distribution by country

RESULTS AND DISCUSSION

Geographical results.

The research geographically covered worldwide papers without distinction of latitudes or spatial conditioning, within the search it was found that most of the papers that used remote sensing to analyze the environmental effects in areas affected by armed conflicts, are in areas near the Equatorial line, which in turn are the most highly biodiverse areas of the planet, countries like the Democratic Republic of Congo, South Sudan, and Colombia concentrate almost half of the papers; 21 of the 43 analyzed. Thirteen papers are scattered in small quantities (1 to 3 papers per country) in other tropical areas near the equator, especially in Southeast Asia (Myanmar, Cambodia, Sri Lanka and Thailand), in Sub-Saharan Africa (Rwanda, Liberia, Sierra Leone, Uganda) and in Central America (Nicaragua and El Salvador). On the other hand, nine papers are geographically located in Europe (Bosnia Herzegovina and Belgium) and Western Asia (Syria, Turkey, Afghanistan, and Pakistan), areas where on average the forest cover is lower and the arid, semi-arid or grassland areas are predominant. An exception is made for two research, one in the case of Belgium papers that refer to remote sensing methods using aerial photographs to analyze effects on the landscape during the First World War (Gheyle et al., 2018; Note et al., 2018). And the second is the analysis of the conflict intensity in Arab countries especially in Syria during the Arab revolution (Levin et al., 2018). Some works use remote sensing images to assess the ecological and wildlife consequences of the conflict or to identify populations at risk of conflict, but these lines of research are beyond the scope of this review and therefore were not considered for this investigation.

The outcome yielded by the research were obtained by cross-checking the data between geographical location and the causes of the impact on the environment. These indicate that regarding to direct causes (Bombing, Direct Confrontation/Military Infrastructure and Landmines) the papers that focused on the bombings (10) are spatially located in countries mostly outside the intertropical area such as Belgium and Kuwait (5) and to a lesser extent (3) in Bosnia, Syria and Turkish Kurdistan and few (2) in tropical areas such as Sierra Leone and Cambodia. The papers of direct confrontation and/or military infrastructure (9) were carried out more spread in countries of diverse regions as Colombia and Congo (3) and equally and jointly in Kuwait, Syria, Turkey, Sierra Leone, Cambodia, and Liberia. In terms of the use of remote sensing to analyze the use of landmines and their impact on the environment, there were only two documents on this subject in Sri Lanka and Bosnia-Herzegovina each. In terms of the geographical location of the papers that through satellite image analysis studied the indirect causes, it was found that most of the forced migration was analyzed in African countries (11), Colombia and Central America (4), Southeast Asia (2), Pakistan (2) and Bosnia (1), being the indirect cause, most analyzed. Concerning unforced migration, three documents were found in Africa and one more in Sri Lanka. Mining as an indirect cause has been studied in Colombia (3), Congo (2) and Liberia (1) times. Illicit crops as an indirect cause have been studied by remote sensing mainly in Colombia (5) and to a lesser extent in Afghanistan and Myanmar with one study each. Agriculture as a direct cause has been strongly studied in Colombia (5) and in one study each in Pakistan and Afghanistan, as well as livestock has been an indirect cause of study in Colombia (5) and Afghanistan (1). Finally, logging (2) and fires (1) have only been studied in Colombia through the use of remote sensing (Figure 7).

Subsequently, the literature review found that the geographical location of the papers that through satellite image analysis studied the consequences of the armed conflict on the environment are distributed as follows: deforestation mostly in Colombia (11), Central America (2), Sub-Saharan Africa (12) especially in South Sudan (4) and Congo (3), in Southeast Asia (3) comprising Myanmar, Sri Lanka and Cambodia with one paper each, East Asia; Pakistan (2), Turkey and Afghanistan 1 each, being the most studied consequence (32).

Regarding afforestation as a consequence, only South Sudan (1) and Uganda (1) were analyzed. Desertification and land degradation were studied in South Sudan (2), Liberia (1)

and Uganda (1). In terms of land-use change, 24 related documents were found in total, distributed as follows: Colombia (8), Congo (3), South Sudan (2), Liberia (1), Zambia (1), Myanmar (1), Thailand (1), Sri Lanka (1), Pakistan (1), Kuwait (2), Turkey (1), Afghanistan (1) and Bosnia-Herzegovina (1). Mine craters were studied only in Congo (1) and Belgium (2). Regarding military infrastructure as a consequence, they were also studied only in Congo (1) and Belgium (1). The abandonment of agricultural lands was analyzed scattered in Africa (2) Western Asia (2) and Europe (1). Finally, water pollution has been studied only in southern Sudan and Kuwait (1) each, through the use of remote sensing methods (Figure 8).

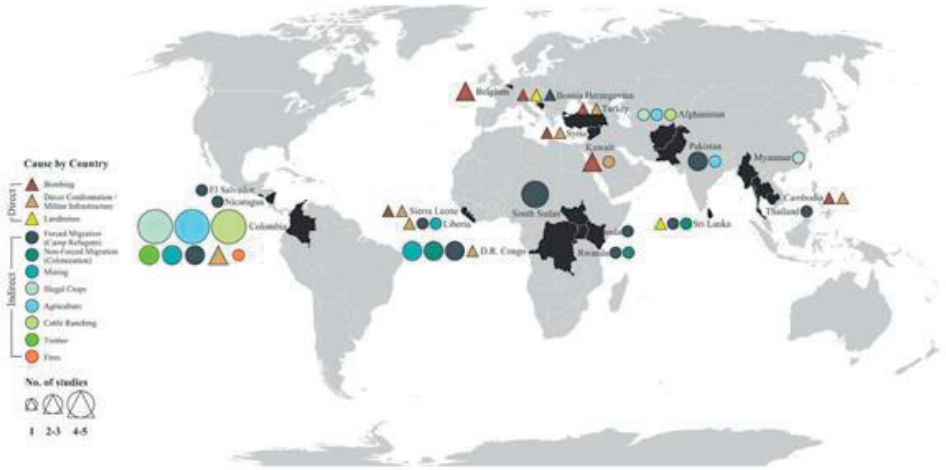

Figure 7. Armed conflict causes analyzed using remote sensing by countries

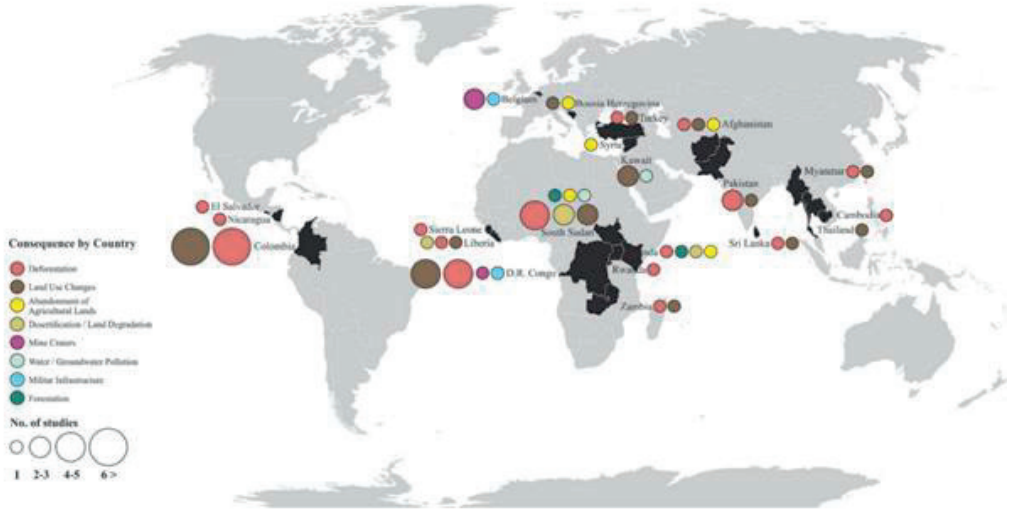

Figure 8. Armed conflict consequences analyzed using remote sensing by countries

Satellite Imagery Results.

Based on the SAGE Remote Sensing Manual classification, we found that 14 papers used Very fine spatial resolution (≤ 1 m) and/or Fine spatial resolution (1-10 m), including SPOT-5 (4), QuickBird (3), IKONOS (3), WorldView-2 (2), GeoEye (1) and ALOS (1) sensors.

Regarding Moderate spatial resolution (10-250 m) we found that is the most times used for Remote Sensing analysis (53), segmented by Landsat 1-5 MSS (3), Landsat 4-5 TM (20), Landsat 7 ETM+ (19), Landsat 8 OLI (6), ASTER (2), Google Earth VHR (1), Sentinel-2 (1) and IRS - LISS-III (1) sensors. Finally, in terms of Coarse spatial resolution (> 250 m), 6 papers used these kinds of sensors; Modis (4), VIIRS (1) and AVHRR (1). It is important to clarify that several papers used more than one sensor to complement the gaps of information that the use of a single sensor can offer, this results in each paper can use satellite images of more than one sensor and makes the statistical study more complex to analyze. It is also important to clarify that aerial photos, Viewit, and RapidEye sensors are not categorized within the SAGE table (Figure 9).

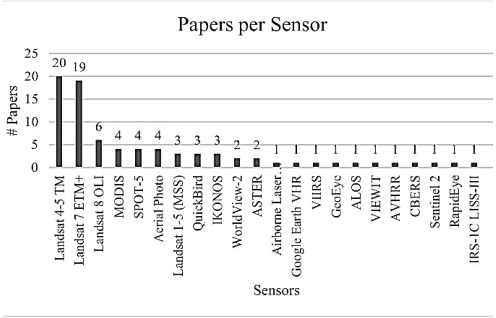

Figure 9. Papers per sensor

Sensors and Causes

In the table of the relation between the analysis of causes generated by armed conflicts and the crossing of data from satellite sensors, we could find that the use of remote sensing is almost five times less for the analysis of direct causes (29) compared to the use of indirect causes (118). In detail and regarding to direct causes (Bombing, Direct Confrontation / Military Infrastructure and Landmines) the Landsat 4-5 TM and Landsat 7 ETM+ moderate spatial resolution sensors are the most commonly used, in five papers for the case of bombing and direct confrontation, it is also worth noting the use of aerial photos for the analysis of bombings (3), ALOS (1) and QuickBird (1).

For the analysis of confrontation and/or military infrastructure, sensors such as Landsat 8 OLI (1), VIIRS (1) were used.

Finally, and to a considerably lesser extent for the analysis of landmines, high-resolution sensors such as QuickBird (1) and moderate resolution Landsat 4-5 TM (1) and Landsat 7 ETM+ (1) were used.

With respect to the indirect causes analyzed by remote sensing, it was found that forced migration was the one that used the most sensors (38), mainly moderate resolution sensors; Landsat 4-5 TM (11), Landsat 7 ETM+ (9), Landsat 8 OLI (3), Landsat 1-5 MMS (2), Google Earth VHR (1). The very high and high-resolution sensors SPOT-5 (2), QuickBird (2) and World View-2 (3). For the analysis of unforced migration, the most used sensors were Landsat 4-5 TM (3) and Landsat 7 ETM+ (4).

For mining moderate and low-resolution sensors were used as Landsat 4-5 TM (2), Landsat 7 ETM+ (6), Landsat 8 OLI (3), ASTER (1), Sentinel-2 (1), CBERS (1) and RapidEye (1). When analyzing illicit crops, the use of very high and high-resolution sensors such as SPOT-5 (1), QuickBird (1), IKONOS (1), GeoEye (1) and ALOS (1) was more noticeable.

Moderate-resolution sensors were also very relevant for the monitoring of illicit crops Landsat 4-5 TM (2), Landsat 7 ETM+ (3), Landsat 8 OLI (1), ASTER (1).

The causes of affectation such as agriculture and livestock were analyzed mainly by Landsat 1-5 MSS (2) Landsat 4-5 TM (7), Landsat 7 ETM+ (10), Landsat 8 OLI (5), ASTER (2), by high resolution sensors; SPOT-5 (1) and GeoEye (2) and by uncategorized sensors such as CBERS (2) and RapidEye (2) times.

Finally, the Landsat 4-5 TM (3) and Landsat 7 ETM+ (3) sensors were used to analyze logging and fires (Table 2).

Table 2. Cause vs Sensor

Cause vs Sensor		Direct			Indirect								
		Bombing	Direct	Landmines	Forced	Non-Forced	Mining	Illegal Crops	Agriculture	Cattle Ranching	Timber	Fires	**Total**
Very fine (≤1m) and Fine (1 - 10m)	SPOT-5				**2**			**1**	**1**				4
	Quick Bird	**1**		**1**	**2**			**1**					5
	IKONOS							**1**					1
	World View-2				**3**	**1**							4
	GeoEye							**1**	**1**	**1**			3
	ALOS							**1**					1
Moderate (10-250 m)	Landsat 1-5 (MSS)				**2**				**1**	**1**	**1**		5
	Landsat 4-5 TM	**5**	**5**	**1**	**11**	**3**	**2**	**2**	**4**	**3**	**2**	**1**	39
	Landsat 7 ETM+	**3**	**4**	**1**	**9**	**4**	**6**	**3**	**6**	**4**	**2**	**1**	43
	Landsat 8 OLI		**1**		**3**	**1**	**3**	**1**	**3**	**2**			14
	ASTER						**1**	**1**	**1**	**1**			4
	Google Earth VHR				**1**	**1**							2
	Sentinel 2						**1**		**1**	**1**			3
Coarse (>250	MODIS				**3**								3
	VIIRS	**1**	**1**										2
	AVHRR				**1**								1
No Category	Aerial Photo	**3**	**1**		**1**								5
	CBERS						**1**		**1**	**1**			3
	Rapid Eye						**1**		**1**	**1**			3
	Airborne Laser Scanning (ALS)	**1**											1
	ESDA							**1**					1
	Total	14	12	3	38	10	15	13	20	15	5	2	

Consequences and sensors.

Crossing the analysis of the consequences of armed conflicts on the environment with the use of satellite sensor data, we could find that the use of remote sensing is strongly focused on the analysis of deforestation (63) and changes in land use (49). In detail and concerning deforestation very fine and fine sensors were used: SPOT-5 (1), QuickBird (2), IKONOS (1), WorldView-2 (1), GeoEye (1) and ALOS (1).

The use of moderate resolution sensors was the highest (42) segmented by; Landsat 1-5 MSS (3) Landsat 4-5 TM (16), Landsat 7 ETM+ (16), Landsat 8 OLI (4), ASTER (2) and Sentinel-2 (1). Low resolution and non-categorized sensors were used in a small proportion to analyze deforestation, MODIS (3), AVHRR (1), Aerial Photos (1), CBERS (1), RapidEye (1), ESDA (1), ViewIt (1) and IRS 1C LISS (1). As for the effects of land-use changes, very fine and fine sensors were used: SPOT-5 (3), QuickBird (2), IKONOS (1), WorldView-2 (2), GeoEye (1) and ALOS (1). The use of moderate resolution sensors was the highest (31) segmented by; Landsat 4-5 TM (11), Landsat 7 ETM+ (10), Landsat 8 OLI (6), ASTER (2), Google Earth VHR (1) and Sentinel-2 (1).

Low resolution and non-categorized sensors were used, but in a small proportion to analyze changes in land use, MODIS (2), AVHRR (1), CBERS (1), RapidEye (1), ESDA (1), ViewIt (1) and IRS 1C LISS (1). As for the other consequences of the armed conflict on the environment, we find that they have been considerably less studied from remote sensing approaches.

In the case of Afforestation, Desertification and Land Degradation, Landsat 4-5 TM (3), Landsat 7 ETM+ (3), MODIS (2), QuickBird (1) were used. For mine craters and military infrastructure, Landsat Landsat 4-5 TM (2), Landsat 7 ETM+ (2) and ALS (1) were the only ones used.

Abandonment of agricultural land is the third most analyzed using various types of sensors such as; Landsat 4-5 TM (3), Landsat 7 ETM+ (2), MODIS (2), QuickBird (1), GeoEye (1) and VIIRS (1) (Table 3).

