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Volume VII

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and Veterinary Medicine of Bucharest
Faculty of Land Reclamation
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CARBON DIOXIDE EMISSIONS RELATED TO FUEL CONSUMPTION FOR GROUNDNUT PRODUCTION IN TURKEY

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Abstract

The main objective of this study is to quantify and evaluate CO_2 emissions related to fuel consumption for groundnut cultivation in Turkey between 2011 and 2016. The methods were used for calculating CO_2 emissions are recommended by the Intergovernmental Panel on Climate Change (IPCC). Between 2011 and 2016, in Turkey, peanut was produced on an area of 35325.45 ha. The average groundnut production and the average yield were 129464 ton and 3655 kg per hectare (ha) over the last five-year period. It was found that the average fuel (diesel) consumption for groundnut cultivation were 13.06 g per kg of seed yield. The total CO_2 emissions based on lower heating value of diesel fuel and lubricant oil were 5551.3 t CO_2 per year. It was calculated that the average CO_2 emission was 43.16 g per kg of groundnut seed.

Key words*: CO_2 emissions, groundnut production, fuel consumption, Turkey.*

INTRODUCTION

It is predicted that global CO_2 emissions, which remained almost constant in the last three years, may rise again in 2017. According to a statement made by the Global Carbon Project (GCP, 2017) based on data not yet finalized, CO_2 emissions from human activities will increase by 2% in 2017. The main factor in this increase is that consumption of coal in China has started to increase again. China will be responsible for 30% of global emissions alone, with CO_2 emissions rising by 3.5% in 2017. It is reported that the slowing of the US and European economies in decarbonization will be another important factor in the increase of emissions. In December 2017, the Council of Europe recommended that member states of the European Union determine binding emission reduction targets in the transport and industrial sectors, excluding buildings, agricultural sector non-CO_2 greenhouse gas emissions, waste management, aviation and navigation. According to the proposal, EU member states will have to set binding emission reduction targets in these areas between 2021-2030. These targets will be between 0% and 40% of 2005 levels and will be in line with the main target of 30%, based on countries' per capita gross domestic product (GDP). The European Union has pledged to reduce greenhouse gas emissions by 2030 to at least 40% below 1990 levels through the declaration of intent under the Paris Climate Agreement.

The sustainable production of agricultural products by reducing the use of fossil energy is very important. The effective energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil fuels preservation and air pollution reduction (Pervanchon et al., 2002). To develop production systems that require less fossil energy and at the same time maintain satisfactory performance and reduce greenhouse gas emissions, requires efficient use of fossil energy in agricultural systems.

The main objective of this study is to quantify and evaluate CO_2 emissions related to fuel consumption for the groundnut cultivation in agricultural regions of Turkey. The CO_2 emissions associated with direct fuel and lubricant oil consumptions are estimated according to the Intergovernmental Panel on Climate Change (IPCC) approach. The specific values for fuel consumption, seed production,

energy consumption and CO_2 emission were defined to analyze the relationship between fuel consumption and CO_2 emission for groundnut production.

MATERIALS AND METHODS

The CO_2 default emission factors depending on fuel type based on lower heating values are from IPCC, 1996, Volume 2, Section 1 (Table 1).

Table 1. Emission Factors and Heating Values for Diesel Fuel and Lubricant (IPCC, 1996)

Fuel type	Lower heating value (GJ/L)	Emission factors (kg CO_2/GJ)
Diesel	0.0371	74.01
Lubricants	0.0382	73.28

The methods for calculating CO_2 emissions recommended by the *GHG Protocol - Mobile Guide (03/21/05) v1.3 (Calculating CO2 Emissions from Mobile Sources Guidance to calculation worksheets)* were used in this study. The following equation outlines the recommended approach to calculating CO_2 emissions based on fuel use (assuming data is first obtained in terms of mass or volume).

CO_2 emissions = Fuel used × Heating value × Emission factor

Diesel-based CO_2 emissions = Diesel used × Heating value × Emission factor

Diesel-based CO_2 emissions = L/ha × 0.0371 GJ/L × 74.01 kg CO_2/GJ.....(1)

Diesel-based CO_2 emissions are measured in kg CO_2/ha.

Lubricant oil-based CO_2 emissions = Oil used × Heating value × Emission factor

Lubricant oil-based CO_2 emissions = L/ha × 0.0382 GJ/L × 73.28 kg CO_2/GJ.....(2)

Lubricant oil-based CO_2 emissions are measured in kg CO_2/ha.

The value of the specific fuel consumption (*SFC*) indicates the amount of fuel consumed (L) to produce the unit quantity (t) of product.

SFC = FC/GY.....(3)

where: *SFC* is the specific fuel consumption (L/t), *FC* is fuel consumption (L/ha) and *GY* is yield (ton/ha).

The specific seed production (*SSP*) is the ratio of fuel consumption to yield and indicates fuel consumption (L) per kg of groundnut seed.

SSP = SP/FC.....(4)

where: *SSP* is the specific seed production (kg/L), *SP* is seed production per hectares (kg/ha) and *FC* is fuel consumption per hectares (L/ha).

The specific carbon dioxide emission (SCO_2) was defined to analyze the relationship between CO_2 emissions and production. The SCO_2 is the ratio of total CO_2 emissions to groundnut yield and indicates CO_2 emissions ($kgCO_2$) per ton of groundnut seed.

$SCO_2 = CO_2/GY$.....(5)

where: SCO_2 is the specific carbon dioxide emission (kg CO_2/ton), CO_2 is carbon dioxide emissions (kg CO_2/ha) and *GY* is groundnut yield (ton/ha).

RESULTS AND DISCUSSIONS

The change of production area for groundnut cultivation in Turkey between 2011 and 2016 is given in figure 1. On average over the period 2011-2016, in Turkey, groundnut has been produced on 35325.45 ha area. The average groundnut production was 129464 ton over the last five year period (Figure 2). The average groundnut yield was 3655 kg per hectare (ha) over the last five year period (Figure 3).

The change of specific fuel consumption for groundnut production in Turkey between 2011 and 2016 is given in figure 4. The specific fuel consumption for groundnut production ranged from 12.17 g_{diesel}/kg_{seed} to 14.42 g_{diesel}/kg_{seed} and the average specific fuel consumption for 5 years was determined as 13.06 g_{diesel}/kg_{seed}. For groundnut production, CO_2 emissions ranged from 3999.66 t CO_2/year to 6632.53 t CO_2/year, with a five year average CO_2 emission of 5551.3 t CO_2 per year (Figure 5).

An average of 5499.38 t CO_2/year of annual total CO_2 emissions were derived from diesel fuel consumption for production operations and 51.92 t CO_2/year from tractor oil consumption.

The change of the specific CO_2 emissions for groundnut production in Turkey between 2011 and 2016 is given in figure 6.

The specific CO_2 emission for groundnut production ranged from 40.20 g CO_2/kg_{bean} to 47.81 g CO_2/kg_{bean} with an average specific CO_2 emission of 43.16 g CO_2/kg_{bean}.

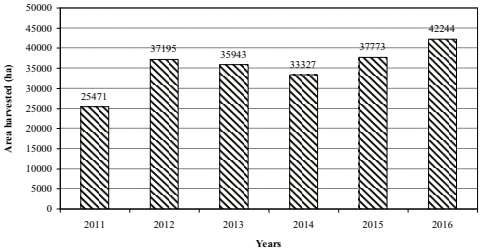

Figure 1. The change of cultivation area for groundnut production in Turkey

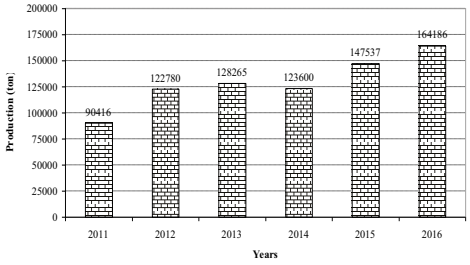

Figure 2. The change of groundnut production in Turkey

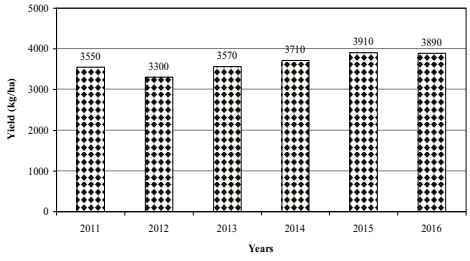

Figure 3. The change of groundnut yield in Turkey

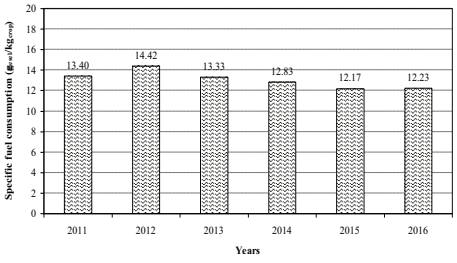

Figure 4. Change of specific fuel consumption for groundnut production in Turkey

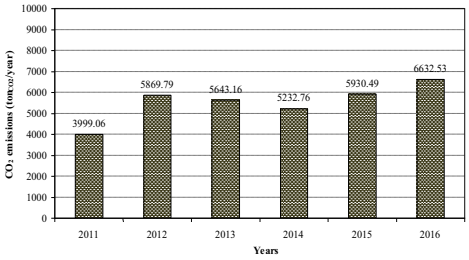

Figure 5. Change of CO_2 emissions for groundnut production in Turkey

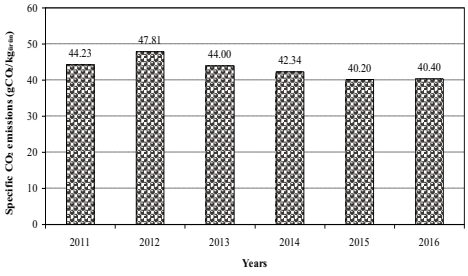

Figure 6. The change of specific CO_2 emissions groundnut production in Turkey

CONCLUSIONS

Climate change is a global problem that arises as a result of human activities. World states that have come to realize the reality of global warming in recent years have started to incorporate climate policies into sustainable development strategies, economic sectors such as energy, transport and agriculture. This shows us that more efficient use of energy can be possible, so that the same level of development can be achieved with less energy use and less emissions.

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STUDY ON EVALUATING THE CONSERVATION STATUS OF SPECIES OF MAMMALS AT THE NATURAL PROTECTED AREA „GILORT RIVER"

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Abstract

The „Gilort River" Natural protected area lies in Gorj, Getic Subcarpathians in the Ciolanei Depression and is a site of community importance forming part of the Natura 2000 European network. The purpose of „Gilort River" protected area is to protect and conserve important species at national and community level (Lutra lutra, Bombina variegata, Eudontomyzon mariae, Gobio albipinnatus, Barbus meridionalis, Sabanejewia aurata). The paper presents the methodology for assessing the conservation status of mammal's species of Lutra lutra. There have been carried out evaluations in the field, between Januarys to April 2015, with a frequency of 3-4 per month, applying the multi-criteria method, which was based on the following criteria: local distribution, population, habitat of the species and prospects. Following the evaluation and presentation of the distribution of the Lutra lutra species and of the areas favorable for its protection, it was shown that there were traces of the presence of the otter in the river Gilort, on sandy beaches in inaccessible areas difficult to access, close to areas with greater depth of water, being identified a maximum of two family groups of otters, meaning 7 individuals. The evaluation demonstrated that the conservation status is unfavorable and inadequate.

Key words*: Natural Protected Area, assessment, conservation.*

INTRODUCTION

The ***Gilort River protected area*** is a site of community importance and belongs of the Natura 2000 European network.

The purpose of Gilort River protected area is to protect and conserve species of important national and Community level (*Lutra lutra, Bombina variegata, Eudontomyzon mariae, Gobio albipinnatus, Barbus meridionalis, Sabanejewia aurata*).

The reason for designating area Gilort River as protected was due to existence on its territory of the species of relevant community interest for conservation in the biogeographic region they belong.

The Gilort River protected area lies in Gorj, in Getic Subcarpathians , in the Ciolanei Basin and is bordered by the localities: Pociovalistea and Bumbesti-Pitic at north, natural protected area Prigoria-Bengesti and localities Mirosloveni, Albeni, Bolbocesti and Barzeiu de Gilort at east, locality Doseni at south and localities Albeni, Bengesti, Ciocadia and Balcesti at weast.

The natural protected area develops longitudinally from north to south, with a length of 21.75 km Gilort River (Figure 1).

The Gilort River protected area is located within the territorial administrative units of Bengesti, Albeni, Novaci, Bumbesti-Pitic and Targu Carbunesti in the Gorj County, including an area of 873 ha (Figure 2).

The landscape is characterized by the presence of hills and riverbed topography created by the action of rivers.

From the geographically point of view, the Gilort River protected area is located at the 45.076561 north latitude and 23.612975 eastern longitude.

The average altitude is 300 m. The access to the protected area Gilort River is by National Road 67, in the north, north-east or the west of the protected area.

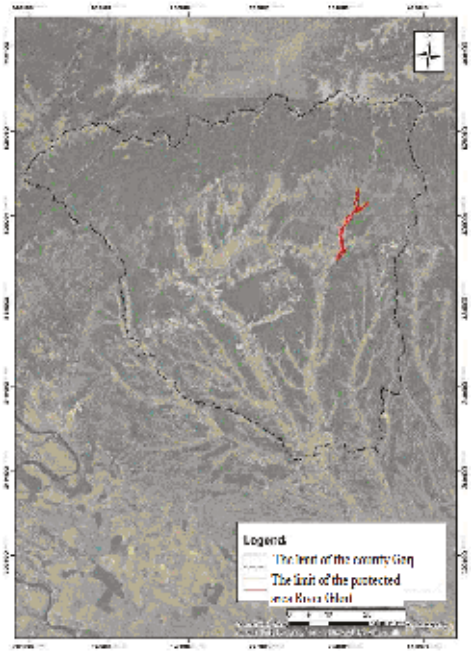

Figure 1. Localisation of the Gilort River natural protected area *(GIS software)*

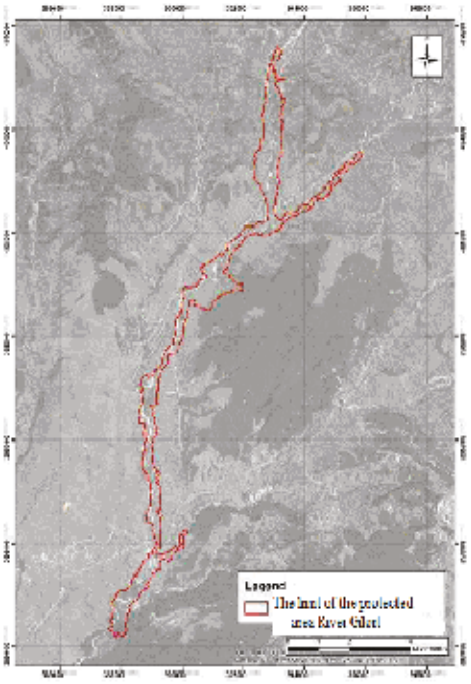

Figure 2. Limits of the Gilort River natural protected area *(GIS software)*

Abiotic environment

From the geological point of view, the protected area is located on the fluvial and fluvial-lacustrine deposits formed in the Quaternary and Holocene Lower and Upper, Pleistocene Quaternary and Neogene Miocene Ages.

In terms of relief, the Gilort River protected area is located in the Subcarpathians of Gorj, positioned in the central of Gorj County.

The hydrology protected area is characterized by the presence of Gilort River with the tributaries: Ciocadia (on the right) and Yellow Creek and Calnicul (on the left). The basin which includes the area is the Jiu Basin wich is characterized by a reception area of 10080 km^2 and an oblong shape which is taken over by the river Gilort River, the most important left tributary of the river Jiu. It collects water from the southern slope of the mountain Parang, with an area of springs located at 1.800 m altitude (Figure 3).

From the climate perspective Gilort River protected area is located in the temperate continental climate, specific of hills and plateaus climate, with variability from north to south.

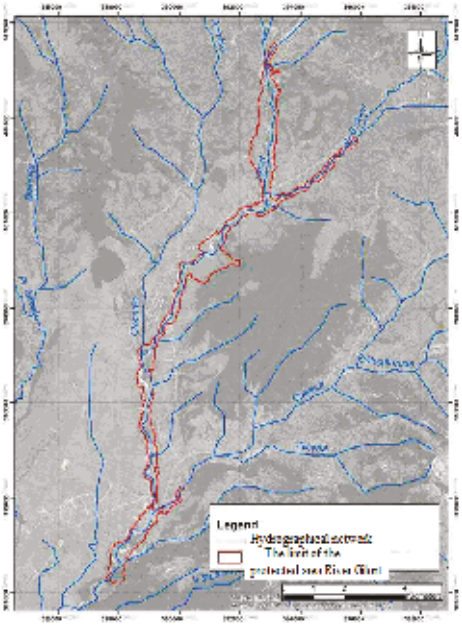

Figure 3. The hydrographic network of the Gilort River natural protected area *(GIS software)*

Analyzing the edaphic potential, the soils present in the analyzed area are included in four major classes of soils. The soil distribution within the protected area has a high variability, comprising 6 types of soils. The specific vegetation formation is influenced, among others, by the characteristics of soils. This, in turn, influences the fauna that inhabit different habitats developed as it is the case of species of amphibians and mammals.

Biotic environment

The ecosystems within the Gilort River protected area are differentiated in 5 main categories: forest ecosystems, grassland ecosystems, agricultural ecosystems, aquatic ecosystems and urban ecosystems.

Characteristic for *Lutra Lutra* species and for fish species is the aquatic ecosystem. Within the protected area was identified the habitat of community interest 91E0* *alluvial forests cu Alnus glutinosa and Fraxinus excelsior (Alno-Padion).*

The fauna is represented by species of national and community interest: mammals *(Lutra lutra),* amphibians *(Bombina variegata)* and fishes *(Eudontomyzon mariae, Gobio albipinnatus, Barbus meridionalis, Sabanejewia aurata)*

MATERIALS AND METHODS

For evaluating the conservation status of species of mammals *Lutra Lutra* assessments were developed on the field in the period January-April 2014, with a frequency of 3-4 ratings per month. The assessment of the conservation status of the community interest species of *Lutra Lutra* from the protected area was carried out as specified in table 1.

Table 1. Specifications for evaluating the conservation status of mammal's species of community interest (*** Guidelines for Application of IUCN Red List at Regional Levels)

Parameters	Conservation status			
Species code	**Favorable**	**Unfavorable Inappropriate**	**Unfavorable totally inadequate**	**Unknown**
Aria distribution	- distribution area stable or increasing; - reduction area distribution with less than 10%	- reduction distribution area with 11-20%	- reduction distribution area with more than 20%	- insufficient data
Population	**A** ≥33 ex./year	**A** = 25-20 ex./year (a decrease of 10- 40%)	**A** < 13 ex./year (a decrease of more than 40%)	- insufficient data
Habitat of the species	- the habitat of the species is stable or increasing; - reduction habitat with less than 5%	- reduction habitat with 6% - 15%	-reduction habitat with more than 15%	- insufficient data
Future prospects (maximum 30 years)	**1** = perspectives Good - viability and prosperity of species are provided	**2** = perspectives Weak – it is probably that species meet difficulties if conditions of environment are not modified.	**3** = perspectives Bad – species under the influence of severe threats its viability is not assured	- insufficient data
Evaluating the conservation status	**All "green" or three "green" and one "unknown"**	**One or More "orange" but neither "red"**	**One or more "red"**	

Specific habitats for *Lutra Lutra* identified within the protected area Gilort River are mosaic type and subject to anthropic pressure (by hydraulic engineering, operating aggregated minerals activities, tourism activities, fishing, grazing, the presence of free or wanderer dogs), following which trophic resources and habitat are limited, adversely affecting otter populations within the site.

The current observed trend is of slow degradation under the effect of specific habitat threats.

In Romania the otter is widespread close to all waters rich in fish but its abundance is low.

The overall population in Romania was estimated at 3,000 specimens, considering that it shows a declining trend, although in some regions (eg. Tisa basin) has a slight improvement due to a lower demand for fur

and to the cessation to use some pollutants used in the past (eg. DDT). However, there are no extensive or long-term studies to monitor the situation at the national level of the *Lutra Lutra* populations. Of the ten subspecies of European otter in the whole Palearctic area for the Romania territory, there is only the subspecies nominated – *Lutra Lutra* Linnaeus, 1758.
As habitat they prefer lakes and ponds, rivers and any body of water bordered by high vegetation and even coastal areas in general all aquatic environments that allow diving and finding food. Otter's habitat preference for such areas makes it vulnerable to pollution and to the annoyance done by tourism activities.

RESULTS AND DISCUSSIONS

In Natura 2000 site Gilort River, the otter traces of presence were recorded along the Gilort River, mainly on sandy beaches in the human inaccessible areas, usually near areas with deeper water where they can search for food.
The area occupied by *Lutra Lutra* is estimated at 32.5 km^2 and is expressed by the minimum convex polygon.
The minimum convex polygon is the unit used by IUCN for determining the area of distribution of species and expresses the surface determined by the extremes appearance points of the species (Table 2).

Table 2. Minimum convex polygon for *Lutra Lutra* from the Gilort River protected area

Species	MCP (km^2)
Lutra lutra	32.5 km^2
	size distribution = 21.9 km^2
	size distribution = 45.4 km^2

Corroborating the data from the literature concerning the territorial size of the otters family groups with the surface of protected area it is considered that the population of otters that may exist in the Gilort River protected area do not exceed two family groups, which is also the number identified from field observations (7 specimens).
The distribution of *Lutra Lutra* species and the favorable areas for the protection of the species are shown in figures 4 and 5.

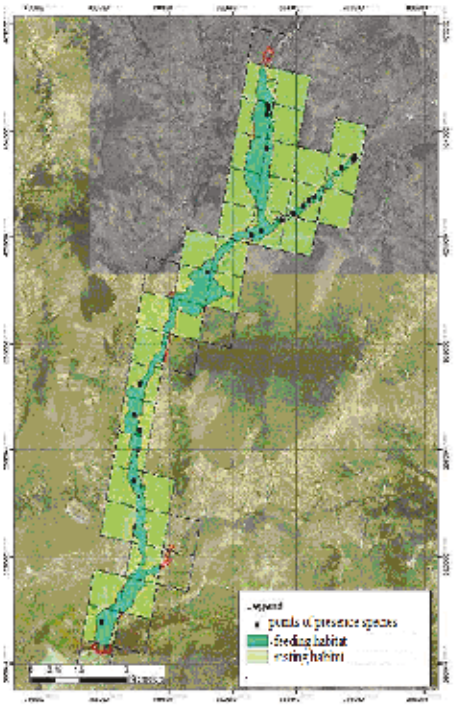

Figure 4. Distribution of the *Lutra Lutra* species *(GIS software)*

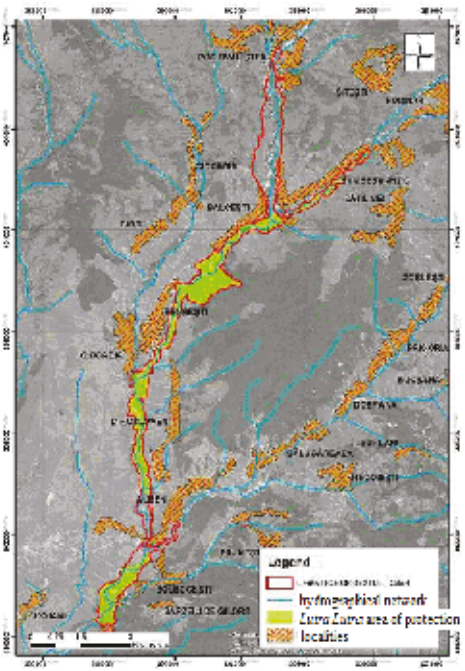

Figure 5. Favorable areas for protection of *Lutra Lutra* species *(GIS software)*

At the Natura 2000 site Gilort River level, the state of the preservation of the species of *Lutra Lutra* was evaluated on the following criteria: local distribution (spread of the species in the protected area), population, habitat of the species, perspectives (concerning population, area and habitat presence) and resulted as ***unfavorable inadequate*** (Table 3).

Table 3. Conservation status of *Lutra Lutra* in Natura 2000 Site Gilort River

Parameters	**Conservation status**			
Species code	**Favorable (green)**	**Unfavorable conditions (orange)**	**Total unfavorable conditions (red)**	**Unknown (insufficient information)**
Distribution local (spreading species in the protected area)	Observation of tracks attendance were identified evenly between the boundaries of protected area			
Population	There were seen and confirmed the presence of two family groups in the studied area			
Habitat of the species		Specific present habitat mosaic type, but under anthropic pressure of grazing activities, the presence of of free or wanderer dogs, mining mineral aggregates and fishing		
Perspectives (relating to population, area and the presence of habitat)		The current trend observed is of slow degradation under the effect of threats on the specific habitat		
Evaluating the conservation status		**Unfavorable inadequate**		

CONCLUSIONS

For evaluating the conservation status of species of mammals *Lutra Lutra* assessments were developed on the field in the period January-April 2014, with a frequency of 3-4 ratings per month. Corroborating the data from the literature concerning the territorial size of the otters family groups with the surface of protected area it is considered that the population of otters that may exist in the Gilort River protected area do not exceed two family groups, which is also the number identified from field observations (7 specimens).

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THE THERMAL POWER PLANT IMPACT ON THE ENVIRONMENT AND SOME POSSIBILITIES OF REDUCE IT BY ASH AND SLAG RECICLING AND REUSE

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Abstract

The paper aimed to present the impact of thermal power plant from Oltenia Mining Basin and the same time 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 point. The energy production in thermal power plant involves burning of huge amount of coal - lignite. Due to high ash content of lignite, the electricity production in thermal power plants generates significant amounts of slag and ash, which are stored in large deposit that involves the coverage of large areas of land generating environmental impact by air, water, and soil pollution. The reuse of ash and slag as raw material for other industry represent an economic way to reduce the environmental impact and represents an important way to preservation of natural resources.