Table 3. Consequence vs Sensor

Consequence vs Sensor		Deforestation	Forestation	Desertification / Land	Land Use Changes	Mine Craters	Militar Infrastructure	Abandonment of	Groundwater Pollution	**Total**
Very fine (≤1m) and Fine (1 -	SPOT-5	**4**			**3**					7
	QuickBird	**2**		**1**	**2**			**1**	**1**	7
	IKONOS	**1**			**1**					2
	WorldView-2	**1**			**2**					3
	GeoEye	**1**			**1**			**1**		3
	ALOS	**1**			**1**					2
Moderate (10–250 m)	Landsat 1-5 (MSS)	**3**								3
	Landsat 4-5 TM	**16**	**1**	**2**	**11**	**1**	**1**	**3**	**1**	36
	Landsat 7 ETM+	**16**	**1**	**2**	**10**	**1**	**1**	**2**		33
	Landsat 8 OLI	**4**		**1**	**6**					11
	ASTER	**2**			**2**					4
	Google Earth VHR				**1**					1
	Sentinel 2	**1**			**1**					2
Coarse (>250	MODIS	**3**	**1**	**1**	**2**			**1**		8
	VIIRS							**1**		1
	AVHRR	**1**			**1**					2
No Category	Aerial Photo	**2**	**1**	**1**		**1**	**1**	**1**		7
	CBERS	**1**			**1**					2
	RapidEye	**1**			**1**					2
	Airborne Laser Scanning (ALS)					**1**				1
	ESDA	**1**			**1**					2
	VIEWIT	**1**			**1**					2
	IRS 1C LISS	**1**			**1**					2
	Total	63	4	8	49	4	3	10	2	

Relationship between Causes and Consequences

The study showed that the relationship between the causes and consequences of armed conflicts in the environment is complex and varies depending on the social and geographical context of each conflict. In spite of the above, we found some differentiated patterns of repetition. From the investigative approach of remote sensing to analyze each cause and its relationship with the environmental effects generated, we can clearly distinguish that with regarding the direct causes (34) they are three times less than with indirect causes (92). Segmenting the direct causes one by one, the direct confrontation (17) is the one that generates more consequences in the environment; deforestation (7), changes in the use of the soil (5) and only in one paper each in degradation of the soil, craters of mines, abandonment of agricultural lands and groundwater pollution. Another important direct cause is the bombing, which has been mentioned as a cause of deforestation (3), changes in land use (4), mine craters (2), abandonment of agricultural lands (2) and groundwater pollution (1). The use of landmines was found to cause deforestation (1), changes in land use (2) and abandonment of agricultural lands (1) times. In terms of indirect causes that are most often present, it is evident that forced migration is the most recurrent cause at the time of generating effects on the environment; deforestation (16), afforestation (1), desertification (1), changes in land use (11), abandonment of agricultural lands (2) and groundwater pollution (1). Non-forced migration is linked exclusively to deforestation (4) and changes in land use (2). Mining is found as one of the biggest causes of deforestation (5), desertification (1), changes in land use (5) and mine craters (1). Illicit crops are another important cause of changes in the environment distributed as follows: deforestation (7), changes in land use (4) and abandonment of agricultural lands (1). Agriculture and livestock are shown as indirect causes of deforestation (6), (6) and changes in land use (5), (4). Finally, logging and fires are the lowest cause of deforestation (3), (1) generated from armed conflicts and tackled from remote sensing (Tables 4 and 5).

Table 4. Cause vs Consequence

Cause vs Consequence	Direct			Indirect							
	Bombing	Direct Confrontation	Landmines	Forced Migration	Non-Forced Migration	Mining	Illegal Crops	Agriculture	Cattle Ranching	Timber	Fires	**Total**
Deforestation	**3**	**7**	**1**	**16**	**4**	**5**	**7**	**6**	**6**	**3**	**1**	59
Forestation				**1**								1
Desertification / Land Degradation		**1**		**3**		**1**						5
Land Use Changes	**4**	**5**	**2**	**11**	**2**	**5**	**4**	**5**	**4**	**1**		43
Mine Craters	**2**	**1**				**1**						4
Militar Infrastructure	**1**	**1**				**1**						3
Abandonment of agricultural lands	**2**	**1**	**1**	**2**			**1**		**1**			8
Groundwater Pollution	**1**	**1**		**1**								3
Total	13	17	4	34	6	13	12	11	11	4	1	

Table 5. Type of Cause vs Consequence

Type of Cause vs Consequence	Direct	Indirect	Both	**Total**
Deforestation	**2**	**24**	**5**	31
Forestation		**1**		1
Desertification/Land Degradation		**3**		3
Land Use Changes	**3**	**17**	**4**	24
Mine Craters	**2**		**1**	3
Militar Infrastructure	**1**		**1**	2
Abandonment of agricultural lands	**1**	**2**	**1**	4
Groundwater Pollution	**1**	**1**		2
Total	10	48	12	

CONCLUSIONS

The paper covers general aspects of conflict-environment from the remote sensing approach and demonstrated that conflict has extensive negative impacts and just a few positives. The impacts of conflict on environments are diverse and complex, increase mainly deforestation and land-use changes. In social terms and general human well-being, the causes and effects of conflict can be difficult to separate. This can lead to a cycle of conflict in which the detrimental effects of conflict create the conditions for increased violence. Many of these effects (e.g. reduced living standards, hunger, disruption of the economy and the education system) are difficult, if not impossible, to measure through remote sensing images. Thus, while the physical causes and effects of conflicts can easily be intertwined, the studies included here focus on the environmental effects of conflicts. On the other hand, through research we were able to verify that changes in coverage over large areas are more common to detect and quantify through the use of remote sensing methods, mainly consequences such as deforestation, land-use changes and abandonment of agricultural lands, contrasting with changes in coverage in smaller areas and shorter permanence time as military infrastructure, land degradation, craters and groundwater pollution. This is mainly due to the resolution of the available sensors, to the electromagnetic refraction contrast, and to the fact that these effects also require in situ verification, since in these cases the use of remote sensing is not sufficient to produce conclusive results.

Regarding the location of remote sensing studies of causes of armed conflicts, it can be inferred that most of these studies are in intertropical areas, and especially in sub-Saharan Africa and Colombia. The papers of direct causes such as bombings and direct confrontation are distributed mainly in Europe and western Asia since due to the specific conditions of the conflicts in these zones, bombings are more frequent. On the contrary, in the tropical zones of Latin America, Africa, and Southeast Asia, the greatest cause of affectation are indirect causes such as forced and unforced migration, illicit crops, mining, agriculture, and livestock. This can be explained because migrant populations are larger in these zones and require large resources to both moves and settle. In the case of Colombia and Afghanistan, illicit crops are a major factor in deforestation and land-use change. The conclusions on the geographical location of the studies analyzing the consequences of armed conflicts are that deforestation and land-use change are the most predominant effects in tropical areas because

their forest cover is greater and often these conflicts occur in nature reserves or rural areas with little or low population especially in the case of Colombia and Central America forcing people to colonize forest areas, while in areas such as western Asia and Europe, the effects are more measured in changes in land use, abandonment of arable land, craters and military infrastructure as deforestation is not predominant in these areas.

The research allowed us to conclude that the relationship between sensors, causes and consequences shows marked trends of which are the most used sensors and why. The trend is that the Landsat 4-5 TM and Landsat 7 ETM+ sensors are by far the most used to analyze all kinds of causes and consequences in all the countries analyzed. This is due to several reasons among which can be found in the good relationship between resolution, number of bands, price, versatility in bands and availability of images. Very high and high-resolution sensors such as SPOT-5, QuickBird, WorldView2, and IKONOS are especially used to monitor indirect causes such as forced migration and illicit crops and consequences such as deforestation and land-use changes. It is due these studies require higher resolution, more constant monitoring but at the same time, the acquisition of these images is more expensive. Finally, we can conclude that low-resolution sensors such as MODIS, VIIRS, and AVHRR were used in very few studies, mainly MODIS to calculate deforestation, land-use changes and abandonment of agricultural lands due to forced migration or bombing. Its low use is because it does not have sufficient resolution, although its acquisition costs are low or free, also an important reason is that several of these satellites have ceased to function and have ceased commercial use in recent years. Given the recent and current peace processes in most of the armed conflicts, it would be especially interesting to continue tracking deforestation, land-use changes and other consequences in those countries. Tracking of year-to-year changes using high-resolution data would be especially useful for correlating specific economic and political conditions with landscape, land use, and deforestation rates and distributions.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

IMPLEMENTING U.A.V. TECHNIQUES IN MODELLING HYDROAMELIORATIVE WORKS - A CASE STUDY

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Abstract

The scientific and technological progress recorded in the last years in the field of geodesy, cartography and land surveying allows the use of some modern techniques and methods towards realizing some complex objectives. This evolution of techniques allows for high level accuracy data to be obtained in short period of time, on large surfaces. U.A.V. photogrammetry serves a wide variety of domains. The present study follows an interdisciplinary research, and modern concepts from land improvement field are approached. For the photogrammetric flight a DJI Phantom 4 Pro drone was used. The photos were taken after a manual flight conducted with the DJI GO application. The generated dense point cloud consists of 82191720 points, having both spatial coordinates and an RGB code. The resulting orthophoto map has a ground resolution of 1.37 cm/pixel. Also, within the project, the Digital Elevation Model (DEM) was obtained which has a resolution of 2.74 cm/pixel, the point density being 1335.85 points/m^2. The obtained products can be exported, thus allowing them to be integrated into specialized software for further analysis.

Key words*: drone, flight, land improvement, U.A.V. photogrammetry.*

INTRODUCTION

Photogrammetry is a technical science that studies the Earth's surface based on the land photographic image processing in order to obtain informative data for the preparation of plans, maps and topographic and thematic studies.

According to Anurogo et al. (2017), aerial photogrammetry is one of the alternative technologies for obtaining data in a relatively short time.

Applications made with the help of drones in the geospatial field are in full development and demand, due to the relatively affordable costs compared to satellite systems (high resolution satellite images) (Colomina and Molina, 2014).

Authors like Toderas (2007) recall the development of techniques and technologies and also the extension of the scope of photogrammetry and implicitly with it the subclasses: aerial photogrammetry, cosmic photogrammetry, extra-terrestrial photogrammetry, terrestrial photogrammetry, analogue photogrammetry, digital photogrammetry, analytical photogrammetry architectural photogrammetry and topographic photogrammetry.

Hidayat and Widartono (2014) cited by Anurogo et al. (2017) presents as a benefit obtained by using drones obtaining aerial photographs, which are then processed so that they are used to support spatial data acquisition. This modern method has many areas in which it can be applied, especially agriculture, forestry, topographic and thematic mapping.

Drones can also be used in the field of hydrological processes, studies being carried out by authors such as Caroloo et al. (2015).

Based on the aerial images taken and subsequently used in the specific geo-information programs, models with centimetres accuracy can be obtained.

MATERIALS AND METHODS

The area targeted in the study is represented by the upstream part of a slope located in the area of Feleacu, Cluj County, slope arranged with hydro ameliorative works. The targeted area is the one in which we find the channel with concrete falls, realized in order to reduce the slope and limit the drainage speed under the non-erosion speed (Figure 1).

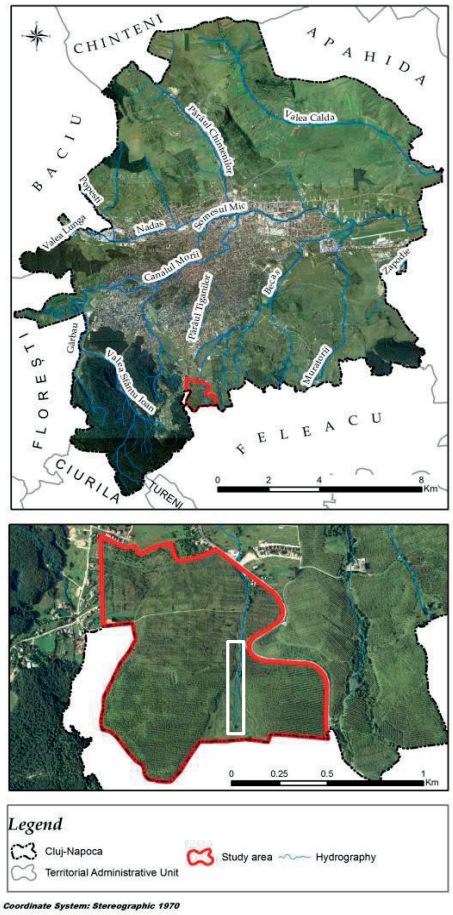

Figure 1. The geographical location of the study area, Cluj-Napoca

Regarding the planning and conduct of the flight activities, a notice was requested from the Civil Romanian Aeronautic Authority, being registered the flight with reference number 44 with the drone having the identifier YRD 0760.

In order to model the terrain using U.A.V. (Unmanned Aerial Vehicle) photogrammetric methods, a DJI Phantom 4 Pro drone was used (Figure 2). The photos were taken after a flight conducted with the DJI GO application.

Taking the aerial photos was done by performing a manual flight. A predetermined flight was not chosen, due to the high altitude differences between the upstream and downstream part of the studied area.

The manual mode allowed the altitude change during the flight and tracking the natural terrain, however, in the case of a predetermined flight, the altitude of the drone will remain constant compared to the average altitude of the flight plan, at the value set at the time of flight planning and take-off.

The flight followed the path of the channel with concrete falls, at the return we tried maintaining a line relative parallel with the channel (Figure 3).

Figure 2. DJI Phantom 4 Pro drone

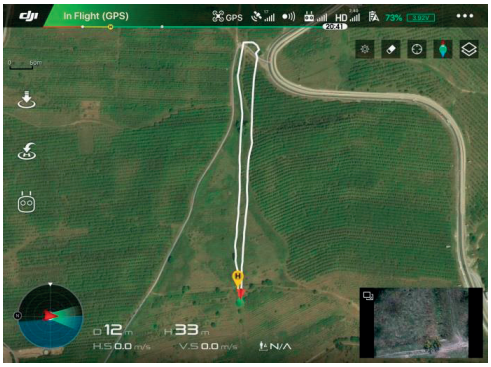

Figure 3. The photogrammetric flight path, DJI GO application

For the photogrammetric processing, the specialized software solution Agisoft PhotoScan was used, which allows the generation of the dense point cloud, the digital elevation model (DEM - DTM or DSM) and the orthophoto map.

The data was downloaded and a number of 145 photograms were obtained at an average flight altitude of 54 meters.

RESULTS AND DISCUSSIONS

With the help of the application Adobe Photoshop Lightroom Classic, the contrast improvement was done by the histogram equalization method. The histogram equalization represents an accentuation operation of the contrast and its main purpose is to obtain a uniform histogram. Improving the photogram contrast was done automatically at the same time for all the taken photograms (Figure 4).

Figure 4. The photogram before and after the histogram equalization process

Once the project was created, the photograms were imported, the coordinate system was selected, and then the coordinates of the photograms from the WGS 84 projection system were converted to the Stereographic 1970 projection system.
The next stage was represented by the alignment of the photograms, a stage in which the accuracy of identifying the connection points, the maximum number of key and connection points, as well as establishing the pair selection variant was set (Figure 5).

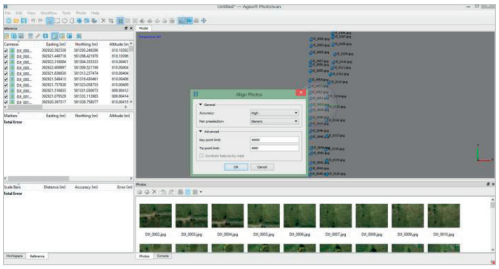

Figure 5. Photograms alignment

In order to georeference the digital model, the coordinates of the ground control points previously determined by GNSS methods (Paunescu et al., 2012) have been uploaded within the project and will be identified on the photograms (Figure 6).

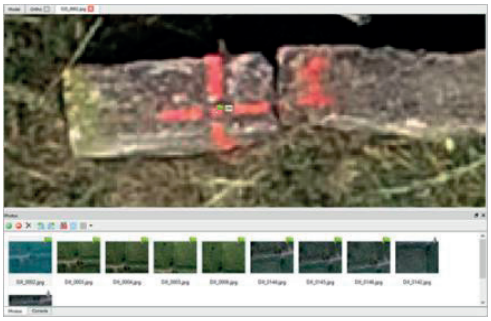

Figure 6. Identifying the ground control points on the photograms

In the model adjustment stage, these ground control points were used, without taking into account the coordinates of the photograms, these being recorded by the internal GPS of drone which does not offer a sufficiently high accuracy. The accuracy of the drone's internal GPS is ± 0.5 m for the vertical position and ± 1.5 m for the horizontal position.
After constraining the model, using the bundle adjustment method, based on the ground control points, the dense point cloud was generated. This consists of 82191720 points, which have both spatial coordinates and an RGB code.
Figure 7 shows both the dense point cloud and the camera position.