Key words*: ash and slag, heavy metals, material recovery, thermal power plant pollution.*

INTRODUCTION

The most important lignite reserves of Romania are stationed in the mining basin of Oltenia, across the two counties, Gorj and Mehedinti, in 13 daily surface mining perimeters, by continuous-line extraction technologies using rotor excavators, high capacity belt conveyors and dumpers, which belong to Oltenia Power Complex joint-stock Company (CEO) (RAREASH, 2016).

The quality of lignite production at the existing industrial provision is (RAREASH, 2016):

- Calorific power: Q=1.740 kcal/kg;
- Ash: A=39.5%;
- Moisture: W=41.6%;
- Sulfur: S=1.2%.

Given the existence of these resources, they were built in Gorj County the power plants Rovinari (1975) and Turceni (1979).

The Rovinari power plant - Rovinari Termocentrala is a steam power plant built at the „mine mouth", that means the coal delivery is made directly from the quarries, on the belt conveyors, the cost being insignificant. At the present time this power plant works 4 power units 330 MW each. The breeze and the ash resulted from the burning of the coal in the caldrons are hydraulic discharged using Bagger pump stations to the plant spoiling dumps: Balta Uncheasului, Cicani-Beterega and Girla (RAREASH, 2016; Racoceanu et al., 2012). The breeze and ash dumps are at 2-5 km distance outside the plant on a surface of 478.9 ha:

- Girla Dump: 160 ha, with a storage capacity of about 32 million m^3;
- Cicani – Beterega Dump: 284.7 ha, with a storage capacity of about 74 million m^3;
- Balta Uncheasului Dump: 34.2 ha, with a storage capacity of about 6 million m^3 (closed dump and covered with natural vegetation).

The breeze and ash dumps Cicani and Beterega are at 4.5 km of power plant, the car access are the technological roads to the above mentioned quarries. Beginning with 2000 year, the two dumps are unified and aggravated in tandem, working united.

The annual breeze and ash amount of Rovinari power plant is about 3 million tones, assuming the operation of four power units.

The Turceni power plant has 6 power units of 330 MW (RAREASH, 2016).

For storing the breeze and the ash of the Turceni Power Plant there are two dumps:

- *The breeze and ash dump number 1* – surface of 250 ha and capacity of 42 million m^3.
- *The breeze and ash dump number 2* – used as buffer or emergency dump. Now this dump is used to discharge the breeze and the ash in coal sludge technology. It has a surface of about 200 ha with a capacity of 32 million m^3 (RAREASH, 2016; Racoceanu et al., 2012).

The annual breeze and ash quantity of Turceni power plant is about 2.3 million tones, assuming the operation of four power units.

Previous works in the LIFE project and RAREASH project (RAREASH, 2016; Project LIFE10 ENVRO 729), proved the high uniformity of the compositional and dimensional characteristics of the ash in entire volume of the dump, considering this as an alternative raw material which can immediately enter into industrial exploitation circuit (Project LIFE10 ENVRO 729).

The electricity production by burning of fossil fuels represents the activity with the most important impact on the environment. We refer here to atmospheric pollution through release of large volume of greenhouse gas, acidifying gas, dusts or it is about of large amounts of wastes (ash and slag) deposited in landfills which are occupying large areas of land, as we already show above.

The fine particle of ash, moved by wind from dry surface of deposit affects all environmental factors: water, growth, living bodies, soil and human settlement. These fine particles of ash affect animal bodies and plants even far from deposit. Are affected, also, digestive and respiratory tract of human and animals.

The flora from deposit area both the spontaneous and the cultivated, specially, suffers negative effects by the fine fractions of ash which will lead to reduce the plant vitality and the crop production. Ash and slag have a high content of heavy metals and other substances that are known to be harmful to health. In relation with this, another effect of pollution is accumulation of quantity of heavy metals (chrome, plumb, arsenic, molybdenum) to toxically level with implication for human and animal's health.

Because of the absence of the impermeability and inappropriate drain of deposit tank, the infiltration from deposit affects ground water sheet. These determine the increased mineralization of ground water sheet and soil salinization considering the cumulative aspect. In the case of damage and other incidents by overflowing of hydro mixture is affected quality of surface water.

The best way to solve the disposal issues of ash is to decrease the quantity for disposal with utilization of ash in the industry (Carlsson et al., 1993).

Currently ash and slag can not find an economic use in Romania, now constituting within the category of harmless industrial waste category. However, the diverse physical, chemical, mineralogical and morphological properties of ash offers an opportunity to use in other industries, leads to reduce the environmental impact and to conservation of the natural resources.

MATERIALS AND METHODS

By the technological process results two kind of ash: 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; bottom ash, with a diameter 0.25 – 1 mm and more, which is collected at the furnace bottom (Figure 1).

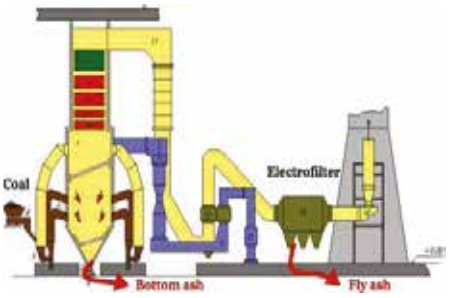

Figure 1. Ash generation in thermal power plant

Both of them - bottom ash and slag (this last one after crushing) and fly ash - are transported in the form of hydro-mixtures (solid/liquid 1:8 and 1:10, respectively) or dense slurry into landfills, generating a strongly impact upon

environment (LIFE project; RAREASH, 2016; Popescu et al., 2016).

In the project RAREASH the ash stored in Division no. 1 of the Valea Ceplea dump of the Turceni power plant was complex characterized (physical and chemical). In order to ensure the representativeness of the ash samples on the dump surface map it was drawn an equidistant line web which make a squared grid, the crowns of these squares mark 180 points at a distance of 50 m of each other. On this surface were bounded 5 circular areas, each of 9 reference points.

From the sampling points selected in this way there were drill extracted ash samples of 5 m, 10 m, 15 m and 20 m, resulting 180 depth individual samples (named elementary samples), which ensure the representativeness of the entire ash mass of the Division no. 1.

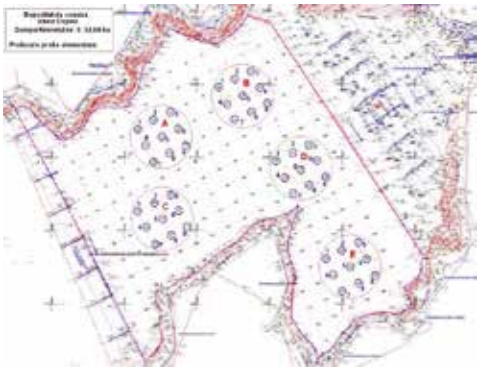

Figure 2. Delimit the circular sampling areas (RAREASH, 2016)

RESULTS AND DISCUSSIONS

In order to identify the use possibilities of ash is essential to know the ash characteristics, in term of physical, chemical and mineralogical characteristics.

1. Physical characterization

The depth level samples were tested to determine the physical parameters of bulk density (non-compressed and compressed) and the dimensional distribution of the component particles (grading).

The total moisture of the ash samples was determinate by using the thermo balance, and the soaking moisture, by oven-dying at 105^0C, according to STAS 1913/I-82.

The volume density was determinate using the lab balance according to the STAS 1913/3-76. The determination of the grading composition was made in accordance with STAS 1913/5-85, using the AS 200 Basic sieve machine. The results are presented in table 1, 2 and 3.

Table 1. Bulk density of the average samples

Sample	Bulk density (g/cm^3)	
	Unsettled	Settled
Cota 0	0.70	0.79
Cota -5	0.73	0.81
Cota -10	0.75	0.85
Cota -15	0.72	0.81
Cota -20	0.74	0.82
Total sample	0.75	0.83

Table 2. Grain distribution of the average samples

Sample	Pass (%) throught sieve (mm)							
	4	2	1	0.5	0.25	0.125	0.09	0.063
Cota 0	100	98.6	94.1	84.5	67.2	42.8	30.5	21
Cota -5	98.8	93.6	85.2	73.4	50.5	25.5	14.7	4
Cota -10	100	97.6	91	79.8	60.9	36.6	25	15.7
Cota -15	99.9	97.7	92.2	81.7	61.2	35.3	22.9	13.7
Cota -20	99.9	97.2	91.4	82.8	66.9	44.2	31.7	20.1
Total	99.7	97.2	91.5	81.3	62.7	38.3	25.3	15

Table 3. The moisture of the average samples

Sample	Moisture (%)
A	25.47
B	26.78
C	25.83
D	25.99
E	25.87
ABCDE	25.96

2. Chemical composition

The chemical composition of ash depends on the quality and composition of lignite as well as on combustion condition.

Oxide composition analysis indicates that it consists mainly of Al and Si oxides. The ash type is silicoaluminous with a composition

close to clay lands, characterized by 45.6% SiO_2, 18.8% Al_2O_3. Some other constituents are CaO (10.45%), MgO (2.40%), Fe_2O_3 (8.72%) and in smaller quantities Na_2O (0.21%) and K_2O (1.44%). Most of the CaO and MgO are bound in sulfates and mixed oxides with SiO_2 and Al_2O_3.

In terms of basic physical characteristics, the ash can is assimilated to a natural sand aggregate of granular type, except for bulk density characterized by lower values.

Chemical properties of ash samples reveal adequate characteristics in comparison with those of the ceramic raw materials usually used in the ceramic industry.

Some directions of thermal power plant ash using

Given the characteristics of the power plant ashes, it could be developed some recovery directions, thus:

1. The first direction supposes their use in the building material industry. The recovery possibility of this industrial waste used as granular aggregate in the manufacturing of building materials based on hydraulic binder (cold-straining briquettes, concrete blocks and precast) proved by researching results in the Project LIFE ENV 729 RO, and by using them in manufacturing of briquettes, concretes, mortars and stamping tables (RAREASH, 2016; Anghelescu et al., 2015; Abagiu et al., 2013). In technological applications tested on technological flows at industrial level in project LIFE (Popescu et al., 2013) were obtained (Figure 3):

a. *using the hydraulic binding technologies („cold-straining")of the products:*
- briquettes with high ash content (over 60%);
- building blocks (breeze blocks) with a minimum 15% ash content;
- building blocks (precast) with a minimum of 50% ash content and of 20% breeze LF;
- building elements for roads and footways (borders and paving's);

b. *using high temperature binding technologies (sintering):*
- briquettes with 50-70% ash content, molded of semidried mixtures;
- briquettes with15-35% ash content and 10-20% slurry, molded of plastic and seniplastic mixtures;
- thermal insulating concretes with maximal using temperature of 800-1100 with 40-70% power plant ash content.

On the other hand, the ash can be used to obtain ceramic pellets with high absorption characteristic that can be used to execution of water capture layers in road construction.

a) Pressed bricks b) Vibropressed bricks c) Burned bricks d) Building blocks e) Demonstrative building realised in inside of University Student's campus

Figure 3. The different kind of building material obtained by ash recycling

2. The second direction - the recovery of rare and heavy metals from the power plant ash

The Oltenia lignite bottom ash contains high amounts of some kind of heavy and rare metals, from lanthanide's group (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu), as well as scandium and yttrium. Also, these industrial wastes show the valuable concentrations of indium, gallium, rubidium and wolfram (RAREASH, 2016; Popescu et al., 2013; Predeanu et al., 2015).

Under the scope of RAREASH project positive anomalies were found in HRM concentrations at Oltenia lignite bottom ashes in relation to those occurring in the upper continental crust, which is a promising result taking into account the huge amounts of bottom ash available, its unconsolidated nature, and the proximity to an

industrial complex (Table 4) (Predeanu et al., 2015; Popescu et al., 2016).

Table 4. Average concentration (ppm) of rare earth elements, yttrium and Sc, and other elements of interest in Oltenia lignite bottom ash, and normalized concentration of the trace elements to the upper continental crust (UCC) (Rudnick and Gao, 2014)

Analyte	Bottom ash (average)	UCC	Normalize
Co	22.10	17.30	1.29
Sr	224.08	320	0.69
Sb	2.49	0.40	6.43
W	2.03	1.90	1.07
Be	3.04	2.10	1.47
Sc	11.93	14	0.85
In	0.07	0.06	1.31
Y	20.72	21	0.99
Rb	11.50	84	0.10
Nb	17.37	12	1.47
Ga	26.35	17.50	1.53
La	25.65	31	0.82
Ce	60.48	63	0.96
Pr	6.90	7.10	0.97
Nd	26.49	27	0.98
Sm	5.46	4.70	1.17
Eu	1.15	1	1.15
Gd	5.20	4	1.31
Tb	0.69	0.70	0.89
Dy	4.23	3.90	1.09
Ho	0.87	0.83	1.06
Er	2.40	2.30	1.04
Tm	0.35	0.30	1.16
Yb	2.24	1.96	1.15
Lu	0.34	0.31	1.08

3. The third direction: the recovery of unburned coal and its using

Bottom ashes resulted from Gorj lignite burning process has a high unburned coal content mostly from the xilitique type formations, which due to their characteristic properties (especially the elasticity) are very finely ground in the coal mills and reach the breeze and the bedstone ash in the form of charcoaled particles (majority in the 2 – 4 mm dimensional type), which can be separated by simple methods of calibrated sieving, water floatation or magnetic separation. Thus, it could reach to unburnt coal concentrates with a total ash content of 40-60% which can be utilized to reach the burning briquettes for domestic boilers. The advantage is, unlike the initial coal, this carbonized residue type which suffered a quickly heating at about 1000^{o}C, is characterized by much less volatile substances and generates a more reduced level of burning emissions (Contract UEFISCDI nr. 15/2016).

On the other hand, the unburned carbon from the power plant ash is a potential precursor of the graphitizable carbon, having suitable structural characteristics to be used in industrial applications, like: the developing of new electro catalysts with high catalytic activity, bigger endurance, lower costs, scalability which could greatly facilitates the improvement of the clean energy infrastructure (Contract UEFISCDI nr. 15/2016).

CONCLUSIONS

Ash and slag deposits cover large surface of land having the negative impact on the environmental because of different reasons, that were being expose above.

The recovery of power plant ashes represents an important way to reduce the impact against the environment caused by its dumping.

The use and the reuse of huge power plant ash quantities in accordance with the possible using directions as the above, aim to gain some benefits, in this respect, for example:

- The contribution of developing new domains, economical consolidation, the creation of new high qualified jobs, autonomy and security in supplying with critical materials in UE;
- The preservation of natural resources:
  - i) by using the ash as replacement for natural aggregates (sands) used in making of building materials;
  - ii) by using the ash to extract strategic materials, as Lantanides: Ga, Sr, Rb, Y and W;
  - iii) by using the ash to recovery the unburned coal which after the preconcentrating operations it could be used as precursor of graphite or for briquetting to reborn, as well.
- The raising of life quality in urban and rural areas, reducing the impact against the environment caused by the activities of power and mining industry.

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PERCEPTION OF ROMANIAN CONSUMER ON ORGANIC FOOD PRODUCTS

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Abstract

The purpose of this paper is to identify the perception of consumer on organic products in Romania market in November 2016. The methodology used was a simple survey which was done on 201 respondents from Galati, Romania, who answered to different questions in order to identify their perception and needs on organic products.
The questions are closed questions with multiple options of answers. As a conclusion, Romanian consumers seem to be interested in consuming organic products because of their health benefits and taste, versus conventional products. First option in preference of organic products is fruits and vegetables followed by meat products. The survey showed us that organic products are easy recognized on the market after their specific labelling.

Key words*: food, healthy, labelling, organic products, Romania.*

INTRODUCTION

In last time, food industry has shown a lot of interest in food labelling, healthy products, organic products, clean label products, nutrition, healthy or marketing claims taking in consideration culture difference, consumer perception and their needs. As is mentioned in abstract the scope of this paper is to identify the perception of consumer on organic products in Romania market.

Food labelling at EU level is defined by Regulation (EU) No 1169/2011 of the European Parliament and of the Council on the provision of food information to consumers. According to Regulation 1169/2011, health and nutritional claims are not mandatory on the food product labels, but if such claim is being used it should comply with the requirements of Regulation (EC) No 1924/2006 of the European Parliament and of The Council of 20 December 2006 on nutrition and health claims made on foods.

Additional requirements for the organic food products labeling are available in the Regulation (EU) 1169/2011 and are defined in Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labeling of organic products and repealing Regulation (EEC) No 2092/91.

According to the Regulation (EU) 1169/2011, the information which should be displayed on the food products labels are followings: name of the product, list of ingredients, ingredients and processing aids which contain substance causing food allergies or intolerance, quantity of certain ingredients or categories of ingredients which are included in the name of products or emphasized on the label, net weight, data of minimum durability, special storage condition - if necessary, name of business operator who is responsible for inserting the product on EU market, country of origin - only for food products required by law, instruction for preparation or use - if in the absence of this instruction would be difficult to make appropriate use of food, the alcohol content for alcoholic beverages with more than 1.2% alcohol, and nutritional declaration.

All this mandatory information should be displayed in words and numbers and additional in pictograms or symbols, in such way not to be misleading for consumer.

Based on Regulation (EC) No 834/2007 organic foods are food products without synthetic chemicals, which comply with the rules and principles governed by the specific legislation and which are certified by an inspection and certification body in all stages of production, preparation and distribution in order to be sure that these products are not out of control. Organic means coming from or related to organic production.

The increasing importance of improving human health through food and the impact on the environment of the consumers' food choice is

very well documented in the literature (Jolly et al., 1989; Grankvist & Biel, 2001; Mondelaers, K., et al., 2009; Magnusson, Arvola, et al., 2001; Lee, Shimizu, et al., 2013).

Several studies reported different benefits of organic foods over the conventional products. Tests performed on fruits and vegetables indicated the existence of high contents of biologically active compounds in the organic products: apples, pears and potatoes contain high amounts of minerals (Smith, 2003), tomato are rich in lycopene, vitamin C, carotenoids and total polyphenols (Caries – Veyrat et al., 2004; Toor et al., 2006), and strawberries were reported to exert anti-carcinogen effect (Olsson et al., 2006).

Organic meat, poultry, dairy products and eggs are seen as free of antibiotics or growth hormones. In the same time, organic food ingredients are not grown or processed with synthetic fertilizers, conventional pesticides, ionizing radiation or bioengineering (USDA, 2007). It was reported that organic food products contain lower contents of pesticides in comparison to conventional products. Anyway, as indicated by Borguini & Torres, (2006) it was not possible to have a definitive conclusion on this issue because of the lack of wider data on the presence of pesticide in the organic products. It was considered that a common declaration stating that these products could be considered free of pesticides could significantly influence the decision making in buying food products and diets of the population (Roitner-Schobesberger et al., 2008).

Cereals and oilseeds crops are in top of organic land cultivated cross world. According to the information released in 2016 by FIBL & IFOAM Organic International, Australia has the largest areas of organic agricultural land of 17,150,000 hectares, followed by USA-2,178,471 hectares, China -1,925,000 hectares, Spain-1,710,475 hectares, Italy-1,387,913 hectares, Uruguay-1,307,421 hectares, France-1,118,845 hectares and Germany-1,047,633 hectares, whereas Romania has 289,252 hectares (FIBL & IFOAM Organic International. The world of organic agriculture „Statistic and emerging trends 2016", www.organic-world.net).

This paper present that consumers seems to be informed about their healthy issue and they try to consume weekly organic products or more frequently, depends on their needs and their financial possibilities. The study show also that women are more interested to consume health products, maybe because in Romania culture, the woman take care family and meals, even the meals are prepared at home or are ordered from different place. It is an indication that future study should focus on nutrition labelling, product segmentation and consumer information.

MATERIALS AND METHODS

A questionnaire was presented directly to 202 male and female consumers from Galati, Romania town in November 2016. Most of interrogated consumers reside in Galati city (171 respondents) and the rest reside in the near villages (31 respondents).

A total of 185 consumers who filled the questionnaire had the age between 18 - 65 years and only 7 with age above 65 years. The questionnaire had 22 questions with multiple choice answers. Questions were elaborated in a simple way, in order to be easy and clear for consumer and to obtain answers accurate as possible.

Interrogation was done on the street, near the various supermarket and traditional markets during the first 7 days of November. Around 30 respondents per day were been interrogated.

The method used for approaching the consumers consisted in a simple discussion that help filling the answers to the questions of the survey, in order to collect all information necessary for our study.

All questioned persons were first asked if are available to fill the questionnaire, and only after granting permission they were provided with the questions and potential answers in a step by step manner.

RESULTS AND DISCUSSIONS

The main demographic characteristic of the respondents, such as gender, education level, budget and age are described in Table 1. Out of 202 respondents a total of 117 consists of females (58%) and 85 were males (42%). One justification is that women are more involved in shopping than men.

Table 1. Demographic characteristic of respondents

Gender	Education level	Monthly budget	Age, years 18-30	Age, years 31-50	Age, years 51-60	Age, years >61
Women	Primary school	< 250 euro				
		250 ÷ 400 euro			3	
		400 ÷ 700 euro			4	
		> 700 euro				
	High school	< 250 euro			2	3
		250 ÷ 400 euro			4	
		400 ÷ 700 euro				
		> 700 euro	12	2		4
	University	< 250 euro				
		250 ÷ 400 euro				
		400 ÷ 700 euro	43			
		> 700 euro	20	2	17	
	Post University	< 250 euro				
		250 ÷ 400 euro				
		400 ÷ 700 euro				
		> 700 euro		1		
Total	**117**		75	5	30	7
Male	Primary school	< 250 euro				
		250 ÷ 400 euro				
		400 ÷ 700 euro				
		> 700 euro				
	High school	< 250 euro				
		250 ÷ 400 euro	7			
		400 ÷ 700 euro	4			
		> 700 euro	5	26		
	University	< 250 euro				
		250 ÷ 400 euro				
		400 ÷ 700 euro	18			
		> 700 euro	5	5		
	Post University	< 250 euro				
		250 ÷ 400 euro				
		400 ÷ 700 euro				
		> 700 euro		15		
Total	**85**		39	46		

Analysing the information available in Table 1, it is observed that younger consumers with age ranging between 18 - 30 years (approximately 56%) are more available to answer to the questionnaire, followed by respondents with age between 31 - 50 years (25%) and finally by of consumers over 51 years old. According to their statements, the main reason for the low participation of the elderly consumers to the survey was the belief that their answers will not

be taken into consideration. The highest interested in organic products was shown by women, most probably because of Romanian culture the women are responsible for meals of the family, education of children, providing healthy food and solving nutrition problems. Zugravu et al. (2017) also reported that women are more responsible in family for health and nutritional habits than men.

Among the respondents, a total of 62% reported to be highly educated, having university and post-university studies and with a monthly budget between 400 - 700 euro or even more than 700 euro in almost equal proportions. The people with high level of education are more interested in organic products and health benefits provided by their consumption. Zugravu et al. (2017) also reported that Romanian people with university degree are more preoccupied by including healthy food in their diets.

Also, previous studies have found a significant relation between consumption of organic food products and consumer's demographic characteristics. From gender point of view, Lockie et al. (2004) and Lea and Worsley (2005) identified that women have a positive attitude towards organic food products in comparation with men. In 2007, Stobbelaar et al., find that adolescent girls are more positive towards organic food products. In term of age, are registered contradictory findings: Rimal, Moon & Balasubramanian (2005) registered that older respondents were less interest to buy organic foods than younger respondents. Geen and Firth (2006) noted in the UK that organic consumers tend to be older than the average population. Lockie et al. (2002) find organic food products consumption is not different across the age. In any case, in different studies is registered that age affect also consumer attitudes on organic products. Young consumers are more conscious from environmental point of view but less willing to pay more because of their lower power to purchase these products in comparation with older consumers which are more conscious from health benefits point of view of organic products and are more willing to pay a high price for organic food products (Fotopoulos and Krystallis, 2002).

The respondents were asked to identify the definition of organic food products by choosing one answer out of three options presented. A high percentage of the respondents (83%) described the organic products as a product or a mix of ingredients which are coming from organic agriculture, (11%) of respondents declared that are products with low levels of preservatives and the rest declared that are products which should be processed before consuming. Among the respondents who described the organic food products as a product which are coming from organic products, about 64% are respondents with higher education.

Education it is also reported as an important factor which affect consumer also consumer attitudes towards organic products. Consumer with higher level of education are more likely to have a positive attitude towards organic food product, they require more data about the product and technological process of organic food products (Wier et al., 2003).

Consumer knowledge on organic food products. When was ask what categories of organic products they know, the respondents had the opportunity to choose out of four possible answers. Most of the respondents (48%) recognised fruits, vegetables and cereals as organic products, 27% declared eggs, milk and milk and eggs derivate, 21% declared meat products, and finally spices and mixes of ingredients were indicated by 4% of the respondents.

The respondents were also questioned on how they identify organic food products on the market. The results of our survey showed that 86% of respondents are able to recognise the organic products based on the specific label, 9% of consumers reported the importance of smell and taste attributes in recognising the organic food products, and 5% indicated that colour, shape and dimension of the products are decisive for deciding if a food product can be classified as organic or not. Mostly women (63%) were interested to check if the label is specific for organic products. The respondents with high level of education are more cautious in organic products identifying.

According with study found in literature, Dutch consumers are aware of food organic products and around 96% from them know to recognize

them in the market. This is the higher per cent registered in European consumer as a whole (Zanoli, 2004). It is registered also that Dutch consumers have a positive attitude towards organic food products (Motivaction, 2000; Netherlands Institute for the Public Opinion and Market research (NIPO), cited in Biologica, 2002).