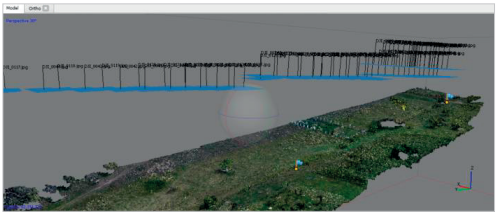

Figure 7. The dense point cloud and the camera position

In order to obtain the 3D model of the studied area, a MESH was generated, consisting of 5398054 triangles.
The model consists of a network of triangles arranged irregularly based on known elevation points, the dimensions of the triangles varying depending on the terrain. The resulted model is

known as TIN (Triangulated Irregular Network) (Figure 8).

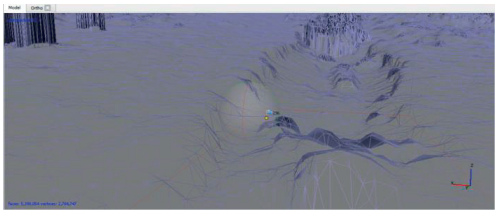

Figure 8. TIN network - detail point of view

If the faces of the triangles are assigned the colours taken from the photograms, the realistic model is obtained.
The digital orthophoto map of the studied area was generated, having as support the obtained 3D model and applying the mosaic method of the photograms (Figure 9). The resulting orthophoto map (Figure 10) has a ground resolution of 1.37 cm/pixel.
Both the obtained orthophoto map as well as the point cloud can be exported, thus allowing them to be integrated into specialized software for further analysis.

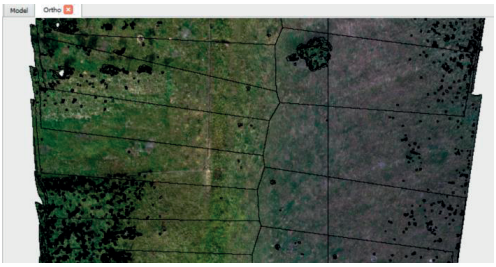

Figure 9. The mosaic method

Also, within the project, the Digital Elevation Model (DEM) was obtained (Figure 11) with a resolution of 2.74 cm/pixel, the point density being 1335.85 points/m^2.
The DEM is a valuable tool for the topographic parameterization, especially for erosion and drainage analyses, hill-slope hydrology, watersheds, groundwater flow and contaminant transport studies (Walker and Willgoose, 1999; De Vantier and Feldman, 1993; Jenson and Domingue, 1988).
The photogrammetric processing is synthesized in the form of a report, which includes the calibration elements of the camera, details about the digital elevation model, details about the ground control points, errors, resolutions obtained (Processing Parameters: General - cameras, markers, coordinate system; Point cloud; Alignment parameters - accuracy, alignment time; Optimization parameters; Dense Point Cloud; Model - faces, vertices; Orthomosaic - size, coordinate system, channels, blending mode; Reconstruction parameters).

Figure 10. The ortophoto map of the study area

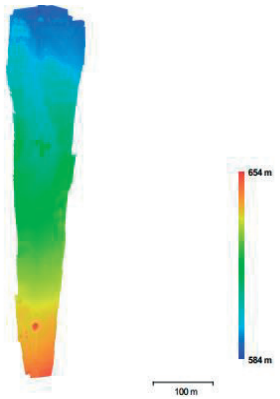

Figure 11. Digital elevation model

The obtained products can be used for various purposes, respectively complex analysis, spatial modelling, and profile creation.
The geo-informational application Global Mapper allows data processing and analysis, having many significant tools. Within the version 18.3 of Global Mapper, the point cloud was loaded (Figure 12) for preview and terrain analysis.

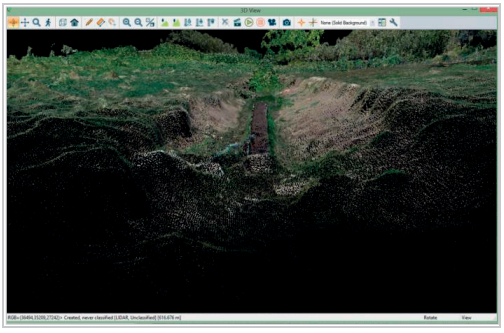

Figure 12. 3D visualisation - point cloud

At the same time cross-sections were generated throughout the point cloud, which rendered the shape of the terrain, of the channel and of the concrete falls from the studied area (Figure 13, Figure 14).
These cross-sections obtained using the application Global Mapper can be exported as x, y, z files or in a CAD format -dxf.

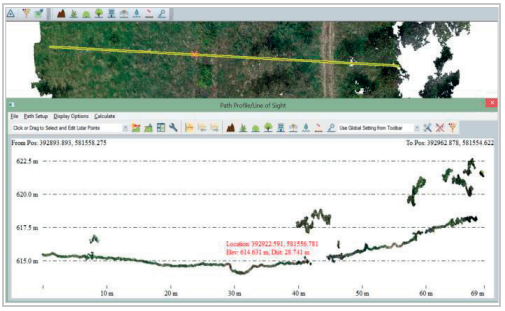

Figure 13. Cross section within the point cloud

Figure 14. Cross section within the point cloud, fall

CONCLUSIONS

Modelling the terrain was done throughout U.A.V. photogrammetric methods. The resulting orthophoto map has a ground resolution of 1.37 cm/pixel and the obtained digital elevation model has a resolution of 2.74 cm/pixel. The obtained products can be used for various purposes, respectively complex analysis, spatial modelling.
The photogrammetric techniques carried out can be used to future design works in order to redesign the channel as well as the falls. Cross-sections can be used in modelling hydraulic and hydrological processes.
U.A.V. photogrammetric methods are used with success in the field of land improvements, having as deliverable material the point cloud, the orthophotomap and the digital elevation model with a centimetric accuracy.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

IN SITU GEOMETRIC CALIBRATION OF A HYBRID SYSTEM COMPOSED BY UAV/GNSS/IMU/AERIAL CAMERA AND LiDAR

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Abstract

The paper aimed to present the in situ geometric calibration of a hybrid system composed by an Unmanned Aerial Vehicle (UAV) which is equipped with Global Navigation Satellite System (GNSS), Inertial Measurement Unit (IMU), aerial optical camera and a LiDAR. For a realistic representation of a geographic area by combining optical and LiDAR data, captured with UAV, we need first of all to calibrate the both sensors (passive and active) optical and LiDAR. In our study, we used a digital camera, and influences of focal length and principal point coordinates were needed to be treated as unknown parameters for adjustment purposes. We used LiDAR data for in situ calibration of digital camera and the test site which was selected in the project area and control points have been obtained from LiDAR point cloud and intensity data. The in-situ calibration of digital camera was based on a large number of tie points and the LiDAR derived control points using a conventional bundle block adjustment with self-calibration. The in situ geometric calibration of our hybrid system, was achieved and verified for validation in a test area, near Bucharest, checking the spatial data sets used (optical and LiDAR) and for final data validation we used the ground truth, given by GNSS measurements in the field.

Key words*: calibration, GNSS, LiDAR, photogrammetry, UAV.*

INTRODUCTION

The concept of *in situ* system calibration (also called self-calibration which originates from close range applications) for aerial optical cameras has been clearly demonstrated in the last decades, and nowadays most final system calibrations provided by aerial camera manufacturers, particularly for digital cameras, are produced by aerial, *in situ* approaches. Many examples of geospatial accuracies provided by *in situ* calibrations may be found in few scientific articles of analytical and digital photogrammetry (Brown, 1969; Merchant et al., 2012).

The camera calibration process involves the geometric calibration, resolution determination and radiometric calibration of camera. In this paper we are referring to geometric calibration only.

The laboratory calibration is a standard method for analog airborne frame cameras. The interior camera geometry, focal length, principle point location and lens distortion parameters are included in the calibration certificate of the digital camera. As a general concept, all those parameters which were not corrected for in the image provided to the user should be treated as unknown parameters in the calibration computations. The calibration report must state the mathematical model used to represent the interior orientation of the camera, the estimates of parameter values of the model and estimates of errors in the adjusted parameters.

Camera calibration reports provided by digital aerial camera manufacturers also provide a rich source of high-quality results.

In situ system calibration requires a calibration field with signalized control points of high accuracy and so the camera calibration parameters can be estimated in standard airborne flight configuration with the camera positions given by GNSS.

Another approach for the *in situ* camera calibration is used to estimate the interior orientation parameters of the digital camera used in the flight conditions which does not require a calibration test field and also neither traditional ground control points (Mitishita et al., 2017). So, the LiDAR dataset was used as a control of position information for the photogrammetric survey performed by the

direct sensor orientation technology. Using the collinearity equations and Least Squares Bundle Block Adjustment, the theoretical collinearity condition among the point image, camera exposition station and point object was in practice recovered by additional parameters related to lens distortions, coordinates of principal point and the sensor distortion. So, in this case, the *in situ* camera calibration must use LiDAR Derived Control Points (LCPs) and a small sub-block of images extracted from the entire image block obtained in the aerial survey.

Light Detection and Ranging (LiDAR) is a remote sensing technology that has been widely used in many fields, for example: canopy cover estimations, Doppler measurements (Scotti et al., 2015), oceanological monitoring of fishing areas (Chernook et al., 2014), city planning and disaster management (Chen et al., 2014), etc. The data collected by LiDAR system could be processed into the LiDAR Digital Surface Model (DSM) which contains not only Digital Elevation Model (DEM) information but also all the objects lying on the Earth's surface. The elevation information helps to classify different objects of with different heights, such as trees, buildings and so on. LiDAR has been shown to be a very useful tool for classification purposes. LiDAR data and aerial images, both captured with the same UAV, have their own unique advantages and disadvantages and it is natural to integrate those two data sets for a good realistic representation of a geographic area in terms of horizontal and vertical accuracy. Compared with aerial images, LiDAR data provide more accurate height information but less accurate boundaries. Aerial images provide more extensive planimetric information such as high-resolution texture and colour information. Although 3D height information can be estimated from one or several images by the use of several photogrammetric methods, the height information extracted from aerial images is still relatively less accurate, and the experimental results indicate that this combination improves the overall accuracy.

MATERIALS AND METHODS

In this paper, it is presented a hybrid system based on UAV equipment using a combination of two technologies LiDAR and photogrammetry. UAV was a hexacopter DJI MATRICE M600 PRO with vertical take-off and landing which are collecting high density of LiDAR points and RGB digital colour aerial images.

The UAV system, presented in this paper, was realized within the project “System for rapid monitoring and interactive mapping”, co-financed from the European Regional Development Fund through the Operational Program Competitiveness 2014-2020, financing contract 124/2016 concluded with the National Research and Innovation Authority as Intermediate Body (OI), on behalf of the Romanian Ministry of European Funds (MFE) as Managing Authority (MA) for the Competitiveness Operational Program.

The specific objectives and results of the project were the development of advanced and accurate methodologies based on UAV systems equipped with LiDAR and photographic camera for obtaining several geospatial products like "digital topographic map in a GIS structure", "realistic representation of a geographical area" and "landscape change detection complete report".

For these products were studied the technical conditions and the optimum steps in the technological process of their generation. One of these steps was geometric calibration, and the results of this research are presented in the next chapter. The DJI MATRICE M600 PRO drone, used in our study (Figure 1), is a professional hexacopter drone, being one of the most efficient in terms of flight performance (high stability and transport capacity). The pre-installed arms reduce the time required to prepare the UAV system for flight.

Figure 1. Hexacopter DJI MATRICE M600 PRO

The ability of these arms to fold, helps in easy transport but also in speeding up the drone mounting. In addition, the ability of rotor propellers to tighten emphasizes these advantages over other air platform solutions available on the market.

The DJI MATRICE M600 PRO platform was equipped with the latest technologies of DJI, being from this point of view a latest generation product. The platform is equipped with the A3 Pro Flight Controller, radio remote control and iPAD PRO 9.7 inches tablet, Lightbridge 2 HD transmission system, smart battery charging station and high-performance flight batteries. The system also includes flight control software: one for the iPAD PRO tablet, called DJI GO and one for the computer, for connecting systems of the Drone (Lightbridge, D-RTK, ProLink Model etc.), called DJI Assistant 2.

The integrated LiDAR on the same drone, was designed for the acquisition of LiDAR data with high accuracy (between ± 2 cm and ± 5 cm RMSE at an average acquisition distance of 40 m and 100 m, respectively), and supplemented with RGB information for each point. Our LiDAR system was composed of several subassemblies, as follows:

- System platform, CPU integrator developed by the Phoenix LiDAR Systems (Figure 2) for the LiDAR-GNSS-IMU assembly, which has the function of correlating in real time the data acquired from all the sensors of the system.

Figure 2. LiDAR-IMU-CPU-Camera

- GNSS navigation system (Figure 3) is a dual frequency RTK-GNSS system, with GPS / GLONASS support. The DJI D-RTK system used for the UAV system is partially used, because the LiDAR system has its own GNSS subassembly composed by two GNSS antennas. This GNSS is also used for improving the heading and the alignment of the entire system. This kind of GNSS subsystem is used in correlation with a medium or low accuracy IMU sensor (for example like ADIS sensors). When the system has a precise IMU sensor, it can be used just a single GPS antenna.

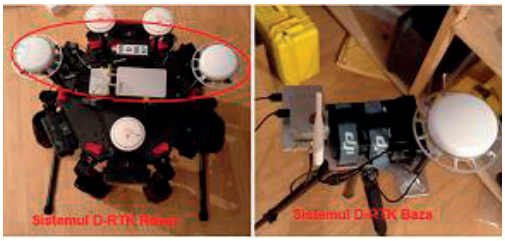


Figure 3. The DJI D-RTK system (Rover and Base)

- IMU System - Analog Devices model ADIS 16488 (IMU-14) or STIM (IMU-27), integrated into the system platform (CPU).
- Velodyne VLP-16 PUCK or Velodyne VLP32C LiDAR sensors for acquiring the point cloud.
- Photo Camera Sony A6000 and Sony A7R II (shown in Figure 4) are used to capture RGB images for each point determined by LiDAR technology.

Figure 4. Photo Cameras Sony A6000 (left) and Sony A7R II (right)

The images thus acquired can be used for photogrammetric products (photograms, stereo-restitution, orthophotos), if the flight of data retrieval is designed in such way to ensure the necessary longitudinal and transversal coverage of the images.

RESULTS AND DISCUSSIONS

For testing different parameters for fly, three flights were designed from different heights with the DJI M600 VLP 16 LiDAR system.

The first day that flew was when the average temperature was 11ºC, the wind speed was

6 km/h, the visibility was 7.6 km, the humidity was around 70 mmHg. On this first day the flight was made at a flight height of the drone set at 60 m, so chosen to have visibility between operators and the drone, but also between the drone and the WIFI long range antenna.

Another flight was made at a flight height of 40 m, on a length of 1.6 km, with LIDAR and optical data being acquired for objects such as roads, houses, cars, electric poles, high and low vegetation.

We concluded that the interior orientation and the mounting parameters can vary over time. For instance, the interior orientation parameters can change under flight conditions due to the effects of temperature and pressure, and to improve the accuracy of the direct sensor orientation, the system calibration (including the interior orientation and mounting parameters) is recommended before or after each photogrammetric mission.

Internal parameters, of a digital camera calibration, are: the focal length in pixels, the principal point coordinates, skew coefficient defining the angle between the x and y pixel axes (stored in the scalar) and the image distortion coefficients (radial and tangential distortions).

A scene view, which is formed by projecting 3D points into the image plane using a perspective transformation, is shown in Figure 5 (https://docs.opencv.org/2.4/index.html).

If we consider a point „P" in the space-object and its correspondent point „p" on the image, we have the following formula in matriceal form (OpenCV, 2019):

$$\mathbf{s * p = A * [\,R|T\,] * P} \qquad (1)$$

$$s\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

where:

(X, Y, Z) are the coordinates of a 3D point in the world coordinate space;

(u, v) are the coordinates of the projection point in pixels;

A is a camera matrix, or a matrix of intrinsic parameters;

(c_x, c_y) is a principal point that is usually at the image centre;

(f_x, f_y) are the focal lengths expressed in pixel units.