Attitude towards on organic food products.

In order to determine whether organic food products meet the quality required by consumers, the respondents were asked to identify the main differences between organic and conventional products. The organic products were identified to be more healthy and natural compared to the conventional ones by 61% of the respondents, 22% indicated better sensorial characteristics, 10% declared that this product have particular packages and the rest of consumers think that this product is easier perishable.

When asked about the reason for consuming organic food products, the benefits for health were mainly invoked by 65% of respondents for the consumption of organic products. Another reason indicated by 23% of the respondents for consuming organic food products is the fair quality /price ratio. Finally, a total of 12% respondents mentioned the particular taste of this products, the habits or that they do not like processed food.

Dutch consumers mentioned following reasons for buying organic food products: taste is better, it is healthier, are better for their children health, are better for the environment, it serves animal welfare; it is of more reliable quality (Platform Biologica, 2002).

McEachern and McClean found in 2002 in a Scottish study that taste was the major reason for procure organic dairy products (30%), followed by food safety (24%) and benefits of health (17%).

When asked to report on the relationship between products quality and price, 41% of respondents declared that the price asked for these products is not fair, 31% consider that depends on the product, and only 28% declared that the price quality ratio is correct.

When investigating the most efficient channel for promotion the organic food products, the respondents were provided with the following possible answers: newspapers, mass media or combination between mass media and newspapers. Our survey indicated that mass media is the most important player for promote organic food products on Romanian market, followed by different tools as newspaper

According with studies published in 2007, by A. Gracia and T. Magistris, promotion of organic agricultures it is an important option for the society and for marginal and fertile agricultural areas, because these products are considered free of chemicals agents, with high nutritional value and in the same time allow gradually restore of natural equilibrium of agriculture systems; as is know this equilibrium was broken by chemical treatment used in conventional products. In South of Italy, Public Institutions are oriented to promote organic agriculture in rural areas, because this type of agriculture can represent an important alternative of agriculture production.

The results of this research proved that communication campaigns focused on organic products benefits for the consumer health and environment could stimulate the organic product consumption and also the market for organic food products (Gracia and Magistris, 2007). In order to see what are Romanian's consumer preference for organic food products and what are the channels of increase promotion of organic products, we asked them them to identify on a scale between 1 to 5 if they are checking if the product is organic, what is frequency of consuming, organic category food product preferred, source of purchasing and what is the monthly budget for this type of products (Table 2).

Table 2. Organic food product category preferred by Romanian's consumer

Gender	Check if the product is organic on scale 1 -5		Frequency of consuming		Organic category product preferred		Observed defect of organic products		Source of purchasing		Monthly budget for organic products	
Women 117	1	4%	daily	3%	Fruits, vegetables, cereals	52%	packaging, organoleptic	4%	internet	20%	< 10 euro	20%
	2	11%	weekly	37%	meat	32%	did not observe	39%	special store	23%	10 - 30 euro	59%
	3	49%	monthly	49%	milk, eggs and derivate	6%	no	57%	markets	17%	> 30 euro	12%
	4	26%	occasionally	11%	combination of different categories	10%			supermarket hypermarket	40%	varies monthly	9%
	5	10%										
Men 85	1	9%	daily	16%	Fruits, vegetable, cereals	45%	packaging, organoleptic	48%	internet	1%	< 10 euro	7%
	2	9%	weekly	36%	meat	28%	did not observe	11%	special store	32%	10 - 30 euro	59%
	3	44%	monthly	41%	milk, eggs and derivate	25%	no	41%	markets	40%	> 30 euro	16%
	4	27%	occasionally	7%	combination of different categories	2%			supermarket hypermarket	27%	varies monthly	18%
	5	11%										

According with information from Table 2, we observed that on a scale between 1 to 5 our consumer check if the products is or not an organic product as a 3rd option and that organic food products prefered by our respondents are fruits, vegetable and cereals followed by meat category products and after by milks, eggs and derivate products or combination from differentorganic category products. Organic products are consumed weekly in almost the same percent by men and women. Organic products are being selled better in supermarket and hypermarket followed by stored specialised on organic food products. Mens (48%) are more carefully if the product present defect or not in comparatio with women (4%). The montly budget consumed by our respondents on organic products is between 10 and 30 euro, small budget in comparation with the country wich have a culture in consuming organic products.

It is also reported in studies, that fresh fruit and vegetables, dairy and 'chilled convenience' products are most purchased organic food products (Soil Association, 2013). The principal reason for purchase organic food products is because they think that this products are more healthy (Soil Association, 2013).

According to Spaargaren (2000), in order to get a good picture on the circumstances under which people buy the organic products, the lifestyle and systems of food products purchasing should be investigated.

CONCLUSSIONS

Only a small per cent of Romanian consumers purchase organic food products on a daily basis and seems that the majority has a positive attitude towards organic products. Anyway, one must take into account that this positive attitude towards organic food products will not guarantee that the consumers will buy more organic food products. It is anyhow an important step for develop the organic products market.

Also, the culture of Romanian's consumer should be developed through different communication channels where the benefits of organic food products should be underline and also e-commerce should be friendlier for them in order to increase the consuming of organic food products.

This segment of products and improve of consumer's knowledge in understanding of label, nutritional label and benefits of products which become a must for Romanian's consumers.

A tool for make our life easier for read the label and understands nutrition labelling, benefits of organic products is required in Romania market.

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START-UP PHASE OF DENITRIFYING BIOREACTORS USED FOR AGRICULTURAL RUNOFF TREATMENT

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Abstract

Denitrifying bioreactors are a useful passive treatment technology for the removal of nitrates from agricultural runoff. The start-up phase is the most critical period of their operation. In this phase, denitrification rates gradually increase and organic compounds, which are necessary for denitrification, are released from the bioreactor fill media in excessive amounts. The aim of our study was to evaluate the start-up phase of laboratory denitrifying bioreactors filled with six wood-based materials. The effluent quality of all bioreactors achieved a steady state after max. 9 weeks. The denitrification rates at the end of this period ranged from 0.16 to 5.8 g/m^3/d. Initial outlet chemical oxygen demand and biochemical oxygen demand leaching rates, which were in the hundreds and tenths of g/m^3/d, respectively, decreased below 55 and 30 g/m^3/d, respectively. Based on the results reported both for the leaching of organic compounds and the removal of nitrates, poplar seems to be the most suitable denitrifying bioreactor fill medium out of all the tested materials.

Key words*: agricultural runoff, denitrifying bioreactor, organic compound leaching, start-up phase, wood-based. materials.*

INTRODUCTION

Excessive application of fertilizers and animal manure makes agriculture one of the main sources of nitrogen in the aquatic environment and contributes to nitrate contamination worldwide. The high level of nitrates in surface waters may lead to eutrophication, toxic algal blooms, hypoxia, and habitat deterioration (Galloway et al., 2003).

Denitrifying bioreactors are a useful passive treatment technology for nitrate removal from agricultural outflow. They can take the form of beds (containerized systems treating concentrated discharge) or walls (permeable reactive barriers intercepting groundwater flow) (Schmidt and Clark, 2012). They are filled with carbonaceous material, usually wood-based, which releases organic C over a long period and thus fosters heterotrophic denitrification, which converts nitrates to gaseous nitrogen or nitrous oxide (Schipper et al., 2010).

Processes based on heterotrophic denitrification rank among the most promising and frequently used nitrate removal approaches (Robertson, 2010). Denitrifying bioreactors were first studied in Canada (Robertson and Cherry, 1995) and New Zealand (Schipper and Vojvodić-Vuković, 1998). Currently, the technology is in use as part of the official nutrient reduction strategies of several US Midwestern states (Illinois, Iowa and Minnesota nutrient reduction strategies) and the Federal USDA Natural Resources Conservation Service conservation practice standard (USDA NRCS Conservation Practice Standard No. 605) (Christianson and Shipper, 2016).

The main advantage of this technology is its simplicity and long-term high efficiency. Denitrifying bioreactors are capable of removing up to 100% of nitrates. They are easy to assemble and maintain, which makes them cost effective. They are durable–they can last for a minimum of 15 years with minimum maintenance and without requiring replenishment of the fill medium (Schipper et al., 2010).

The fill medium and process parameters are factors controlling the denitrification process in bioreactors. Among the various types of organic fill media, wood-particle materials are the most widely used (Schipper et al., 2010). These media are suitable because they provide consistent NO_3-N removal rates (1–20 g/m^3/d) over the long term (Robertson, 2010) and

exhibit high hydraulic conductivity (van Driel et al., 2006) and a high C:N ratio of approx. 300:1 (Robertson and Anderson, 1999). The process parameters of denitrifying bioreactors, including inlet NO_3-N concentration, hydraulic retention time (HRT), and temperature, were summarized and analysed along with their influence on the denitrification rate by Addy et al. (2016). They applied meta-analysis approaches to data from 26 published studies which dealt with 57 separate bioreactor units. They concluded that the NO_3-N removal rate rises with increasing inlet NO_3-N concentration, and that furthermore it is fostered by a sufficient HRT (denitrifying units with a HRT higher than 6 h have greater NO_3-N removal rates than units with a lower HRT) and sufficient temperature (denitrifying units with a temperature that is greater than 6°C exhibit higher NO_3-N removal rates than units with a lower temperature).

The start-up phase of a bioreactor is the most critical because of the potential release of large concentrations of easily soluble organic carbon and NH_4-N via leaching of the fill medium (Robertson and Anderson, 1999; Gilbert et al., 2008; Cameron and Schipper, 2010; Schipper et al., 2010). The release of organic substances can cause dissolved oxygen depletion in receiving waters and adversely affect biota (Schipper et al., 2010). Certain organic compounds occurring in wood leachate (namely phenolic compounds, tannin and lignin) can, at higher levels, be toxic to aquatic organisms (Schmidt and Clark, 2013). The initial period contrasts with steady-state conditions, when leaching of the fill media is assumed to be negligible (Healy et al., 2012). Cameron and Schipper (2010) reported a drop in NH_4–N and biochemical oxygen demand (BOD) leaching concentrations from wood media to below 0.3 mg/L and 10 mg/L, respectively, within two months after commissioning. Longer HRTs and higher temperatures generally produced higher concentrations of NH_4–N and BOD, probably because the higher temperatures supported faster microbial decomposition of carbon media and low flow rates led to elevated concentrations. To minimise the release of NH_4–N and BOD into vulnerable environments during the start-up phase, temperature management measures, i.e. commissioning the denitrification bioreactor during winter, and HRT management measures, i.e. flow rate or hydraulic gradient alteration, which should be performed together with the selection of appropriate fill media, can be employed (Cameron and Schipper, 2010).

The aim of this study was the evaluation of the start-up phase of laboratory denitrifying bioreactors filled with six wood-based materials. The evaluation was based both on nitrate removal and media leaching assessment. The effect of process parameters was also considered.

MATERIALS AND METHODS

Denitrifying laboratory columns

The tests were conducted in a temperature controlled laboratory with six vertical cylindrical bioreactors, each 1,000 mm high, with a diameter of 300 mm. The bioreactors were filled with a weighed amount of organic material. During the test, the bioreactors were loaded with dechlorinated tap water enriched with nitrates (KNO_3). The water flowed vertically from top to bottom. The location of the outlet pipe provided a water saturated environment in the bioreactors.

The effluent quality of all bioreactors achieved a steady state after a maximum of 9 weeks, which agrees with the findings of (Cameron and Schipper, 2010). Therefore, the first nine weeks of operation of the bioreactors were considered to be the start-up phase. Table 1 shows the process parameters of the bioreactors at the end of the start-up phase.

Table 1. Process parameters of the bioreactors at the end of the start-up phase

	Sawdust mixture *	Bark mulch **	Woodchips			
			Larch	Oak	Poplar	Spruce
HRT, d	6.60	2.50	2.04	2.47	13.2	5.95
Temperature, °C	17	17	17	17	9	19
Inlet NO_3-N, mg/L	34.7	34.7	34.2	34.2	38.6	8.6

* Sawdust from a mixture of various trees.
** Commercially available bark mulch.

It is obvious that the operating parameters differed. This is due to the fact that the bioreactors were not started up simultaneously. Three materials were tested at low HRTs (2 to

2.5 d), one material at a long HRT (13.2 d), and in two cases the HRTs were in-between (6 and 6.6 d). Five materials were tested at an ambient temperature of 17 or 19°C; only poplar woodchips were tested at a temperature that was 9°C. Five materials were tested at an inlet water NO_3-N concentration of 34 to 39 mg/L, while the concentration for spruce woodchips was 8.6 mg/L.

Water sampling and analysis

The frequency of inlet and outlet sampling was set to one week. Temperature was measured via a portable probe and the data were recorded by a Hach HQ40d multi-parameter meter. The chemical oxygen demand (COD), BOD, NH_4-N and NO_3-N were analysed by the following methods: COD–semi-micro method with potassium dichromate and photometric evaluation; BOD–dilution and seeding method with allylthiourea addition and five-day incubation time; NH_4-N–photometric determination with Nessler agent; NO_3-N–UV absorption method with a Hach Nitratax plus sc Sensor.