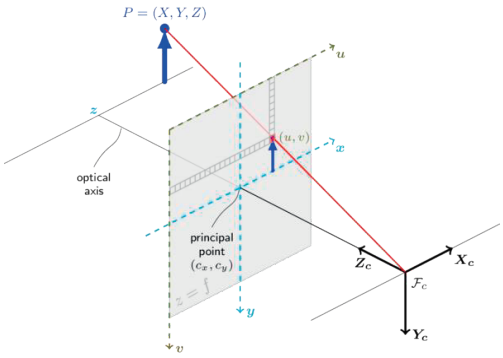


Figure 5. Coordinate systems used in perspective transformation for digital camera calibration (OpenCV, 2019):

When an image from the camera is scaled by a factor "s", all of these parameters should be scaled (multiplied/divided, respectively) by the same factor. The matrix of intrinsic parameters does not depend on the scene viewed. The joint rotation and translation matrix **[R|T]** are called a matrix of extrinsic parameters. It is used to describe the camera motion around a static scene, or vice versa, rigid motion of an object in front of a still camera. That is, translates coordinates of a point to a coordinate system, fixed with respect to the camera. The transformation above is equivalent to the following, when $z \neq 0$:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = R \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + \mathbf{T} \qquad (2)$$

$$x' = x/z$$
$$y' = y/z$$
$$u = f_x * x' + c_x$$
$$v = f_y * y' + c_y$$

Because the lenses of the camera objective, usually have some distortion, mostly radial distortion and slight tangential distortion, the above formula is extended, as follows (OpenCV, 2019):

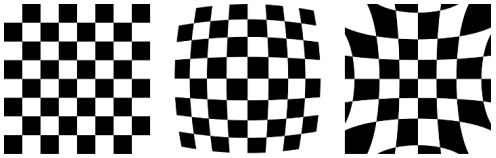
$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = R \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + T \quad (3)$$

$$x' = x/z$$
$$y' = y/z$$
$$x'' = x' \frac{1+k_1r^2+k_2r^4+k_3r^6}{1+k_4r^2+k_5r^4+k_6r^6} + 2p_1x'y' + p_2(r^2+2x'^2)$$
$$y'' = y' \frac{1+k_1r^2+k_2r^4+k_3r^6}{1+k_4r^2+k_5r^4+k_6r^6} + p_1(r^2+2y'^2) + 2p_2x'y'$$
where $r^2 = x'^2 + y'^2$
$$u = f_x * x'' + c_x$$
$$v = f_y * y'' + c_y$$

Finally, we have the output vector of distortion coefficients (**k_1, k_2, p_1, p_2[, k_3[, k_4, k_5, k_6]]**) of 4, 5, or 8 elements.

These coefficients of camera calibration **k_1, k_2, k_3, k_4, k_5** and **k_6** are radial distortion coefficients; **p_1** and **p_2** are tangential distortion coefficients and higher-order coefficients are not considered in this application.

For example, in Figure 6, are shown two common types of radial distortion: barrel distortion (typically **$k_1>0$**) and pincushion distortion (typically **$k_1<0$**).



No distorsion Positive distorsion Negative distorsion

Figure 6. Two common types of radial distortion

The calibration of a digital camera is usually performed in laboratory and the determined parameters may not reflect the flight conditions due to the effect of temperature and air pressure. For this reason, these parameters are frequently determined or refined with *in situ* calibration using a test field with distributed control points of high accuracy.

In present, UAVs use the combination of imaging and navigation sensors, such as digital camera, LiDAR, GNSS and IMU. Usually, these systems use direct geo-referencing for imaging sensor orientation, and the calibration of individual sensors and the relation between them is very important because any difference between assumed calibration parameters and physical parameters can cause significant errors in object space. The geometric sensor calibration parameters for camera, estimated by adjustment, are: 2D coordinates of principal point, principal distance and image distortion parameters (number of radial and tangential distortion coefficients). In Figure 7, we presented an extract from the calibration certificate of the Sony A6000 optical camera, a component of the LIDAR SCOUT system, which is part of the UAV assembly, issued by Phoenix LiDAR Systems from USA, the distributor company of the camera.

Camera 0 Type:	Sony a6000	
Camera 0 Serial #:	6450763	
	X (width)	**Y (height)**
Sensor Size (mm)	23.500	15.6670
Pixel Size (px)	6000	4000
Principal Point (px)	2976.670	1981.860
Focal Length (px)	4127.793	4127.793

	k1	**k2**	**k3**
Radial	-0.008	-0.001	0.007

	p1	**p2**
Tangential	0	0

Figure 7. Extract from the calibration certificate of the Sony A6000 optical camera

In Figure 8, we presented an RGB image before (a) and after (b) geometric calibration using *Spatial Fuser software of* Phoenix LiDAR Systems.

a) RGB image before calibration

b) RGB image after calibration

Figure 8. RGB image before (a) and after (b) calibration

If it is necessary to apply geometric corrections in a processing medium other than *Phoenix*

LiDAR Systems Spatial Fuser, it is necessary to obtain the parameters of external orientation, to restore the image retrieval mode (Figure 9).

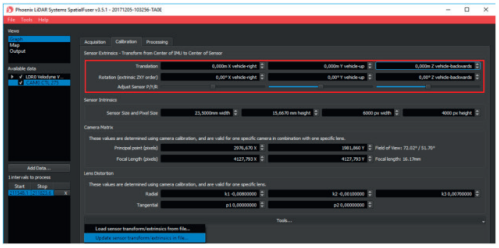


Figure 9. Obtaining the external orientation parameters for the geometric correction of the images

In our project we used also LiDAR data for *in-situ* calibration of digital camera. The test site was selected in the project area and control points were obtained from LiDAR point cloud and intensity data.

The *in situ* calibration of digital camera was based on a large number of tie points and the LiDAR derived control points using a conventional bundle block adjustment with self-calibration. The displacement vector and attitude relationship between digital camera and IMU body frame was determined by comparing the GNSS/IMU derived image orientations and the results of bundle block adjustment.

The aim of the hybrid adjustment is to simultaneously optimize the relative orientation and absolute orientation (georeference) of the LiDAR and image data. The sensor orientations can be optimized by minimizing the discrepancies within the overlap area of flight strips and images and with respect to ground truth data, if it is available. The measurement process is rigorously modelled using the original measurements of the sensors (scanner: polar measurements, camera: image coordinates) and the flight trajectory of the drone. This way, systematic measurement errors can be corrected where they originally occur. Both, LiDAR scanner and photo camera, can be fully re-calibrated by estimating their interior calibration and mounting parameters (lever arm, boresight angles). Systematic measurement errors of the flight trajectory can be corrected individually for each flight strip.

The geometric sensor calibration parameters for LiDAR, estimated by adjustment, are: range offset (bias), range scale, angle offsets (biases) and angle scales. The parameters representing the geometric corrections of the optical data are different for each image separately. These corrections are necessary to restore the image retrieval mode, along with the restoration of the LIDAR data retrieval matrix for their fusion. In this way you finally get the LIDAR point cloud with RGB information. In Figure 10, it is shown an example of the uncalibrated and incorrect data set in the Pantelimon area, made with *Portree-Prosig* software.

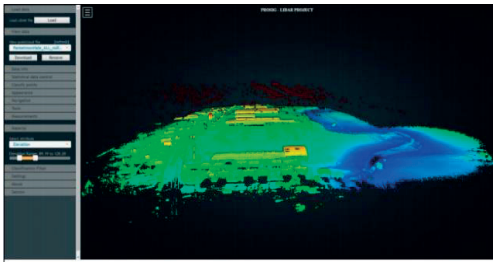


Figure 10. Presentation of the uncalibrated and incorrect data set in the Pantelimon area

The application of the point cloud calibration method is performed using the *LiDAR Tools* application. On the map used, the waveguide curvature in the flight zone is calculated by interpolating between two successive level curves. For example, in the case of flights from the Pantelimon area, the ondulation of the quasigeoid is 35.2647 meters (35.2500 m + 0.0147 m). So, we know the values of differences between the ellipsoidal quota and the normal quota in our test area. After the application of the undulating elevation values quasigeoid, results can be seen in Figure 11. The cloud of LiDAR points is considered now calibrated in the Romanian altimetric "0 Black Sea 1975", 1990 edition.

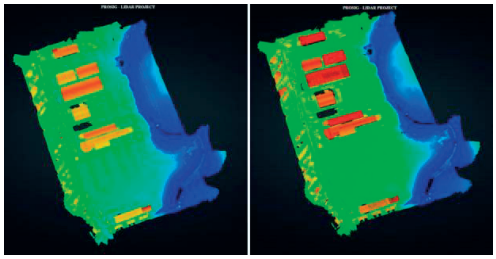


Figure 11. Transforming the LiDAR point cloud before (left side) and after (right side) applying the cvasigeoid ondulation

For calibration and correction of LiDAR data we used, also, an offline software *LiDAR Tools* installed on desktop computer that allowed us: the loading of the LiDAR point cloud in LAS format, its visualization based on the same principles as in the *Potree Prosig* on-line application, different statistical calculations and the classification of the point cloud using some quick and efficient methods (Figure 12).

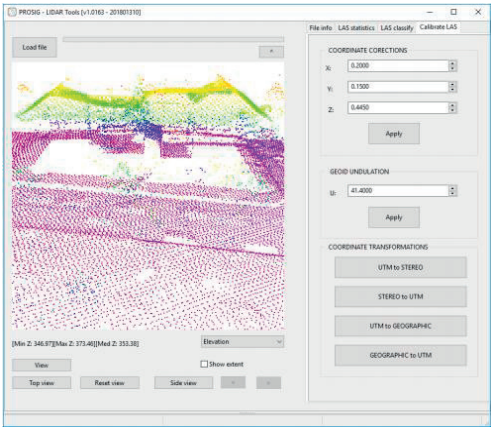


Figure 12. Interface for calibration and correction of LiDAR data

The identification of the values of the low and high Z parameters for the LAS files, is made using the *Potree-Prosig* software (Figure 13).

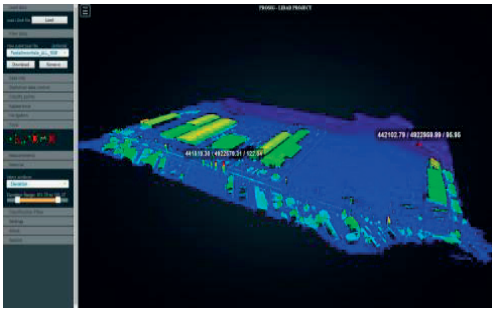


Figure 13. Identification of the values of the low and high Z parameters for the LAS file, using the *Potree-Prosig* software

Regarding the correction of LiDAR and optical data, this is done on LiDAR data, where the algorithms implemented in the *LiDAR Tools* application are applied to filter the data cloud from those points that are improbable, and the correction of optical data is done by applying on the images of the external orientation elements (rotation angles and coordinates of the images acquisition centres). Finally, the calibration performance was evaluated by analysing correlation between the estimated system parameters, the *a-posteriori* variance factor of the Least Squares Adjustment procedure and the quality of fit of the adjusted point cloud to planar/linear features before and after the calibration process.

CONCLUSIONS

The *in situ* system calibration parameters can be classified into two groups: the calibration parameters of individual sensors and the relationships between sensors. The calibration between sensors is comprised of the GNSS antenna offset (lever arm), and the determination of an offset vector and attitude difference between the IMU body frame and the imaging sensor. Combining geo-data acquired from a common platform by both sensors requires that they are in the same coordinate system. So, an approach to achieve this geo-referencing is to process each data stream independently, using the same GNSS/IMU data or by using GCPs acquired in the same datum. The D-RTK Rover system from Figure 3 (left side) contains two GNSS antennas, capable of receiving signals from satellites, both from the NAVSTAR and GLONASS constellations. In the Asia-Pacific area they are programmed to use the signals from the BEIDOU satellites as well. The D-RTK Rover system also contains a satellite data analysis processor, as well as a radio module for receiving basic corrections (DataLINK PRO 900). The D-RTK Base system is basically similar to the one installed on the drone, except that only one GNSS antenna is required for the base and not two (Figure 3, right side).
In addition, the radio module is designed to provide corrections, not receive. The power supply in the case of the basic D-RTK module is achieved by connecting it to a DJI TB47S type battery, or a similar battery.
The D-RTK system is used for precise flights, inhibiting the functionality of the A3 Pro flight GPS antennas (only for the 3 smaller GPS antennas to determine the navigation position and the course angle, with a lower accuracy).

Thus, the DJI MATRICE M600 PRO drone in this configuration can be used for geodetic applications and for scientific research applications where accuracy is a request. The D-RTK GNSS antennas can also be used for improving the accuracy of the IMU sensor (for example on LiDAR Scout 16 system). The main subassembly of those subsystems is composed by the LiDAR sensor, CPU, IMU and the optical camera which are integrated as is seen in the Figure 2. This subassembly is integrated in a single component. This is an absolute condition to obtain a good accuracy of the measured data. All the components are related to the IMU sensor through the measured offsets and the rotation angles between each coordinate system of each component.

Measurement of imagery and processing of the GNSS data and range coordinates have been conducted with a software capable of carrying the parameters of interior and exterior orientation as parameters with the possibility of application of appropriate weight constraints. Error estimates after adjustment should be provided along with the estimated standard error of unit weight. The mathematical model to be used to represent the camera's interior orientation will depend on the level of correction that will be applied to the imagery to be provided to the user. For performance evaluation of the camera calibration parameters and boresight misalignment was analysed by comparing the results of measuring points in stereo models formed using the bundle block adjustment and, respectively, the direct sensor orientation. For performance evaluation of the in situ determined camera and boresight calibration parameters were tested using independent LiDAR target points which were originally used for testing of the LiDAR data accuracy. The UAV LiDAR system calibration attained an accuracy of about 2 cm, which is better than the expected accuracy of around 5-10 cm, keeping in mind the accuracies of the hardware involved. This indicates that the proposed calibration method was efficient and accurate. For the future researching work, we shall focus on combining the mounting parameters (extrinsic parameters) and sensor parameters (intrinsic parameters) to obtain a comprehensive calibration leading to even more accurate point clouds. So, we hope to demonstrate, in the future work, that, a simultaneous calibration of mounting parameters (extrinsic) and intrinsic sensor parameters has better accuracy of the obtained LiDAR 3D point cloud combined with information from other sensors, such as RGB cameras or hyperspectral sensors, to extract more valuable information related to different applications. Exploiting the advantages of both, light detection and ranging and dense image matching, point clouds will improve the quality of the final geospatial products.

The system calibration, in principle, can be performed before or after every mission to check the quality of the mounting and interior orientation parameters. The main challenge in integrating LiDAR and dense image matching data consistently lies in proper consideration of their high variations in resolution and precision. In aerial applications, the dense image matching point cloud is typically of higher density and lower depth precision than the LiDAR data when captured at high altitude. This is due to the resolution limitation of the LiDAR beam divergence and repetition time on the one hand, and the availability of high-resolution large-frame cameras on the other.

The future tendency, is that all new generations of airborne LiDAR systems integrate a LiDAR unit and a passive imaging unit (in a single camera or multi camera fashion) in the same platform for concurrent acquisition of ranging and imagery data.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE USE OF GIS IN REAL ESTATE

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Abstract

The paper aimed to present a different way of identification of a zone of interest for clients of the real estate companies based on the evolution of prices and other essential aspects related to buying a property. For a long time now, they have noticed the need to discover and appreciate the information regarding the real estate domain in a different way. Normally, an agency or private buyer finds information on multiple platforms or other types of advertising, without the possibility of combining all their search criteria in one place but this can change. For this purpose, three types of web maps have been developed based on a data base created in ArcCatalog and ArcMapto help the real estate agencies or individual clients in order to consult as many points of interest as they could. Regarding this aspect, these web maps can ensure a "geographical view" of the details that influence the real estate market by implementing methods of filtering, searching or classifying the points of interest within a certain perimeter. For this paper we used ESRI software's, for the database and also for processing that information, which led to the expected results.

Key words*: geographic view, information, real state.*

INTRODUCTION

For a long time now, the real estate companies, or real estate agents have encountered difficulties in trying to convince potential buyers that the area of their choice is the best according to their criteria. Based on the narratives from real estate conferences in Cluj-Napoca, we deduced that an idea which can help solving this problem, it could be a program that uses GIS data (Salagean et al., 2016).
GIS (Geographic Information System) can be presented as a system that allows the collection, management, processing and analysis of geographical or spatial data. Starting from the base, from the classic geography, a GIS can integrate several types of data. In a geographic information system, it will be possible to process or analyze spatial locations and/or organize them in multiple layers using 2D or 3D maps and scenes.
Using this advantage, a geographic information system will always help users understand data more easily for better decision making (ArcGIS Overview).
Regarding to general information, the study was based on the data about Cluj-Napoca, the city being situated in the North-West side of Romania, and having an official population of 325 000 people (2011 - last census).

MATERIALS AND METHODS

For this project we used ESRI software's, for different stages of the paper.
In order to create a Data Base, we worked for start in ArcCatalog (Figure 1), where we created the layers necessary for the next step. The ArcCatalog application provides a catalogue window that is used to organize and manage various types of geographic information for ArcGIS.
The kinds of information that can be organized and managed in ArcCatalog includes: Geodatabases Raster files, Map documents, globe documents, 3D scene documents, and layer files, Geoprocessing toolboxes, models, and Python scripts, GIS services published using ArcGISfor Server, Standards-based metadata for these GIS information items (Matei et al., 2014).

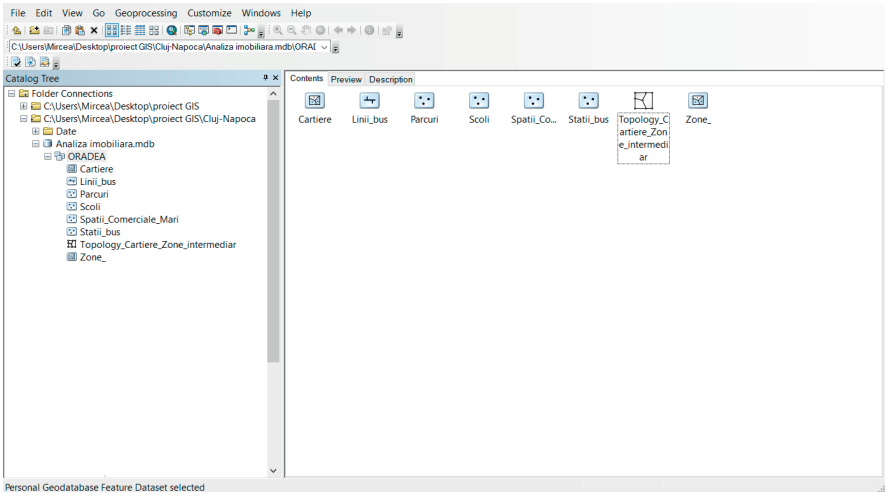
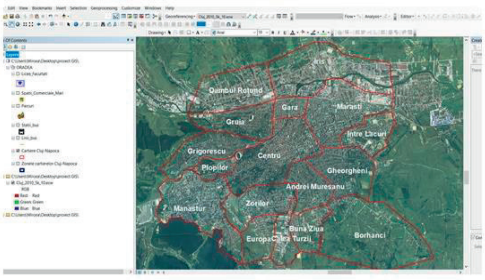
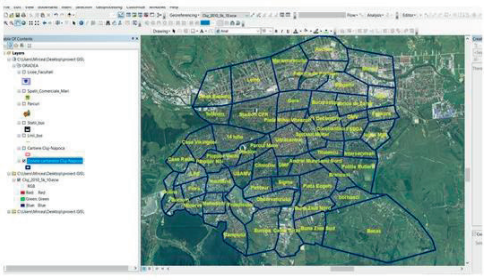


Figure 1. ArcCatalog Data Base

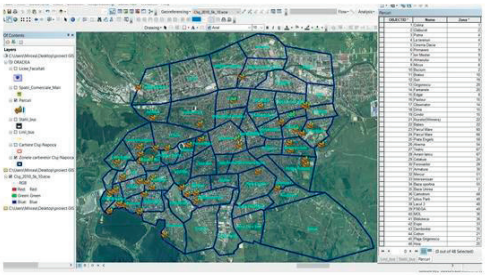
Moving to the next step, we used ArcMap 10.4, which represents geographic information as a collection of layers and other elements in a map. Using an ortophotomap of the Cluj County, we were able to digitize the neighbourhoods, the zones of the neighbourhods, lines of public transport, bus stations, supermarkets, major parks and the high schools and universities (Figure 2 and Figure 3). In each layer we introduced attributes who were received from the local online platforms, like prices/square meter for the last 3 years for each area (Chiorean et al., 2018).



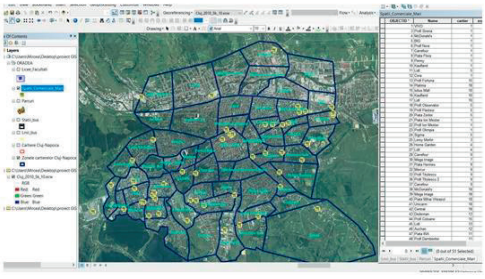
(a) Neighborhoods



(b)Areas

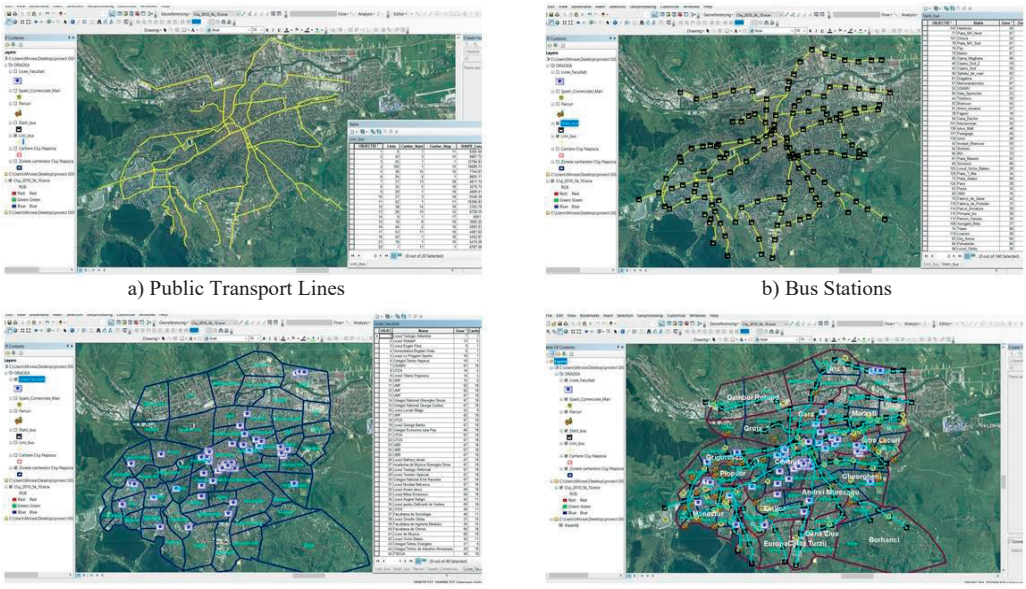


(c) Parks



(d) Shopping Places

Figure 2. Digitizing Map in ArcMap



a) Public Transport Lines b) Bus Stations

c) Teaching Units d) Finish

Figure 3. Completion of Digitization in ArcMap

In the following step we passed to ArcGis for Developers. This application allows to create interactive data visualizations with ArcGIS APIs and SDKs in 2D or 3D, labels and pop-ups, data-driven styling.

When sign in, the dashboard and tools can be accessed to manageapplications, maps, monitor credit usage and manage data. The dashboard also gives access to other ArcGIS applications tools across the platform. In order to be usable, data must beimported in shape format (.shp) from ArcMap, to create a WebMap in ArcGIS Online (ArcGIS Online for Developers).

A Web Map is a 2D map that you can create, style, and share between different applications. Web maps are JSON objects defined by the Web Map Specification and contain configuration settings for the map extent, base map, layers, layer styles, pop-ups and more.The Esri Web Map Specification is a JSON specification which provides a light-weight standard for sharing, creating, editing, visualizing, and consuming web maps across the entire ArcGIS platform. As JSON files, web maps can be hosted on an ArcGIS Server and consumed with the REST API. Technically, web maps are Content Items stored in ArcGIS Online or ArcGIS Enterprise.

Every web map has a unique ID, and may be made public or restricted to certain groups and users. Web maps can be created in ArcGIS Online and ArcGIS Pro, and displayed in many other applications such as Navigator, Collector, Storymaps, Esri's configurable apps and apps built with the ArcGIS APIs and SDKs. When an application loads a web map, it automatically loads previously saved configuration settings, making it easy to develop applications and share 2D maps across the ArcGIS platform (ArcGIS Online Help).

Using the Analysis function which is available only in ArcGIS for Developers, different commands have been executed on the database in order to create a Web Map that can be manipulated in an easy way by the user. In order for the user to obtain a precise result regarding the choice of the area of interest for the investment, the most common and requested search criteria were developed under the form of some queries/analyses (Hickman, 2010):

1) Firstly, the areas were classified according to the average prices per square meter of the last 4 years (Figure 4), also configuring the pop-ups and the details of the map (Kuntz et al., 2014).

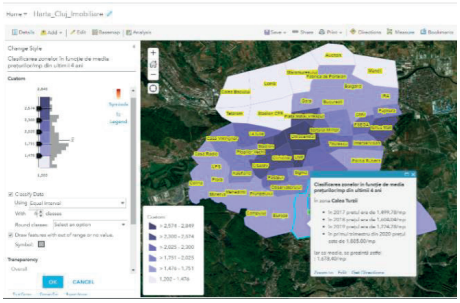


Figure 4. Areas-Prices

2) As a second task,the areas had to be classifiedaccording to the number of educational units, exclusively highschools and universities, this being the second principle after which most clients are guided when they intend to purchase a property, especially an apartment, being about an urban agglomeration such as Cluj-Napoca (Figure 5).

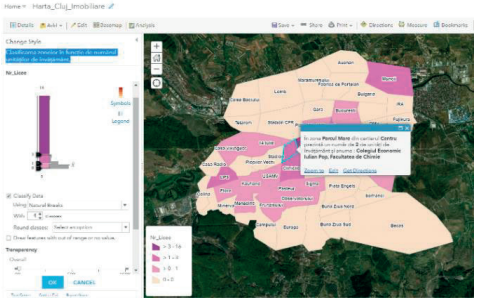


Figure 5. Classification of Areas According to the Number of Educational Units

3) On the third place in criteria rankings came the number of bus stations available for each area (Figure 6).

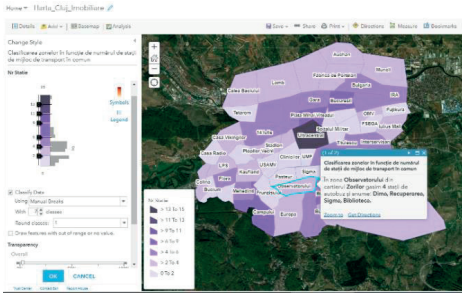


Figure 6. Classification of Areas According to the Number of Bus Stations

4) Because most of the investments in apartments in Cluj-Napoca are related with the rental market, so based on the demand of most tenants, which is taken into consideration by most investors, the further on the list is situated the problem of shopping places (Figure 7).

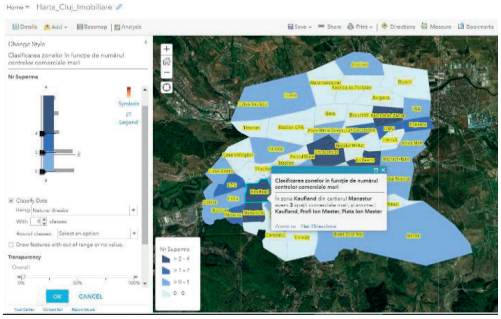


Figure 7. Classification of Areas According to the Number of Shopping Places

5) The possibility of recreation, of sport activities, or just the idea of vegetation, makes buyers to put parks in their preferences when it comes to acquisition so we classified the areas according to number of parks (Figure 8).

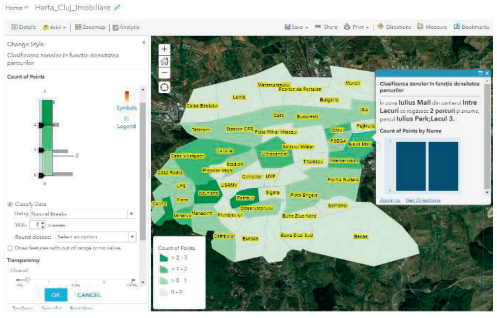


Figure 8. Classification of Areas According to the Number of Parks

6) The last criteria are about the distance between a highschool or a university and a bus station (Figure 9). This way the client/user will be able to see and evaluate the situation according to his needs (Eraker et al., 2015).

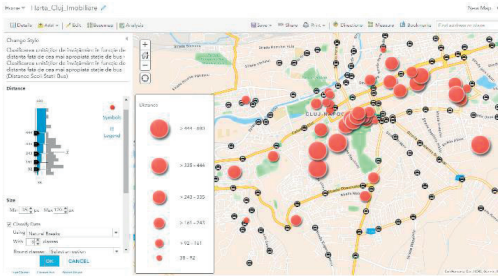


Figure 9. Classification of Areas According to the Nearest Bus Station

Also, in this stage of data processing, we proceeded to make available to the user 3 types of web maps.

The first type of map, makes it possible for the user to view all the classifications on each layer, in particular of the main areas, but also of other types of layers.

The next objective was to create a web map that would allow the users to view all the points of interest within a certain perimeter set by them.

Related to the main idea of the paper, that is to create a webmap with an easy-to-use interface for clients interested in finding the best investment area according to their own criteria, it was proceeded to apply filters from the ArcGIS Online application.

A filter presents a focused view of a feature layer in a map. By limiting the visibility of features in a layer, it can reveal what's important. For example, we created a filter on an area layer so only the areas with prices betweentwo values appear on the map.

As a map authors, we could also set up interactive filters to help our clients explore data themselves. By providing prompts and hints about the available values in the layer, we wanted to guide our clients toward other filters they might want to apply on the features. For example, we set up an interactive filter on the route of the public transport lines layer so that customers can see the areas through which a certain bus line passes along with characteristics related to bus stations.

RESULTS AND DISCUSSIONS

The application allows the distribution of layers, maps or other items created in ArcGIS by a developer to public, or to a group of people or an agency. The public items offered by the developer are accessible without authentication. If they instead try to access the parts set as "private" by the developer, the application will immediately request authentication (ArcGIS Online for Developers).

In order to view the database and the previously executed classifications to be accessible to users/ clients, it was necessary to create a Public Web Map.

The first map that was published makes it possible to view previously created layers and classifications along with every corresponding legend (Figure 10).

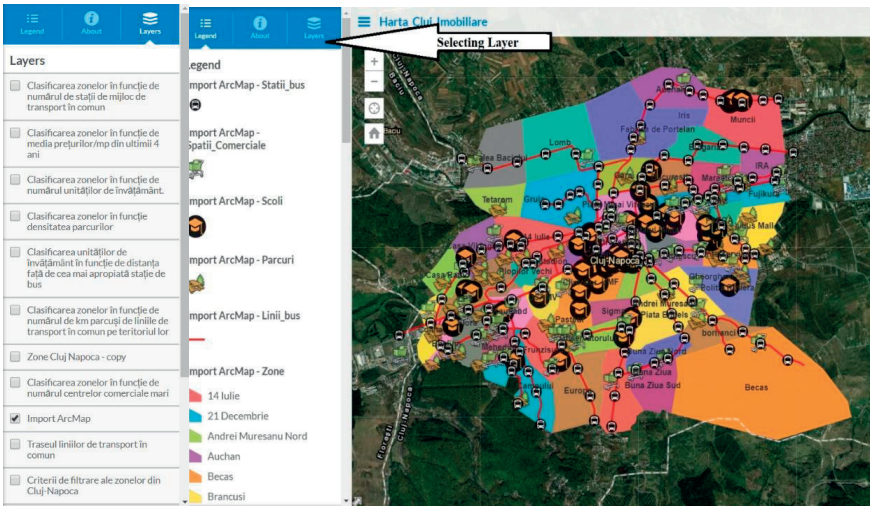


Figure 10. Public Web Map

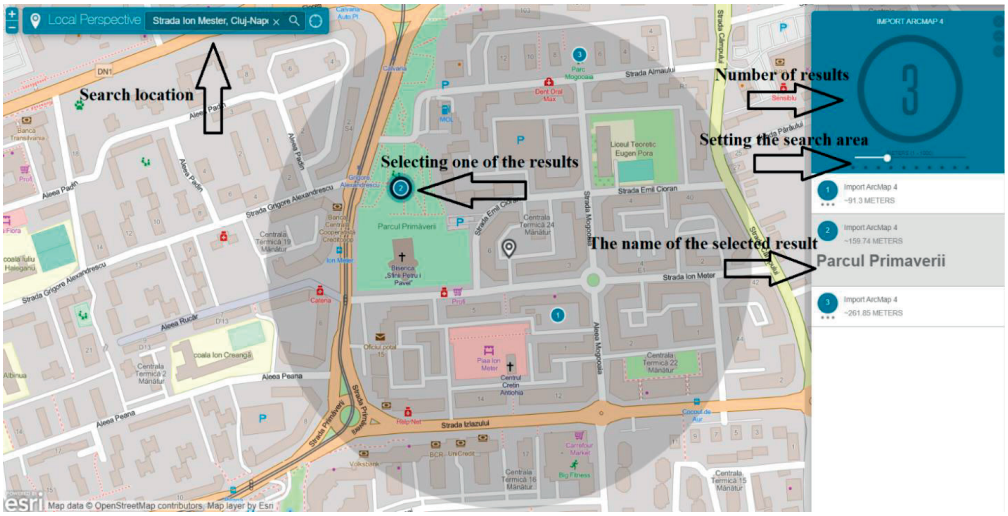


Figure 11. Local Perspective Web Map

The following type of web map, namely Local Perspective made accessible by publication refers to the possibility of the user or client, to search for a location and set a certain perimeter to see the points of interest available in that perimeter, more precisely, high schools or universities, shopping centres, bus stations or parks (Figure 11).