Data evaluation

Nitrate removal was evaluated based both on denitrification rates and removal efficiencies. Denitrification rates (*DR*) in g/m^3/d were calculated from inlet and outlet NO_3-N concentration differences:

$$DR = \frac{\Delta c(\mathrm{NO_3{-}N}) \cdot Q}{V} \quad (1)$$

where: Δc(NO_3-N) is the difference in NO_3-N inlet and outlet concentrations (mg/L), Q is the water flow rate (L/d) and V is the bioreactor filling volume (L). Removal efficiency was calculated from inlet and outlet NO_3-N concentrations.

Release of COD, BOD, and NH_4-N was evaluated based both on concentrations and leaching rates. Leaching rates (*LR*) in g/m^3/d were calculated as mass flow rates in relation to bioreactor filling volume:

$$LR = \frac{c \cdot Q}{V} \quad (2)$$

where: c is the outlet concentration (mg/L), Q is the water flow rate (L/d) and V is the bioreactor filling volume (L).

To estimate total COD leaching, COD leaching rates were fitted to an exponential decay model originally used by Schmidt and Clark (2013) to describe the decrease over time of dissolved organic carbon export rates from denitrifying bioreactor fill media. The model's equation was as follows:

$$LR_{\mathrm{COD}}(t) = LR_{\mathrm{COD}}(0) \cdot e^{-rt} + \theta \quad (3)$$

where: $LR_{\mathrm{COD}}(t)$ and $LR_{\mathrm{COD}}(0)$ are the COD leaching rate (g/m^3/d) in time t and in the initial time, respectively, r is the exponential rate constant and θ is the asymptote rate (g/m^3/d). COD concentration and COD leaching rate were measured and calculated, respectively, for an extended period of time (18 weeks).

The variable r was determined using Microsoft Excel software. The variable θ was manually fitted as the average COD leaching rate in the final three sampling events.

RESULTS AND DISCUSSIONS

Nitrate removal

Denitrification rates gradually increased during the 9 weeks of the bioreactors' start-up phase (Figure 1).

After one week of operation, *DRs* varied from 0 g/m^3/d (spruce) to 2.2 g/m^3/d (mulch). The subsequent increase in *DRs* over time was interleaved by a sigmoid curve.

The smallest and greatest rise in *DR* during the start-up phase was shown by mulch (1.2 times) and sawdust (11.8 times), respectively. However, the highest *DR* (9.04 g/m^3/d) was achieved by oak at the eighth week of operation.

The denitrification rates and NO_3-N removal efficiencies which were achieved by the studied denitrifying bioreactor fill media at the end of the start-up phase are summarised in table 2.

The denitrification rates varied from 0.16 g/m^3/d (spruce) to 5.8 g/m^3/d (oak) with an average of 2.4 g/m^3/d.

All achieved denitrification rates correspond well with the findings of Christianson et al. (2012) and David et al. (2016) - 0.38-7.76 g/m^3/d and 1.2-11 g/m^3/d, respectively, though they are rather lower compared with the general range of 2-22 g/m^3/d published in (Shipper et al., 2010).

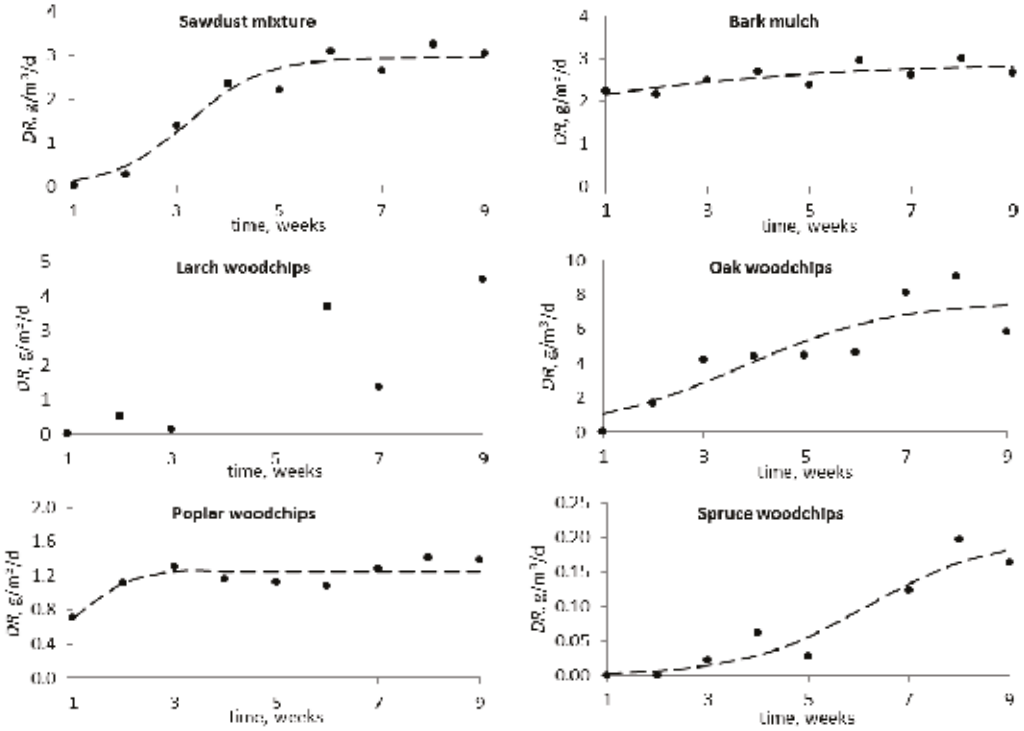


Figure 1. Changes in *DR* during the bioreactors' start-up phase

Table 2. The denitrification rates and NO_3-N removal efficiencies at the end of the start-up phase of denitrifying bioreactors filled with various wood-based media

	Sawdust	Mulch	Larch	Oak	Poplar	Spruce
Denitrification rate, g/m^3/d	3.0	2.7	1.4	5.8	1.4	0.16
Outlet NO_3-N, mg/L	7.4	4.7	31	13	4.6	5.7
NO_3-N removal efficiency, %	79	86	9	63	88	34

From the fact that the highest *DR* (oak) and the second lowest *DR* (larch) were achieved with the same process parameters (HRT 2.0-2.5 d, inlet NO_3-N 34.2 mg/L, and temperature 17°C) it is obvious that the *DR* at the end of the start-up phase largely depended on the fill medium. The lowest *DR* was reported for spruce, which was, unlike the other materials, used with a low inlet NO_3-N concentration (8.6 mg/L). This confirms the conclusions of Addy et al. (2016) that the *DR* increases with increasing inlet NO_3-N concentration. High nitrate removal efficiency is fostered by long HRT (Hoover et al., 2015). However, long HRT is also associated with low flow rate and thus can lead to low *DR* due to a low inlet NO_3-N mass flow rate (Formula 1). This was probably the case with poplar, which achieved the highest NO_3-N removal efficiency of all studied media (88%), but low *DR* (1.4 g/m^3/d). The low *DR* of poplar could also be partly caused by low temperature (9°C).The lowest and highest outlet NO_3-N concentrations were achieved with poplar (4.6 mg/L) and larch (31 mg/L), which correspond to the highest (88%) and lowest (only 9%) NO_3-N removal efficiencies respectively, achieved by these media.

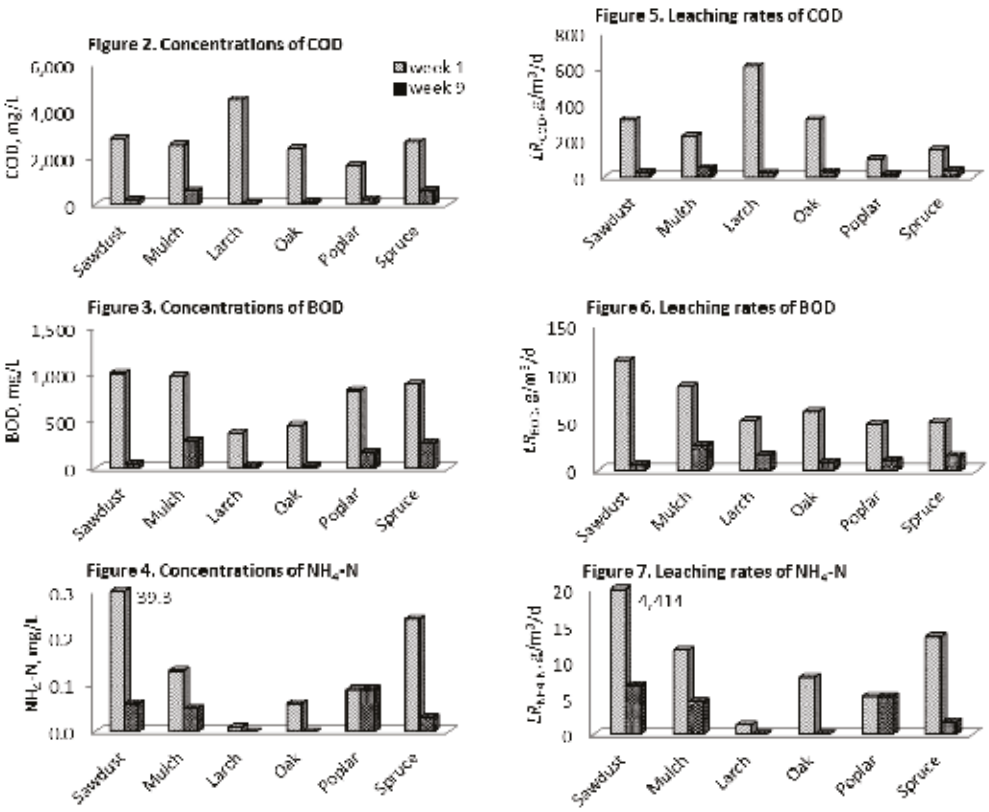
It can be concluded that good results were shown by four of the six studied wood-based media, namely sawdust, mulch, oak (with the highest denitrification rate, 5.8 g/m^3/d), and poplar (with the highest NO_3-N removal efficiency, 88%, despite the low temperature of 9°C). In contrast, unfavourable results were achieved with larch (denitrification rate 1.4 g/m^3/d and NO_3-N removal efficiency 9%) and

spruce (denitrification rate 0.16 g/m^3/d and NO_3-N removal efficiency 34%). Therefore, based on the denitrification rates achieved at the end of the start-up phase it can be said that these two media do not seem to be suitable for use in denitrifying bioreactors.

Denitrifying bioreactor media leaching

The study focused on the release of organic substances (expressed as COD and BOD) and NH_4-N, because increased concentrations of these compounds in bioreactor outlet can threaten the water quality of the recipient.

Figures 2 - 7 show changes in concentrations and leaching rates of COD, BOD, and NH_4-N from the beginning to the end of the start-up phase, i.e. from the first to the ninth week of bioreactor operation.



Figures 2, 3, 4 ,5, 6, 7. Changes in COD, BOD and NH_4-N concentrations and leaching rates from the beginning to the end of the start-up phase. Light and dark bars represent values in the first and ninth week of bioreactors' operation, respectively.

It can be seen from Figures 2 to 7 that although there were differences among the concentrations and leaching rates of the released substances, both concentrations and leaching rates decreased substantially during the start-up phase.

At the beginning of the experiment, the highest bioreactor outlet COD concentration was shown by larch – 4,487 mg/L, while the COD values measured for the other materials were comparable (1,694–2,809 mg/L). Interestingly, the larch also showed the biggest decrease in COD concentration, as outlet COD was only 47 mg/L in the ninth week of the experiment. The outlet COD measured for the other materials ranged from 101 to 590 mg/L (Figure 2).

The COD leaching rates followed a similar pattern, with the highest value at the beginning

of the experiment calculated for larch (613 g/m^3/d) and the lowest for poplar (99 g/m^3/d). At the end of the start-up phase, the COD leaching rates were much lower and more balanced compared with the first week and ranged from 14 g/m^3/d (poplar) to 51 g/m^3/d (mulch) (Figure 5).

In the case of outlet BOD, the differences among the materials were not so large. The initial outlet BOD concentrations ranged from 378 mg/L (larch) to 1,010 mg/L (sawdust), and the initial BOD leaching rates from 48 g/m^3/d (poplar) to 113 g/m^3/d (sawdust). During the start-up phase, the outlet BOD concentrations decreased to 30–289 mg/L (oak–mulch) and the leaching rates to 5.4–26 g/m^3/d (sawdust–mulch) (Figures 3 and 6).

The lowest initial COD and BOD leaching rates were reported for poplar (99 and 48 g/m^3/d, respectively) (Figures 5 and 6). The HRT of this bioreactor was high (13.2 d) in comparison with other experimental units, which had HRTs ranging from 2.0 to 6.6 d (Table 1). This may suggest that although high HRTs can foster an increase in concentrations of released compounds (Cameron and Schipper, 2010), low flow rates help to reduce leaching rates in the start-up phase, which is favourable for the receiving stream. The bioreactor filled with poplar woodchips that showed the best results differed from other bioreactors in its low operating temperature, which was 9°C (Table 1). It confirms the findings of Cameron and Schipper (2010) that low temperatures are favourable for the start-up phase, as they aid in slowing down the decomposition and leaching of the fill media.