For example, if a search was performed on Ion Mester street in Cluj-Napoca, setting a search perimeter of about 300 meters, it was displayed after this command, that in the respective area, there are a number of 3 parks, being possible to also select each of them to see more details about them. Also, without needing another search or setting of another perimeter, only by selecting the type of points of interest to show, the rest of the information can be viewed as follows (Figures 12, 13, 14).

As a last aspect, a Filter Web Map was made available to users with access to the filters created in ArcGIS for Developers.

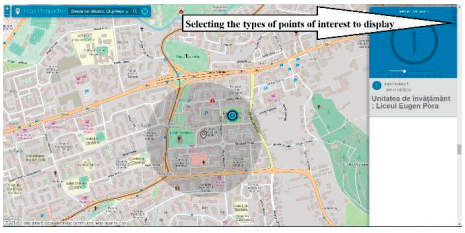


Figure 12. Displaying Teaching Units in the Perimeter

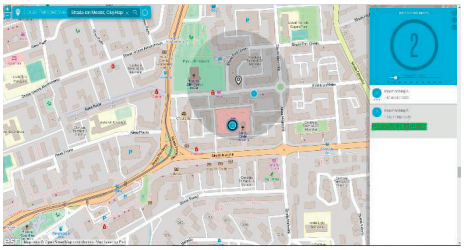


Figure 13. Displaying Shopping Centers in the Perimeter

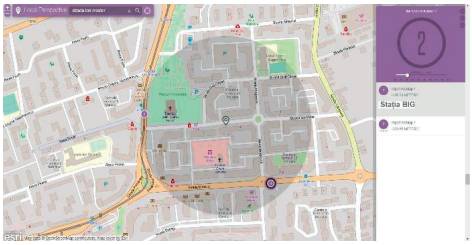


Figure 14. Displaying Bus Stations in the Perimeter

In the left side of the window you can see all the selection options available for each type of filtering chosen, as well as the option for choosing the type of filters you want, in our case being about the criteria for filtering the areas in Cluj-Napoca, and an interesting option for viewing each route of the public transport line (Figure 15).

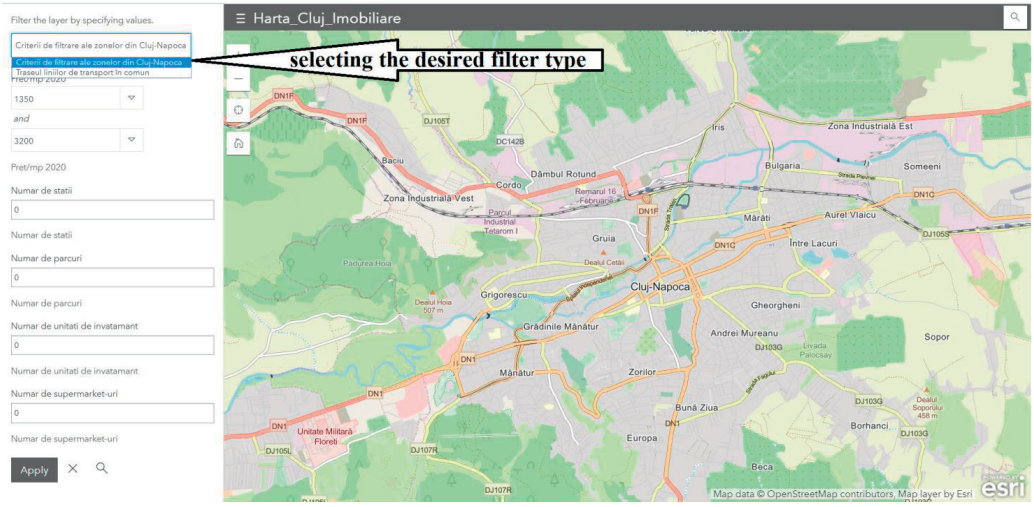


Figure 15. Filter Web Map

For the first type of filtration, namely the Filtering of the Areas in Cluj-Napoca, we have different filling options. If you want, for example, a search for an area that falls in the price range 1900-2100 Euro/square meter, has a minimum of 3 bus stations nearby, at least 2 parks, a school and 2 shopping places, the application will show the following result (Figure 16).

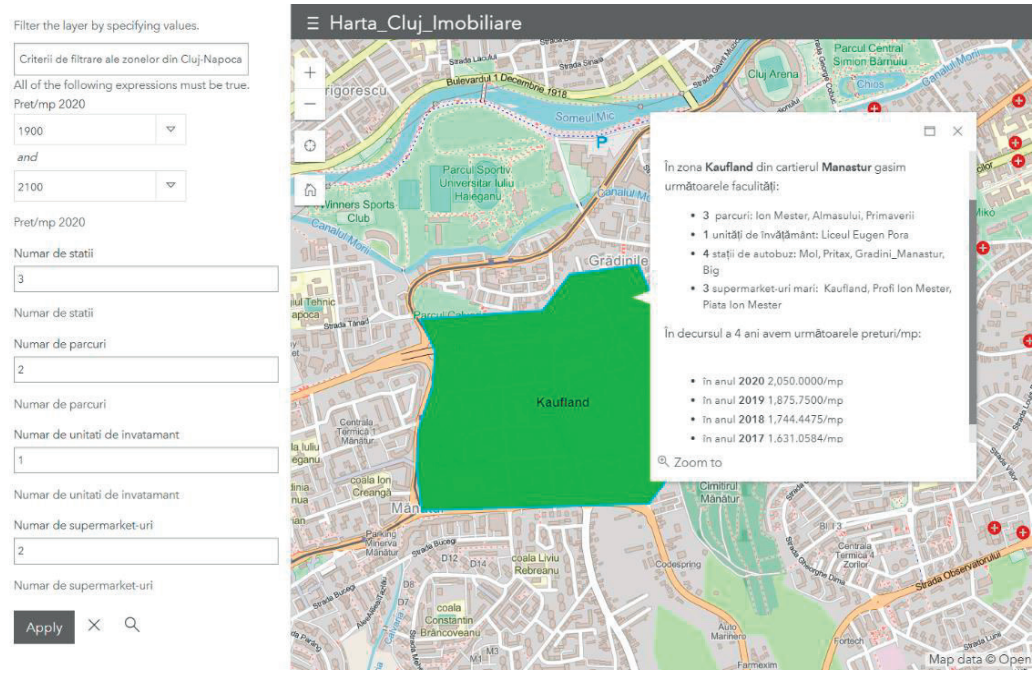


Figure 16. Result of the Filtration

The second type of filtration is called Bus Lines Routes through the areas, so if however, it is desired to visualize the route of a certain bus line through each area, for example the

route of line 52, all we have to do is select the appropriate filter type and enter the line number.
In this way, all areas through line 52 will be displayed, along with the main details of each one, such as the stations of line 52 in that area and of the educational units. This can be paired by a potential investor with the classification from the previous map that was previously made available by developers that refers to the distance between each educational unit and the nearest station (Figure 9). Thus, it can be observed that line 52 passes through 14 zones, and if you want to see the above mentioned details, you can see that the LPS area has 3 bus stations, and 2 educational units (Figure 17).

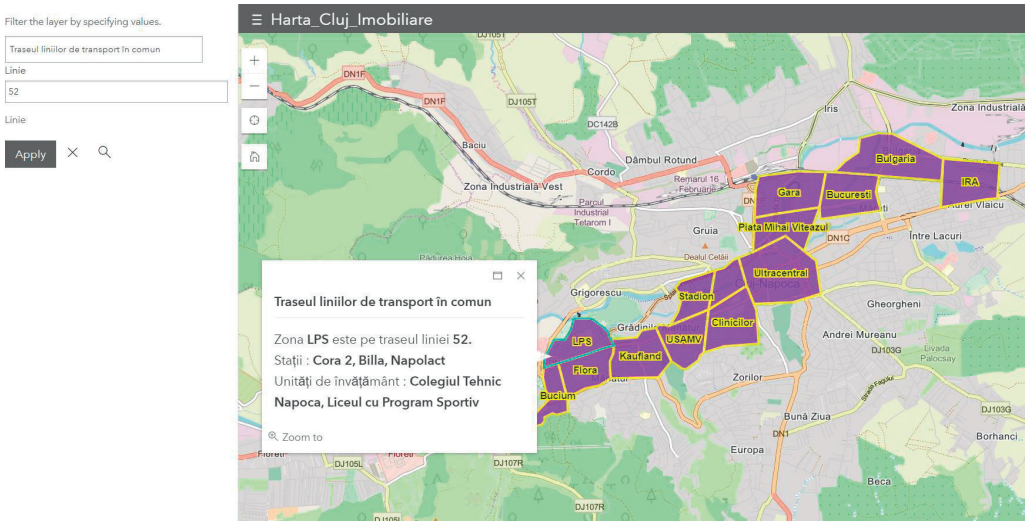


Figure 17. The Route of Line 52

CONCLUSIONS

Considering, the operations performed, starting with the creation of the database in ArcCatalog together with ArcMap and importing them into ArcGIS Online for Developers, brought us one step closer to achieving the objective of this paper. The purpose of the creation of these Web Maps was the geographical visualization of the points of interest and the classifications of the areas of Cluj-Napoca according to them, by the potential clients or users.The geographical visualization allows an overall analysis on the whole city of what means areas of interest and positioning the objectives pursued such as bus stations, parks, shopping places or educational establishments within a certain perimeter set by the user.
Using all the options available for developing web maps from ArcGIS Online such as editing pop-ups that provide a better and more interactive presentation of the details of certain objectives on that map, or introducing filters to help narrow down the search, 3 types of web maps were created to help userswho want a more detailed analysis of their preferences.
In conclusion, if a user manages to take into consideration all the details of the maps made available by the developers, along with the filtering performed by him, he will be able to reach theright decision.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

RESULTS OF HARDNESS RESEARCH AND ENERGY REQUIRED FOR DESTRUCTION OF THE RESIDUES FROM OIL-BEARING ROSE PRODUCTION IN REPUBLIC OF BULGARIA

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Abstract

About 4000 hectares of oil-bearing rose are grown in Bulgaria, of which approximately 20000 tons of residual biomass is harvested annually. For now, there is no unilateral decision on how it can be used. The purpose of this study is to establish: what kind of wood (soft or hard) is the residuals of contour pruning of oil-bearing roses and what are the hardness and energy required to destroy these residues. From the research it was found that a sheet of rosewood mass can be processed with machines for crushing and pelleting/briquetting of softwood and the energy needed to destroy 1 g of these residues with a humidity of about 14% is 16.56 J, which is equal to 46 kWh/t.

Key words*: energy required for destruction, hardness, sticks of oil-bearing roses.*

INTRODUCTION

The need to generate heat and electricity, global warming caused by increased greenhouse gas emissions, rising fossil fuel prices and the demand for energy independence have created a new industry focusing on the production of energy through the use of renewable sources.

In accordance with European Parliament Directive 2009/28, in 2010, our country adopted a National Renewable Energy Action Plan (NREAP), which corresponds to the "20-20-20" EU energy policy objective Marinov K. (2013). The aim of the plan is to ensure a sustainable transition to a low-carbon economy based on modern technologies and the widespread use of renewable energy sources. It establishes a framework to promote the development of renewable energy, with the aim of reaching a minimum of 16% of total energy production, including the biomass share of 36%. In line with this plan, the new Forest Law (Article 88 (5)) provides for energy crops from fast growing wood species for accelerated biomass production falling within forest areas (point 2) and agricultural land or urbanized areas 4), not to be managed as a forest. This act allows the production of biomass as a priority of energy crops.

Among the different options, biomass is the third most important source of electricity generation and is the main source of heat generation Nunes L. et al. (2014). Usually, biomass is processed into solid (pellets, briquettes) or liquid (biodiesel) fuel.

Since the global pellet market is developing rapidly, the use of wood remains is no longer sufficient to meet its needs. Pellet standards provide limits for both physical and mechanical characteristics. They depend mainly on the characteristics of the raw material, such as particle size and moisture content, and operating conditions such as the applied pressure and the temperature of the matrix Mohamed M. et al. (2019)

Biofuel production uses various agricultural products such as cane, hemp, straw, rape meal, sludge and rape residue Nilsson D. et al. (2011), compost from municipal waste Mavaddati S. et al. (2010), cork products Nunes L. et al. (2013). Pellets from garden waste have been found to be conveniently used in residential cooking stoves (Pradhan P. et al., 2018).

Maize cobs have some characteristics that make it possible to use them in industrial plants. However, these properties are not sufficient for use in domestic stoves and boilers where higher fuel quality is required. For this reason, briquetting and pelleting are used Miranda M. et al. (2018).

The main quantities of biomass waste in Bulgaria are obtained from the maize stalk mass of the maize and the sunflower stems, after the harvesting of the main production, as well as the vine rods, after the cutting of the vine massifs Enakiev Y. et al. (2016). It has been found that when granulating sunflower stems and vine rods, the energy consumption is 129 kWh/t, and in the case of maize leaf-stalk mass - 149 kWh/t obtained at a matrix speed of 220 min^{-1} and humidity of the materials respectively 18% for maize, 20% for vine rods and 20.3% for sunflower.

Many attempts have been made in our country and around the world to pelletize livestock waste Mohov V. (2008); Yanakiev J. et al. (2016) and to use the obtained materials as solid fuel or fertilizer.

In the practice of processing waste biomass from logging and wood processing, many machines are separated. Typical of them is that they are designed for different types of wood - soft, hard Peichev K. et al. (2006).

In their study, the authors Nielsen N. et al. (2009), comparing the energy required to pelletize pine and beech wood, conclude that it is much higher in 'solid' beech wood. Masche M. et al. (2019,) reach the same conclusion. An interesting fact is that the energy required for shredding pine wood (10 kWh/t) is greater than that for beech wood (7 kWh/t).

About 40,000 oil-bearing roses are grown in Bulgaria. The total residual green mass is about 20,000 tons. There is currently no unilateral decision on how this biomass can be used.

The aim of this study is to establish:

1. What type of wood (soft or hard) is the residual contour of oil-bearing roses;
2. The hardness and energy required to destroy these residues.

MATERIALS AND METHODS

The experiments were carried out at the Department of Mechanization of the Agricultural University of Plovdiv in the period June-September 2017.

For Brinell 10/100 method, the experimental setup shown in Figure 1 was developed Zahariev I. (2017). The required force of 100 N is created by gravity.

Place the test piece on the base of the unit. The weight, together with the steel sphere, slowly, without any impact, descends until it rests on the surface of the test body and loosens the rope. Wait for 120 s and slowly lift the weight. Remove the test body. Record the size of the footprint in two perpendicular planes (Figure 2) using a binocular magnifier (12.5x magnification) with a built-in Poldi hardness tester.

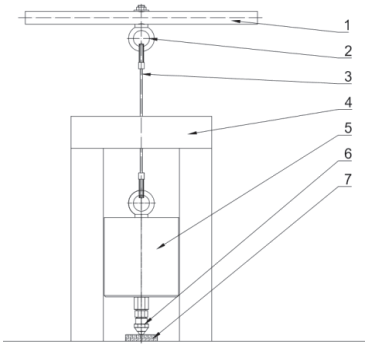

Figure 1. Test facility: 1 - handle; 2 - bolt special; 3 - rope; 4 - an attachment frame; 5 - weight; 6 - spout with steel sphere Ø10mm; 7 - test body

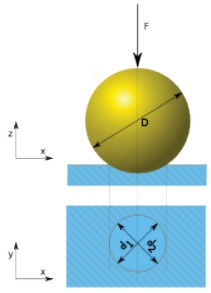

Figure 2. Hardness measurement chart of material using Brinell method. Source: https://bg.wikipedia.org/ Brinell Method (20 February 2017)

Brinell Hardness Number [BHN] https://bg.wikipedia.org/The Brinell Method (February 20, 2017) is defined by the formula:

$$BHN = \frac{2P}{\pi D(D - \sqrt{(D^2 - d^2)})}, \quad (1)$$

where:

P - applied force, N;

D - diameter of the nozzle (steel sphere), mm

d - footprint diameter, mm.

To measure the energy required for destruction, a stand developed and described by Zahariev I. (2018) is used (Figure 3).

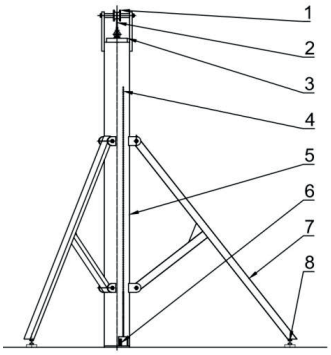

Figure 3. Bench: 1-roller support; 2-rope lifting; 3-stroke body; 4-hole holes; 5-housing; 6-piece body; 7-foot support; 8-foot adjustable

The force required to act on the test body is created by a shock body weighing 144 N and a maximum impact angle of 1.5 m.
The test bodies are correct prisms made according to Rostovsky Y. (2017).
At the bottom of the casing a test body is placed through a window. The impactor rises to a height of 1.2 m and runs on the test body. Remove the test body and visually determine its condition. If it is not crushed, a new test body is placed in the stand and the procedure is repeated, with the impact body rising and running at a higher height. This operation is repeated until the test piece is crushed.
The energy required to break down the test bodies is expressed by the dependence:

$$E = \frac{m.v^2}{2}, \text{ J} \qquad (2)$$

In Equation (2), the body speed is unknown at the moment of impact. For its determination, the impact body is represented as a material point falling freely down into the air. According to Partinov P. et al. (1985) the law of movement of the striking body has the type:

$$y = \frac{g}{k^2}\left(e^{-k.t} + k.t - 1\right) \qquad (3)$$

where:
y - the launching height of the impactor, m;
t - time to impact with the test body, s;
k = 0.055807086 - constant.

To find the speed of the hammer at the moment of impact, the time (t) from release to contact with the test pieces should be determined. This is hampered by the condition that equality (3) can only have an approximate solution.
In the present work, according to Kehayov D. (2007), in equation (3) the time is replaced with real values - 0 to 1 s at an interval of 0.05 s. The path from the impact body for the appropriate time is obtained. A regression equation was constructed with the obtained data Draper N., Smith G. (1986), Draper H., Smith G. (1987); Mitkov A., Minkov D. (1989).

$$Y = A_1.t + A_{11}.t^2, \quad \text{m} \qquad (4)$$

Equation (4) is a quadratic equation with one unknown, namely the motion time of the impact body. The road is equal to the height from which the striking body is released. The speed is obtained privately from the road and the time it takes to travel.

$$v = \frac{Y}{t}, \quad \text{m/s} \qquad (5)$$

RESULTS AND ANALYSIS

The results of the tests and subsequent analyses are given in tabular form and illustrated with figures and graphs.
Hardness of residual biomass from rose production
- Straightness of fiber direction by Brinell method 10/100.

Table 1. Comparison of the average values for stiffness in the direction of the fibers

T-test for Independent Samples Note: Variables were treated as independent samples					
Compare wood	Oil-bearing rose [BHN]	Comparable wood [BHN]	Student's Criterion	Degrees of freedom	Level of significance – p
Oil-bearing rose - Walnut	1.4646	1.7056	-1.9761	13	0.069762
Oil-bearing rose - Elder	1.4646	1.3294	1.0968	13	0.292628
Oil-bearing rose - Elm	1.4646	2.1130	-4.9474	13	0.000267
Oil-bearing rose - Seventh	1.4646	3.2152	-10.8729	13	0.000000
Oil-bearing rose - Dogwood	1.4646	1.8086	-2.8769	13	0.012970
Oil-bearing rose - Beech	1.4646	2.1406	-5.4726	13	0.000107
Oil-bearing rose - Oak	1.4646	2.5350	-6.8969	14	0.000007
Oil-bearing rose - Pine	1.4646	1.1330	2.4318	13	0.030229

The fiber stiffness data shown in Table 1 indicate that the level of significance (p) is greater than 0.05 when comparing oil-bearing rose-walnut (p = 0.069762) and oil-bearing rose-elder (p = 0.292628). In Figure 4 shows that the values for the oil-bearing rose overlap with the walnut and eldered values and partly with the pine values.

- Hardness perpendicular to the fibers by Brinell 10/100 method.

The hardness data perpendicular to the fibers presented in Table 2 show that the level of significance (p) is greater than 0.05 in the variants of oil-bearing rose - walnut (p = 0.760673) and oleaginous oil-bearing rose - elm (p = 0.196778). It can be seen in Figure 5 that the values of the oil-bearing rose overlap with those for walnut and elm and exceed the pine values.

The observations made point to the conclusion that the wood of oil-bearing rose, walnut, elder and elm are of the same group in terms of the monitored parameter. This gives reason to recommend that the waste biomass of oil-bearing rose be processed with the same machines and modes of operation as the other "soft" woods.

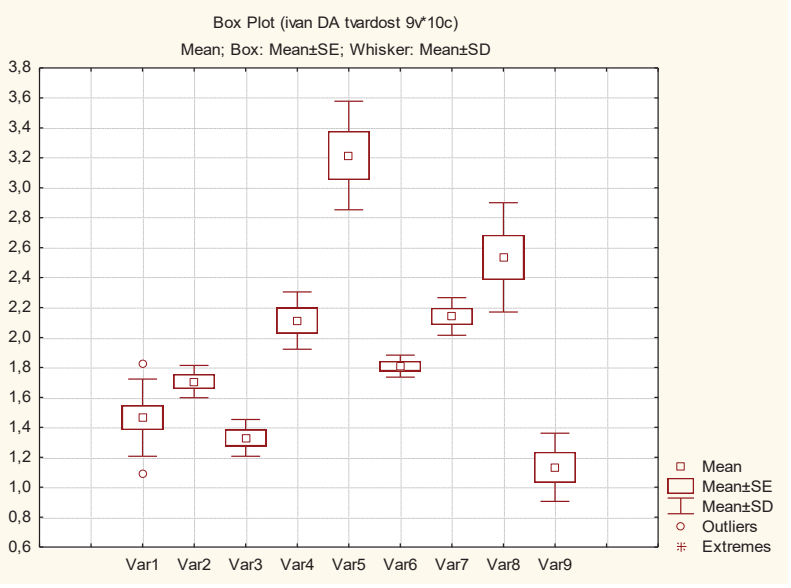

Figure 4. Comparison of the average values of stiffness in the direction of the fibers: Var 1 - oil-bearing rose; Var 2 - walnut; Var 3 - elder; Var 4 - elm; Var 5 - seventh; Var 6 - dogwood; Var 7 - beech; Var 8 - oak; Var 9 - pine

Table 2. Compare the average values for stiffness perpendicular to the fibers

T-test for Independent Samples, Note: Variables were treated as independent samples					
Compare wood	Oil-bearing rose, [BHN]	Comparable wood, [BHN]	Student's Criterion	Degrees of freedom	Level of significance – p
Oil-bearing rose - Walnut	2.8390	2.7662	0.31305	10	0.760673
Oil-bearing rose - Elder	2.8390	1.8648	4.38459	10	0.001368
Oil-bearing rose - Elm	2.8390	3.1712	-1.38295	10	0.196778
Oil-bearing rose - Seventh	2.8390	4.0914	-5.04483	10	0.000503
Oil-bearing rose - Dogwood	2.8390	4,0080	-4.40211	10	0.001331
Oil-bearing rose - Beech	2.8390	3.6388	-3.00885	10	0.013143
Oil-bearing rose - Oak	2.8390	3.7108	-3.97160	11	0.002190
Oil-bearing rose - Pine	2.8390	1.3792	6.35907	10	0.000083

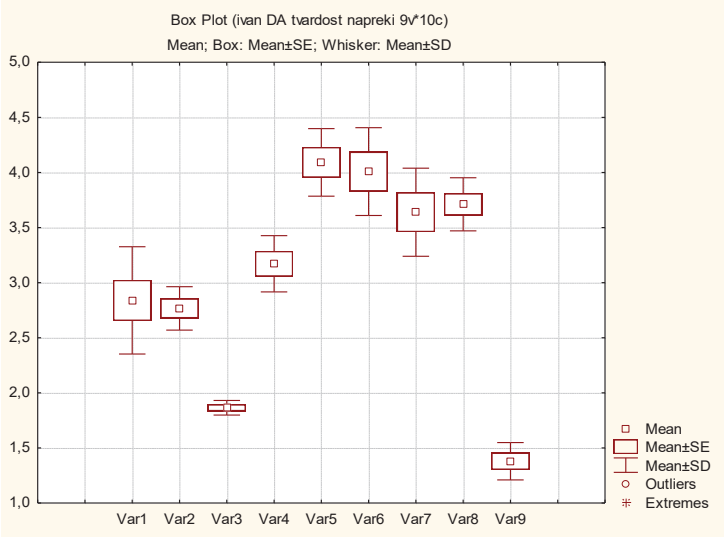

Figure 5. Comparison of average hardness values perpendicular to the fibers: Var 1 - oil-bearing rose; Var 2 - walnut; Var 3 - elder; Var 4 - elm; Var 5 - seventh; Var 6 - dogwood; Var 7 - beech; Var 8 - oak; Var 9 - pine

Energy required to break the sheet

Using the dependence (5) and substituting the constants g and k, the path passed by the free fall body into the air environment for a different time period is determined. The obtained data were processed by the single factor regression analysis method. Results are shown in Table 3.

Table 3 Single-factor regression analysis results

Regression Summary for Dependent Variable: Route-Time R = 0.99990212, R^2 = 0.99980424, Adjusted R^2 = 0.99979026, F(1.14) = 71503, p = 0.000001						
	Beta	Std.Err.	A	Std.Err.	t (14)	p-level
X^2	0.999902	0.003739	4.844342	0.018116	267.4005	0.000001

The regression equation has the form:

$$Y = 4.8443.t^2 \quad (6)$$

In this equation the left side is known - the height from which the hammer is released. The roots of the square equation (6), at different paths Y, determine the time for this path. Knowing the path that the impactor travels to the collision with the test and the time to impact, it is possible to determine the speed at the moment of impact and the applied energy (Table 4).

Table 4. Route, time, speed, and applied energy

Route [m]	1.200	1.240	1.300	1.400	1.500
Time [s]	0.498	0.506	0.518	0.537	0.556
Speed [m/s]	2.410	2.450	2.510	2.600	2.700
Applied energy [J]	41.82	43.22	45.36	48.67	52.49

To determine the energy required for destruction of oil-bearing rose oil samples, a series of experiments were carried out. The results are shown in Table 5.

Table 5. Results of the Experiment of Demolition of Test Bodies

Test body №	Impact height of the impactor [m]	Distance between impactor and test body [m]	Calculated time on fall to stroke [s]	Visual test state of a test body
1	1.480	1.458	0.547984	destroyed
2	1.400	1.379	0.532758	destroyed
3	1.380	1.357	0.528568	destroyed
4	1.360	1.339	0.525073	destroyed
5	1.340	1.316	0.520483	destroyed
6	1.320	1.297	0.516694	destroyed
7	1.300	1.278	0.512877	destroyed
8	1.280	1.257	0.508625	cracked
9	1.260	1.238	0.504749	destroyed
10	1.240	1.218	0.500635	cracked
11	1.220	1.198	0.496489	cracked
12	1.200	1.177	0.492098	cracked

It can be seen from Table 5 that the destruction of the test bodies occurs when the impactor is released from a height of more than 1.28 m.
The applied energy at which 100% destruction of the test bodies is observed, regardless of their geometric tolerances, is at a launching height of the impactor of 1.3 m.

$$E_{1.30} = (2.51^2 * 14.4)/2 = 45.361 \text{ J} \quad (7)$$

From the measurements made during the experiments it was found that the average mass of the test bodies was 2.74 g. Here it follows that the energy needed to destroy 1 g of biomass from oil-bearing rose is:

$$45.361 \text{ J} / 2.74 \text{ g} = 16.555 \text{ J/g} \quad (8)$$

From the equation 1, $J = 2.777 * 10^{-7}$ kWh the required energy in kWh is obtained:

$$16.555 \text{ J/g} * 2.777 * 10^{-7} \text{ kWh} = 4.6 \text{ kWh/t} \quad (9)$$

CONCLUSIONS

1. The results of the experience suggest that a sheet of oil-bearing rose can be processed with machines designed for crushing and pelleting / briquetting of softwood.

2. The energy required to destroy 1g of oil-bearing rose mass with a moisture content of about 14% is 16.56 J, which is equivalent to 4.6 kWh/t.

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Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IX, 2020
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

DETERMINATION THE DEGREE OF COVERAGE WHEN TREATING PEPPER WITH DIFFERENT TYPES OF NOZZLES

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Abstract

A variety of technical means are used to combat pest control. In this study, the operation of slit and diffuser sprays was observed in the coating of the lower and upper pepper leaves. When working with the slot spreader, the coverage of the entire leaf mass is significantly less. The sprayed working fluid does not have sufficient puncture force to penetrate the entire height of the plants. Leaf coverage averages 29% of the underside and 35% of the top. When using a diffuser sprayer, the air generated by the fan intensively stirs the leaf and forces the sprayed liquid with great force. This is a prerequisite for very good coverage of both the top of the leaves and the bottom. The coverage varies from 52 to 63% for the lower and upper leaves, respectively.

Key words*: diffuser and slit sprayer, pepper, spray deposit.*

INTRODUCTION

Pepper is appreciated for the very high nutritional, dietary and taste qualities it possesses. Vitamin C content ranks first among vegetables and even exceeds lemons 4-5 times.
Pepper is a valuable vegetable crop in the United States. The management of insects and diseases relies on chemical control capabilities (Derksen R. et al., 2007). Given the relatively low chemical capacity for pest management, it is crucial to make effective use of pesticides. It is imperative that the leaves be covered top and bottom with a spray. Several delivery systems have been evaluated, including air-induction nozzles and dual fans, air-assisted delivery with conventional hydraulic nozzles and pneumatic atomization nozzles producing electrically charged sprays. Travel speeds of 6.4 and 12.9 km/h were also evaluated. Faster travel speeds did not significantly affect spray retention in double row awnings. The electrostatic sprayer gave the largest differences in the deposition between the middle and the bottom of the canopy. Although there was no more than a 25 cm difference between the leaves taken from the mid and lower canopy specimens, the retention of spraying on the foliage at the locations of the lower canopy had significantly lower retention than the average canopy for almost all spray types. Despite the differences in atomization characteristics, the operation of the dual-fan nozzle and the air-induction nozzle treatment are similar. Air-assisted feeding did not favor the amount of spray retained on the greens, but resulted in a more desirable spray quality on the greens and resulted in more spray retained on whole fruits.
In this study (Rincón V. et al., 2017), the effects of pressure and volume dose of treatment application with a hand spray gun on greenhouse cultures were evaluated. In the first case, three different pressures were evaluated: a standard at 2000 kPa (P20) and two others at 1500 kPa (P15) and 1000 kPa (P10). Three volumes of application were used to test the effects of application volume: one considered as a reference (V100) applied by an experienced manufacturer and two reductions thereof, i.e. 25% (V75) and 50% (V50). The results showed that the use of high pressure does not improve either the deposition or entry into the shed, and the losses to the earth do not differ significantly. On the other hand, a reduction of about 25% of the application rate applied by local farmers has led to a significant reduction in plant canopy deposition, which could compromise the control of pests and diseases. Land losses decreased with the application rate, although the differences were not significant between V100 and V75.
Hand carts have recently been advertised to improve spray techniques in greenhouses in southeast Spain (Llop J. et al., 2016). This

study evaluated the deposition, coverage, and uniformity of spray distribution on the canopy. Leaf deposition is significantly greater when flat fan nozzles and air-assist nozzles are used for both large and small spray volumes. No differences were found between the reference system at high spray volume and the modified trolley at low spray volume. Flat-blower nozzles with air assist increase penetration into the shade. Air assist and flat fan nozzles allow volume reduction while maintaining or improving the distribution of spray quality. The operating parameters of hand-held sprayers must be taken into account in order to reduce the risk of the environment and to increase the efficiency of the spraying process.