There was a big difference between the NH_4-N released from sawdust and from all the other materials at the beginning of the experiment. While sawdust showed an NH_4-N outlet concentration of 39.3 mg/L and a leaching rate of 4,414 mg/m^3/d in the first week, the second highest values (spruce) were only 0.24 mg/L and 13.5 mg/m^3/d, respectively. The high NH_4-N leaching rate from the sawdust could probably be explained by that material's consistency and large specific surface, which also applied in the case of the high BOD release, although in the latter case the difference between it and the other fill media was not so great. In the ninth week, the outlet NH_4-N concentrations of all bioreactors were below 0.1 mg/L and leaching rates were below 7 mg/m^3/d (Figures 4 and 7).

To estimate the total COD leached, COD leaching rates were fitted to an exponential decay model (Figure 9). The variables of the model, $LR_{COD}(0)$, r and θ, are summarized in Table 3, which also includes the determination coefficients. These varied from 0.98 (sawdust) to 0.74 (oak), indicating a good match between the model and real data with a significant correlation at $p < 0.01$.

Table 3. Variables of the exponential decay model, and determination coefficients

Material	Model variables			R^2
	$LR_{COD}(0)$, g/m^3/d	r	θ, g/m^3/d	
Sawdust	442	0.056	14	0.98
Bark	556	0.113	78	0.89
Larch	613	0.074	3	0.79
Oak	317	0.058	9	0.74
Poplar	99	0.027	5	0.96
Spruce	150	0.063	35	0.95

COD leaching rates were initially high, varying from 613 g/m^3/d (larch) to 99 g/m^3/d (poplar). However, their decrease over time was rapid. After only 18 weeks of operation the values exhibited by the denitrifying bioreactors were almost constant. The lowest and highest asymptote rate was achieved with larch (3 g/m^3/d) and mulch (78 g/m^3/d), respectively.

Larch woodchips exhibited the highest initial COD leaching rate and at the same time the lowest asymptote rate. Based on data (COD concentrations) from the first 18 weeks of denitrifying bioreactor operation, the total amounts of COD which would be released from a volume unit of a bioreactor after 1 and 10 years were estimated (using a definite integral), (Figure 8).

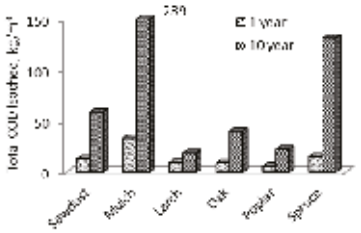


Figure 8. The total amounts of COD which would be released from a volume unit of a bioreactor after 1 and 10 years depending on the fill medium

The 1 year total COD amount increased in the following order: poplar (5.52 kg/m^3) < oak (8.88 kg/m^3) < larch (9.36 kg/m^3) < sawdust (12.9 kg/m^3) < spruce (15.3 kg/m^3) < mulch (33.3 kg/m^3). Over a long-term period the order was similar but not the same. The lowest and highest 10 years total COD amount was achieved with larch (18.7 kg/m^3) and mulch (289 kg/m^3), which corresponds with their asymptote rates. The 10 years total COD amounts which would be released from other studied denitrifying bioreactor fill media were as follows: poplar (22.5 kg/m^3) < oak (39.9 kg/m^3) < sawdust (58.4 kg/m^3) < spruce (131 kg/m^3). From the data it is obvious that total released COD amounts can be very different depending on the fill medium used.

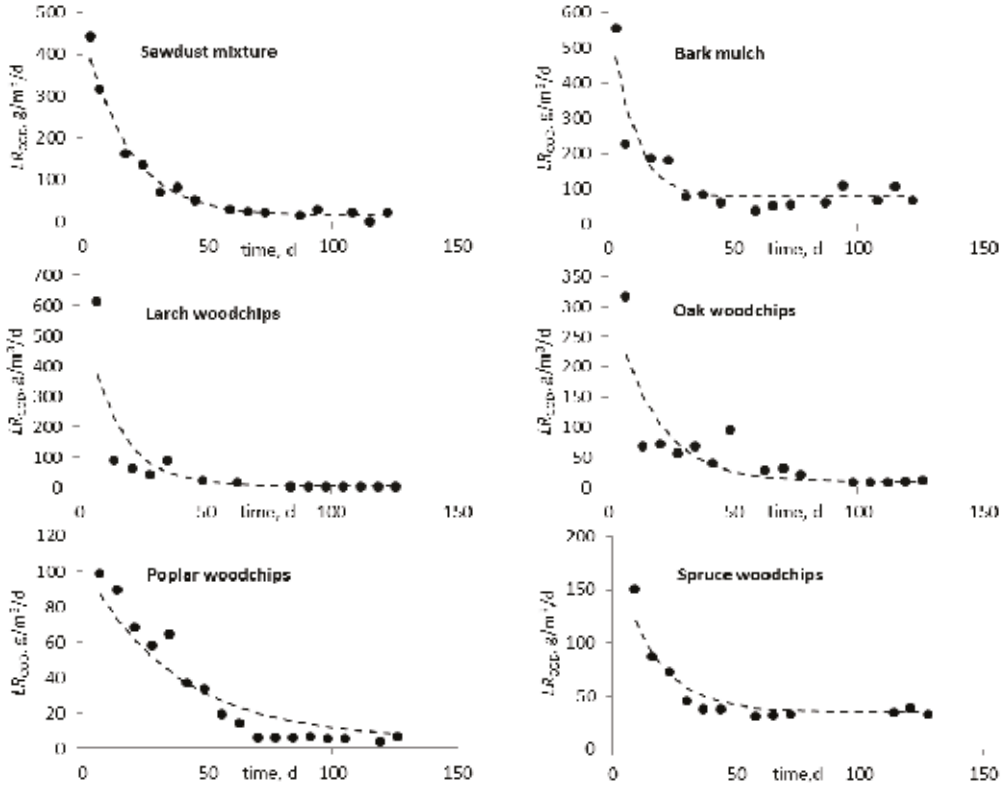


Figure 9. Decrease in COD leaching rates over time

CONCLUSIONS

The start-up phase of denitrifying bioreactors is the most critical period of their operation. During this period, denitrification rates gradually increase and organic compounds, which are necessary for denitrification, are released from the fill media in excessive amounts.

In our experiments, the denitrification rates reported for all fill media increased, but with different slopes. High inlet NO_3-N concentrations and higher temperatures led to higher denitrification rates. With respect to nitrate removal rate and efficiency, good results were achieved at the end of the start-up phase with sawdust, mulch, oak, and poplar. On the other hand, larch and spruce did not appear to be suitable carbon sources for denitrifying bioreactors.

There were differences among the concentrations and leaching rates of the released COD, BOD, and NH_4-N. However, both concentrations and leaching rates decreased substantially during the start-up phase. The best results with respect to initial

COD and BOD leaching rates were shown by poplar, although the lowest 10 years total COD amount would be achieved with larch. Leaching of NH_4-N was generally low, with the exception of sawdust. Longer HRTs and lower operating temperatures foster a slowdown in the decomposition and leaching of fill media.

Based on the results reported both for organic compound leaching and nitrate removal, poplar seems to be the most suitable denitrifying bioreactor fill medium of all the tested materials.

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GEOTECHNICAL AND HYDROGEOLOGICAL STUDIES THAT UNDERLIE THE STABILITY OF THE LAND ON WHICH THE ROVINARI THERMAL POWER PLANT IS LOCATED

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Abstract

The Rovinari Thermal Power Plant is one of the electricity suppliers of Oltenia (together with Turceni Thermal Power Plant, Craiova Thermal Power Plant) covering one third of the national electricity production.
The aim of this paper is to determine practically, by drilling, the physical and mechanical characteristics of the soil in the area of Rovinari Thermal Power Plant. The paper is intended to be an introduction to a broader study on the influence of mining lignite quarries in the Rovinari mining basin on the stability of the buildings in the Rovinari thermal power plant and its coal and slag-ash deposits. This stability depends on the safe functioning of the thermal power plant throughout its lifetime.

Key words*: Rovinari mining basin, Rovinari thermal power plant, lands features, safety, land stability.*

INTRODUCTION

In the Rovinari basin, the influence of day-to-day operations and of the watering works performed on the aquifer system can be clearly seen over very large distances and in the adjacent quarries.
The Rovinari Thermal Power Plant is located at 3 km from the former Garla quarry and near the Rogojelu perimeter (Figure 1) where, a few years ago, there was a landslide caused by the sinking and consolidation of the aquifer with fine grain size but not exceeding 10-15 cm, which had no negative consequences on this very important industrial objective of Romania.
The safely exploitation of lignite deposits, through quarries in the meadow area of the Rovinari basin, required the descent of the groundwater piezometric level by 50-100 m, resulting the formation of a large depression funnel that was extended beyond the boundaries of the quarries.
Intense operations of dewatering and discharge of groundwater can lead severe and even the subsistence phenomena, with breaks and sudden bursts of clay-marl formations in the roof of aquifer layers and horizons.

Figure 1. The location of the Rovinari Thermal Power Plant in the Rovinari mining basin (satellite image)

The inconveniences generated by the phenomena of compaction and subsidence could be avoided if the industrial activity is preceded by geotechnical and hydrogeological studies carried out very carefully at regional level, and if the appropriate measures of planning and management of the activities are taken on the basis of the obtained results from these studies.
This study was performed to determine the physico-mechanical properties of soils/rocks from the site power plant Rovinari.
These properties will form the basis of calculations of load capacity and of the land stability for the constructions made or to be performed on the Rovinari site: buildings, coal deposits, slag and ash deposits etc.

GENERAL CHARACTERISTICS OF THE STUDY AREA

From a morphological point of view, the perimeter under consideration is a plateau located in the Jiu river meadow, on its right bank.
Geological composition of the area includes fine albedo-to-grown quaternary alluvial deposits.
Quaternary deposits are represented by clay, sandy clay, sand, gravel and boulders that are in various stages of consistency.
From a tectonic point of view, the area is part of the Getic depression, in the axis of the anticline Rovinari.

GEOTECHNICAL STUDIES

Geotechnical works carried out in two steps in order to determine the physico-mechanical characteristics of the lands/rocks on the Rovinari site, properties that will be the basis of the load capacity calculations, implicitly stability of the foundation ground for the existing or further constructions.
They consisted of:
- direct observation (geological mapping);
- execution of seven geotechnical boreholes (F1 - F7) with FSC 2.5 drilling rig up to 15 m and 30 m depth, in the North-South and East-West directions on an almost flat and stable surface;
- sampling;
- soil/rock samples analysis in the laboratory.

The study was carried out in two stages: the first stage included the geotechnical investigation of the South-West part of the Rovinari thermal power plant's terrains, and the second, the North-East part.
The stages covered the geotechnical investigation works in order to provide the data needed to solve the following basic problems:
- stratification of the site;
- physical and mechanical characteristics of the soil / rocks encountered;
- hydrostatic level and chemical characteristics of groundwater.

The main factors that influence the land stability are:
- the shape of the land surface;
- the nature of the rocks and the groundwater and surface water regime;
- the physico-mechanical properties of rocks and base fields.

The positions of the boreholes were determined depending on the proposed location for the important building of the thermal power plant and the drilling depth was according to the development of these constructions both planar and vertical. Table 1 presents a synthesis of the mineral-petrographic composition of the material intercepted by drillings in the two stages.
The Table 2 presents the lithology of the formations encountered by the executed drilling works.