In their study (Nuyttens et al., 2004), they work with frame spraying systems for tomato and pepper treatment. The effect of the distance between the sprayers and the distance to the treated objects on the quality of work was monitored. The optimum distance to the treated plants was found to be 0.3 m at spacing of 0.35 m.

Pressure, droplet size classification, and arrangement of a series of nozzles with two flat jets on the number of droplet density on horizontal artificial manifolds were investigated using a fixed application rate (Ferguson J. et al., 2016). The relationship between coating and nozzle type was significant ($P < 0.001$), as was the relationship between coating and pressure ($P < 0.001$). The arrangement of the nozzles has a significant impact on the asymmetric nozzle dual fan spray coating and it would be advisable to alternate these nozzles on a spray boom in order to increase the coverage, especially at higher application rates.

An alternative to improving chemical pest control is the use of electrostatic spray technology (Marques R. et al., 2019). For the application of insecticides, a boom sprayer with an induction electrostatic spray system with indirect electrification was used. There is a significant increase in the deposition by spraying, both in the upper and lower leaves of maize, using electrostatic spraying technology compared to the conventional spraying system. Electrostatic spraying also allowed the spraying rate to be reduced by approximately three times the rate used for conventional hydraulic spraying.

When treating vegetable crops with pesticides, the performance of classic barbells and frames (vertical barbells) was compared. (Sánchez J. et al., 2011) found that the use of a framework provides the same quality of work, but at lower volumes and with lower pesticide losses on the ground. This reduces soil and environmental pollution. The results of (Braekman P. et al., 2009) in the processing of ornamental crops are similar. Although the spray gun performed well in the easily accessible area for runner crops, its performance in the denser area of main crops was lower. With 240% more spraying of liquid (8500 l/ha) and chemicals, the deposits in this culture area do not differ significantly from those obtained with the vertical spraying system applying only 2500 l/ha. Spraying at 5000 l/ha, the vertical spray boom system achieves 82.9% greater overall spray deposition in the area of the main crop than the spray gun at an application rate of 8500 l/ha. In general, a standard vertical spray boom performs better than the reference equipment for strawberry spray (atomizer) and tomato (Twin sprayer) (Braekman P. et al., 2010). The type and settings of the nozzles significantly influence the delay of spraying and the penetration of crops. The use of vertical spray boom is a promising technique for the application of plant protection products in a safe and efficient manner for tomatoes and strawberries, and the selection and adjustment of nozzles must be carefully considered.

Pepper planting and cultivation has become an important red pillar industry in Xinjiang. With the continued growth of cultivated acreage in Xinjiang, diseases and pests are increasing year by year. The purpose of this study was to compare the drip deposition and control efficiency of Unmanned Aerial Vehicles (UAVs) and EAPs on a pepper treatment field. The drone has a poor degree of droplet coverage, droplet density and deposition uniformity, but shows the best deposition (1.01 $\mu g/cm^2$, which is 98% more than the EAP sprayer). The control efficiency of a UAV sprayer when treating pepper fields with *Phytophthora capsici* and aphids is slightly lower than that of the EAP sprayer. When a UAV sprayer is used to control diseases and pests of pepper, it can reduce the dosage of pesticides to provide a controlling effect. Further study of the high concentration of pesticide residues in pepper fruits and the environment sprayed with UAV is needed.

The purpose of the present study is to observe and compare top and bottom leaf coverage when treating pepper plants with slit and diffuser sprays.

MATERIALS AND METHODS

The experiments are carried out on a production field of correct geometric shape with dimensions 60 x 30 m. The planting scheme is 0.60 x 0.15 m. A drip irrigation system is installed. Rows in the middle of the width field, spaced 5 apart, were selected to eliminate the effect of the type of spreader on the results obtained.

Biometric characterization of pepper plants is performed by observing the following indicators: stem height, shrub height and maximum shrub width. For this purpose, measurements of 100 randomly selected plants are made and the obtained results are statistically processed by determining the average value, variance and coefficient of variation (Mitkov A., Minkov D., 1985).

In this work, experiments are performed with 2 sprayers. The first is a traditional flat jet sprayer with a spread angle of up to 110º - № 3 (https://www.lechler.com/de-en/products/). It is mounted on a simple back sprayer. The second is a diffuser sprayer. It is mounted on a back-motor sprayer. The following indicators are: coverage of the top and bottom of the leaves when working with the two plant height spreaders. The plants are divided into 3 layers in height: upper, middle and lower. On 10 randomly selected shrubs, in each layer, the bottom and top sheets of water log paper are attached.

The tanks of both sprayers are filled with water. They are put into operation and each row is processed separately. Then, with a planimeter, the area covered with drops is recorded for each sheet of water log paper. The recorded area relative to the total area of the water log paper gives the coverage of the leaves. The obtained results are processed with the help of Statistica v.7 software package by testing the hypothesis for equality of mean values between different variants.

RESULTS AND DISCUSSIONS

Biometric characteristics of pepper plants

The results obtained are reflected in Table 1.

Table 1. Biometric indicators

Descriptive Statistics			
Indicators	**Average value**	**Dispersion**	**Coefficient of variation**
Stem height, cm	22.90	2.23	9.74
Overall height, cm	65.50	7.28	11.11
Width of shrub, cm	34.60	4.50	13.01

The data shows that the average height of the plants is 65.5 cm, with a variation of this value of ± 7.28 cm. In this situation, the most developed plants are about 75 cm tall. The stem, on the other hand, has an average height of 22.90 cm and a variation of this value of ± 2.23 cm. It follows that the stem of the various plants has a length of 20.50 to 25.00 cm. From the foregoing it follows that when treating pepper plants, a leaf mass of approximately 55 cm height is treated. The three observed layers are: upper - at height from 56 to 74 cm, middle - respectively from height from 38 to 56 cm and lower - at height from 20 to 38 cm.

Cover the top of the leaves

The data from the experience and the primary statistical processing are shown in Table 2.

There is a clear difference in coverage when working with the two dispensers.

During the experiments, the fluid sprayed with the diffuser spray along with the air stream penetrated very well throughout the entire height of the bush. The spray coating ranged from 44% in the lower layer to 69% in the upper layer. There was no difference in coverage between the upper and middle layers. No statistically significant difference, but comparatively less coverage of the top of the leaves in the bottom layer.

Table 2. Cover of top of leaves, %

	Valid N	Mean	Minimum	Maximum	Standart Deviation	Coefficient of Variation
flat jet upper top	10	35.50000	30.00000	45.00000	5.016639	14.13138
flat jet middle top	10	6.80000	0.00000	12.00000	4.541170	66.78191
flat jet lower top	10	1.80000	0.00000	6.00000	1.988858	110.4921
diffuse upper top	10	62.80000	52.00000	69.00000	6.014797	9.577702
diffuse middle top	10	60.60000	52.00000	68.00000	4.402020	7.264059
diffuse lower top	10	53.60000	44.00000	64.00000	7.834397	14.61641

When working with the slit spreader, a much lower degree of coverage of the leaf mass is observed. The sprayed working fluid does not have sufficient puncture force to penetrate the entire height of the plants. It is observed satisfactorily covered in the upper layer, at a height above 56 cm. The middle and lower layers lack a drip on the top of the leaves. In order to have a good treatment of the foliage with this type of sprayer, it is necessary to use another type of spreading device - frame or droplets, which allow for complete treatment of the plant.

The data from the attempts to cover the top of the leaves made a comparison of the mean values (Table 3).

There is a proven difference ($p < 0.001$) between the work of the two spreaders. This is well illustrated in Figure 1.

Table 3. Comparison of average values for top leaf coverage

	Mean 1	Mean 2	t-value	Df	p
flat jet upper top vs. flat jet middle top	35.50000	6.80000	13.4123	18	0.000000
flat jet upper top vs. flat jet lower top	35.50000	1.80000	19.7478	18	0.000000
flat jet upper top vs. diffuse upper top	35.50000	62.80000	-11.0224	18	0.000000
flat jet upper top vs. diffuse middle top	35.50000	60.60000	-11.8926	18	0.000000
flat jet upper top vs. diffuse lower top	35.50000	53.60000	-6.1526	18	0.000008
flat jet middle top vs. flat jet lower top	6.800000	1.80000	3.1893	18	0.005080
flat jet middle top vs. diffuse upper top	6.800000	62.80000	-23.4971	18	0.000000
flat jet middle top vs. diffuse middle top	6.800000	60.60000	-26.9000	18	0.000000
flat jet middle top vs. diffuse lower top	6.800000	53.60000	-16.3433	18	0.000000
flat jet lower top vs. diffuse upper top	1.800000	62.80000	-30.4493	18	0.000000
flat jet lower top vs. diffuse middle top	1.800000	60.60000	-38.4936	18	0.000000
flat jet lower top vs. diffuse lower top	1.800000	53.60000	-20.2657	18	0.000000
diffuse upper top vs. diffuse middle top	62.80000	60.60000	0.933381	18	0.362976
diffuse upper top vs. diffuse lower top	62.80000	53.60000	2.945519	18	0.008650
diffuse middle top vs. diffuse lower top	60.60000	53.60000	2.463269	18	0.024074

Cover the bottom of the leaves

A large dispersion of the experimental data is observed with the flat jet spreader - coefficient of variation over 75%. This is largely due to the height at which the data is recorded from the bush. Due to its small breakthrough force, the working fluid penetrates 10-15 cm into the upper layer of the plant (Table 4).

A large dispersion of the experimental data is observed with the slit spreader - the coefficient of variation varies from 36 to 161% in the individual layers of the plant. It does not create a powerful jet to stir the leaf mass of the plants and due to its small breakthrough force, it penetrates to 10-15 cm depth in the upper layer. For this reason, the middle and lower layers lack coverage on the underside of the leaves. When using a diffuser sprayer, the air generated by the fan intensively stirs the leaf and forces the sprayed liquid with great force. This is a prerequisite for very good coverage of the lower part of the leaves as well.

The data on the coverage of the lower part of the leaf made a comparison of the mean values. The results show that there is a proven statistical difference in the quality of operation of the two broadcasters (Table 5).

The better coverage of the underside of the leaves using a diffuser is very good in Figure 2.

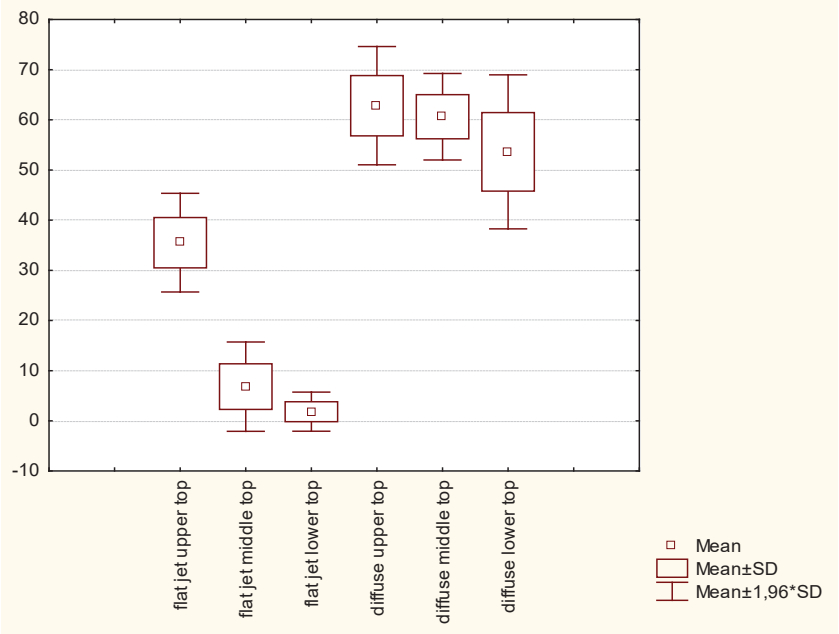

Figure 1. Cover of top of leaves, %

Table 4. Cover of bottom of leaves, %

	Valid N	Mean	Minimum	Maximum	Standart Deviation	Coefficient of Variation
flat jet upper bottom	10	18.00000	6.00000	27.00000	6.548961	36.38312
flat jet middle bottom	10	0.70000	0.00000	2.00000	0.823273	117.6104
flat jet lower bottom	10	0.30000	0.00000	1.00000	0.483046	161.0153
diffuse upper bottom	10	61.00000	55.00000	67.00000	3.399346	5.572698
diffuse middle bottom	10	57.30000	52.00000	61.00000	3.128720	5.460244
diffuse lower bottom	10	46.40000	39.00000	57.00000	5.796551	12.49257

Table 5. Comparison of the mean values of leaf coverage from below

	Mean 1	Mean 2	t-value	df	p
flat jet upper bottom vs. flat jet middle bottom	18.00000	0.70000	8.2884	18	0.000000
flat jet upper bottom vs. flat jet lower bottom	18.00000	0.30000	8.5236	18	0.000000
flat jet upper bottom vs. diffuse upper bottom	18.00000	61.00000	-18.4286	18	0.000000
flat jet upper bottom vs. diffuse middle bottom	18.00000	57.30000	-17.1230	18	0.000000
flat jet upper bottom vs. diffuse lower bottom	18.00000	46.40000	-10.2688	18	0.000000
flat jet middle bottom vs. flat jet lower bottom	0.700000	0.30000	1.3252	18	0.201688
flat jet middle bottom vs. diffuse upper bottom	0.700000	61.00000	-54.5186	18	0.000000
flat jet middle bottom vs. diffuse middle bottom	0.700000	57.30000	-55.3238	18	0.000000
flat jet middle bottom vs. diffuse lower bottom	0.700000	46.40000	-24.6837	18	0.000000
flat jet lower bottom vs. diffuse upper bottom	0.300000	61.00000	-55.9052	18	0.000000
flat jet lower bottom vs. diffuse middle bottom	0.300000	57.30000	-56.9368	18	0.000000
flat jet lower bottom vs. diffuse lower bottom	0.300000	46.40000	-25.0627	18	0.000000
diffuse upper bottom vs. diffuse middle bottom	61.00000	57.30000	2.532557	18	0.020846
diffuse upper bottom vs. diffuse lower bottom	61.00000	46.40000	6.870641	18	0.000002
diffuse middle bottom vs. diffuse lower bottom	57.30000	46.40000	5.232837	18	0.000056

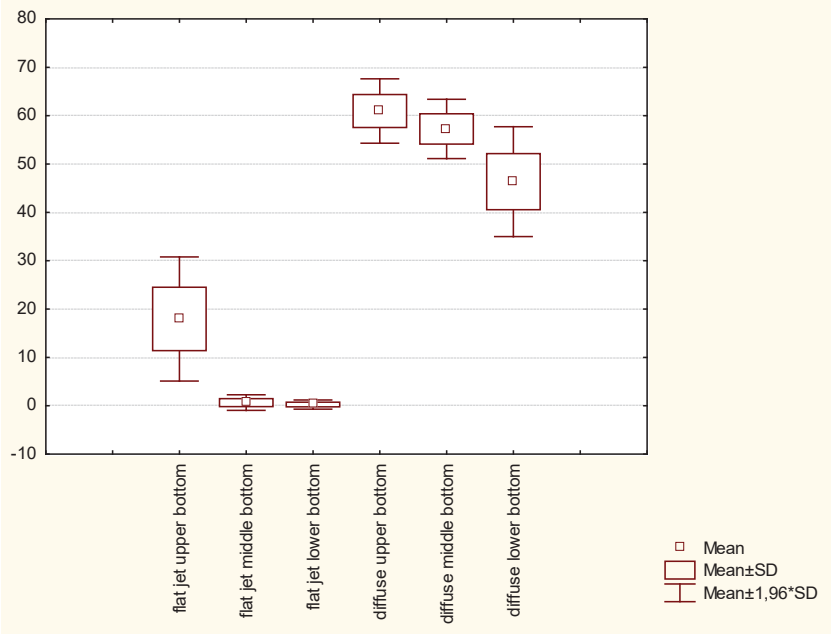

Figure 2. Cover of bottom of leaves, %

CONCLUSIONS

The following conclusions can be drawn from the experiments performed, the processing of their results and the analyzes:

With the help of the air flow, the working fluid sprayed by the diffuser spray penetrates the entire height of the treated pepper plant. However, the coating applied both from the bottom and the top decreases from top to bottom.

With the flat-blower sprayer, there is good coverage only in the upper layer on the top of the leaves.

A statistically proven better coating is obtained when working with a diffuser sprayer.

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ISSN 2285 – 6064
ISSN-L 2285 – 6064