Table 1. Mineral-petrographic composition of intercepted material from geotechnical drilling works

Intercepted material	STAGE I		STAGE II	
	%	Nature of intercepted material	%	Nature of intercepted material
Clay rocks	41	clays, clayey slopes, sandy clays - soft to consistency and prickly with high compressibility to medium, high plasticity (weak clay) to very high (greasy clay), wet-very wet to saturated	27	clay, clayey slopes, sandy clays - are consistently prickly plastic with high compressibility to medium, high plasticity (weak clay) to very high (clayey), wet - very wet to saturated
Rocks of sandy nature	59	sand, clayey sands, silty sands-soft plastic to solid, high plasticity, wet to saturated	66	sand, clayey sands, silty sands- soft plastic to solid, high plasticity, wet to saturated
Rocks of a charcoal nature	-	-	7	Coal and coal clay

Table 2. Lithology of the soil

Directions / Stages	STAGE I	STAGE II
On direction North-South	- From the ground surface into the boreholes F1, F2, F5, had been intercepted by the formations preponderant 7-15 m sand, clay, gravel elements, the drilling F5 left to the bottom; further down to 15 m deep, drillings F1 and F2 crossed clay to sandy clay. - The F7 broke from the surface to a depth of 1m deep dry clayey coal, then up to 5 m of silty sandy clay from 10 m, intercepting coarse sand with water to the bottom. In the south, boreholes F3, F6 crossed a mixture of charcoal clay, sandy clay with coal fragments (filler) from the surface, and then they entered the sandy, sandy coarse sandy formation. Borehole F3 crossed a compact clay lens between 6 m and 9 m. From 15 m to 30 m deep, borehole F6 has intercepted clay on sandy clay.	- From the surface of the land in the F7 and F5 boreholes were intercepted up to 2-3 m of clayey coal, after which they entered predominantly sandy formations, sandy - clayey formations sometimes with small gravel elements. - On the alignment of the F1, F2, F3 and F6 boreholes on the surface in the F2 and F3 boreholes, sandy clay was intercepted up to 6 m, after which a sandy clayey horizon crossed with rare elements of gravel, where F1 remained with the soleplate at 15 m deep. From 12 m, it went into clay in F2 and F3 to the soleplate. The F6 borehole starting 9m identified two charcoal states of 2-3 m thick, separated by a 1m thick sandy-clayey layer. Next, strong plastic silty clay was intercepted up to the drilling soleplate (30 m), with a sandy clay plastic consistent intersection in the range of 18-21 m.
On direction East-West	Boreholes F4 and F5 crossed a succession of clayey sands to rough gravel sands (F5). In the F4 borehole area of the 1 m thick surface, charcoal was found and between 8-9 m depth a soft-bodied silty clay lens with poor physical-mechanical characteristics.	The boreholes traversed a succession of clayey sands, silty sands in rough gravel sands (F5 and F7), and sandy clay with varying thicknesses. In the F5 and F7 boreholes area, clayey charcoal with a thickness of 1-3 m was encountered on the surface. In the deepest borehole F6 crossed from 15-21 m of strong clay to the sole.

Following the laboratory analysis carried out on the soil/rocks collected from the cores, the physical (Table 3) and mechanical (Table 4) properties were resulted.

Table 3. Physical characteristics of the analysed material

Interme-diate material	PHYSICAL CHARACTERISTICS	
	STAGE I	STAGE II
Clayey type rocks	Specific weight γ_s = 24.6 ÷27.0 kN/m^3 Apparent volumetric weight γ_a = 18.0÷20.4 kN/m^3 Natural humidity W = 20.2÷40.5% Consistency index I_c = 0.45÷0.71 (I_c = 0.25 dusty clay F_4) Plasticity index I_p = 26.6÷37.2 Humidity degree S_r = 0.90÷1.10 Granulometric composition: Sand 4-44%; Silt 27-50%; Clay 30-60%	Specific weight γ_s = 23.6÷26.9 kN/m^3 Apparent volumetric weight γ_a = 19.0-20.4 kN/m^3 Natural humidity W = 19-29% Consistency index I_c = 0.64÷0.77 (I_c = 0.25 silty clay F_4) Plasticity index I_p = 29.7-38.8 Humidity degree S_r = 0.78-1.07 Granulometric composition: Gravel 5%; Sand 13-39%; Silt 25-45%; Clay 31-42%
Sandy type rocks	Specific weight γ_s = 25.0÷26.8 kN/m^3 Apparent volumetric weight γ_a = 18.8÷22.0 kN/m^3 Natural humidity W = 10.2÷29.55 Consistency index I_c = 0.30÷0.56 Plasticity index I_p = 9.2÷18.0 Humidity degree S_r = 0.8÷1.04 Granulometric composition: Gravel 4-94%; Sand 6-95%; Silt 4-33%; Clay 5-24%	Specific weight γ_s = 25.0÷27.5kN/m^3 Apparent volumetric weight γ_a = 18.5÷21.5 kN/m^3 Natural humidity W = 12.2÷34.2 Consistency index I_c = 0.46÷0.77 Plasticity index I_p = 13.5÷19.6 Humidity degree S_r = 0.79÷1.05 Granulometric composition: Gravel 2-24%; Sand 31-80%; Silt 10-50%; Clay 6-40%
Coal type rocks	-	Specific weight γ_s = 20.7÷23.3kN/m^3 Apparent volumetric weight γ_a = 12÷15 kN/m^3 Natural humidity W = 29.2÷49.4 Humidity degree S_r = 0.8÷1.04

Table 4. Mechanical characteristics of the analysed material

Intermediate material	CHARACTERISTICS	STAGE I	STAGE II
Clayey type rocks	Compressibility in oedometer	Compressibility module M_{2-3} = 60÷118daN/cm^2 (M_{2-3} = 38daN/cm^2 silty clay F_4) Specific subsidence e_p = 1.95÷5.1cm/m (e_p = 7.6 cm/m silty clay F_4)	Compressibility module M_{2-3} = 65÷181daN/cm^2 Specific subsidence e_p = 1.19÷4.3cm/m (e_p = 7.6 cm/m silty clay F_4)
	Resistance to direct shear	Internal friction angle $\Phi = 12÷18^o$ Cohesion C = 0.13÷0.20daN/cm^2	Internal friction angle $\Phi = 16÷19^o$ Cohesion C = 0.14÷0.28daN/cm^2
Sandy type rocks	Compressibility in oedometer	Compressibility module M_{2-3} = 50÷86daN/cm^2 Specific subsidence e_p = 3.95÷8.25cm/m	Compressibility module M_{2-3} = 105÷200daN/cm^2 Specific subsidence e_p = 2.15÷9.35cm/m (e_p = 7.6 cm/m silty clay F_4)
	Resistance to direct shear	Internal friction angle $\Phi = 22÷24^0$ Cohesion C = 0.07÷0.13daN/cm^2	Internal friction angle $\Phi = 12÷18^o$ Cohesion C = 0.13÷0.20daN/cm^2

HYDROGEOLOGICAL STUDIES

Hydrogeological tests were carried out in all 7 executed boreholes by intercepting the ground-water horizon determined by sandy quaternary deposits.

The hydrostatic stabilized level was at a depth of between 1.5 m (F2) and 12.5 m (F5), with an average of about 6 m. The spring was intercepted at depths between 5.7 m (F6) and 13.1 m (F5) in stage I, and in the second stage the hydrostatic level ranged from 5 m depth (F5) to 14.9 m (F1), with an average of 9.9 m.

The depths at which geotechnical drillings intercepted the aquifer horizon during the execution period and the level stabilized at the end of the period are presented in table 5.

It is noted that in periods of heavy rain the water level can raise more, the aquifer horizon generally having a weak ascent as it is opened by the excavation.

Laboratory analyses of the groundwater have made it possible to assess its aggressive character on building materials (concrete, metal), (Table 6).

Table 5. Depths at which drills intercepted the aquifer horizon and stabilized level

Borehole number	Daily level (m a.s.l.)		Source				Hydrostatic level			
			Depth (m)		Elevation (m a.s.l.)		Depth (m)		Elevation (m a.s.l.)	
	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
F_1	161.5	161.4	5.75	-	155.7	-	5.50	14.9	156.0	146.5
F_2	161.7	162.1	10.8	8.5	150.9	153.6	1.50	6.50	160.2	155.6
F_3	163.2	163.2	10.6	14.9	152.0	148.3	4.60	14.7	158.6	148.5
F_4	163.5	163.6	9.7	14.9	153.0	148.7	3.20	14.8	160.3	148.8
F_5	163.4	163.6	13.1	14.0	150.0	149.6	12.5	5.0	150.9	158.6
F_6	164.1	160.0	5.7	6.0	158.5	154.0	4.10	5.20	160.0	154.8
F_7	163.2	163.0	12.1	9.1	151.0	153.9	11.80	8.40	151.4	154.6
Average	161.5	162.4	9.6	11.2	153.2	151.3	6.10	9.93	156.7	152.4

Table 6. Characterization of intercepted waters in relation to aggressiveness

Borehole number	The nature of the aggression	Registered value (mg/l)	Characterization
F_2	Leaching HCO_3^-	109.50	Weak aggressiveness
	Generally acid	6.18	Weak acid aggression
	Magnesium Mg^{2+}	18.20	No aggression
	Sulphates SO_4^{2-}	139.40	No sulphate aggression
	Cl^-	17.70	No sulphate aggression
	Salinity	367.20	No aggression
F_3	Leaching HCO_3^-	85.40	Weak aggression
	Generally acid	4.47	Weak acid aggression
	Magnesium Mg^{2+}	39.50	No aggression
	Sulphates SO_4^{2-}	331.40	Weak sulphate aggression
	Cl^-	85.10	Weak sulphate aggression
	Salinity	693.50	No aggression
F_4	Leaching HCO_3^-	91.50	Weak aggressiveness
	Generally acid	5.72	Weak acid aggression
	Magnesium Mg^{2+}	29.20	No aggression
	Sulphates SO_4^{2-}	365.00	Weak sulphate aggression
	Cl^-	17.70	Weak sulphate aggression
	Salinity	659.00	No aggression
F_5	Leaching HCO_3^-	79.30	Weak acid aggression
	Generally acid	4.86	Weak acid aggression
	Magnesium Mg^{2+}	25.50	Weak acid aggression
	Sulphates SO_4^{2-}	372.20	Weak sulphate aggression
	Cl^-	24.80	Weak sulphate aggression
	Salinity	658.90	No aggression
F_6	Leaching HCO_3^-	103.70	Weak acid aggression
	Generally acid	6.61	Weak acid aggression
	Magnesium Mg^{2+}	35.90	No aggression
	Sulphates SO_4^{2-}	384.20	Weak sulphate aggression
	Cl^-	21.30	Weak sulphate aggression
	Salinity	700.00	No aggression
F_7	Leaching HCO_3^-	109.80	No aggression
	Generally acid	6.48	Weak acid aggression
	Magnesium Mg^{2+}	25.50	Weak aggression
	Sulphates SO_4^{2-}	487.50	Weak sulphate aggression
	Cl^-	31.90	Weak sulphate aggression
	Salinity	877.40	No aggression

CONCLUSIONS

A thorough geotechnical and hydrogeological study of land on which anthropic targets are located is a sine qua non condition to establish their safety.

The paper is intended to be a stepping stone for building stability calculations (buildings, installations, deposits, etc.) that form the industrial objective of the Rovinari Thermal Power Plant.

Based on geotechnical and hydrogeological investigations carried out, the paper summarizes the entire approach of the authors in establish those physical, mechanical and chemical characteristics necessary for the stability studies of resistance structures from the area of the Rovinari Thermal Power Plant.

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HEAT PENETRATION PARAMETERS OF NEWLY PROPOSED THERMAL INSULATING CONCRETES FROM THE VIEWPOINT OF POWER CONSUMPTION AND ENVIRONMENTAL IMPACTS

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Abstract

For passive and low energy buildings, such an external envelope, which can provide a sufficient thermal insulation function with the smallest overall wall thickness., is thermally and financially the most advantageous. Concrete can be a suitable building material. At present, non-reinforced porous concretes, light autoclaved concretes (sand and ash concretes) are used as good insulating materials. New thermal insulating concretes designed by us can be classified into this category. At the same time it is possible to prove by their previously non-tabulated heat penetration parameters that these materials are of relatively higher quality. Use of these materials brings the same effect of desired thermal insulation by only a comparatively small reduction in the concrete wall thickness. As a result, it is possible not only to achieve savings of the indoor living area, but also to declare a more favourable parameter of the building energy intensity, which is a highly reputable parameter. The solved issues are important in agriculture, especially in terms of dimensioning the purpose-built buildings, such as residential buildings, livestock buildings, silos and various buildings designed for storage. With regard to the assessment of the entire life cycle of buildings and the durability of concrete, the choice of this material is favourable both from the viewpoints of power consumption, environmental impacts and economy.

Key words*: concrete, thermal insulation, environmental impacts.*

INTRODUCTION

Economical and efficient use of energy is becoming increasingly important. It requires a detailed examination of thermodynamic quantities in the context of the laws of thermodynamics, i.e., in particular, the temperature as an internal state quantity of a given thermodynamic system and heat as an external state quantity of this system. In the civil engineering, the investigated thermodynamic system is the building.

The energy losses of the building are related to its properties and the way it is used. In particular, the shape and structure of the building are of principal importance, i.e. what is the size of its outer surface in relation to its total volume, how the building is thermally insulated and, of course, what material the building is built from. That is why the study of different material parameters of different building materials is also so important.

The energy-passive standard of the building can be achieved in particular by using cost-effective technologies, i.e. by using alternative energy sources and energy recovery, as well as using the optimal architectural design and precise execution of the building including its details, such as hermetic sealing of joints and cable and other entries through enclosure structures.

The low-energy building is based on the same principle as the energy-passive building, but it contains relatively fewer energy-optimising elements. The low-energy standard of the building can be achieved with the use of commonly available building materials, i.e. the wall can be built in classic bricks, such as ceramic, porous concrete or lime bricks, it can be based on wood or concrete, but the necessary condition is to find the optimal thickness of wall thermal insulation in dependence on the applicable standards and on the required peripheral load-bearing structure. Concrete can of course not be regarded as an

ecological material in terms of the production process.

Cement as a basic component of concrete requires an environmentally demanding extraction of initial materials, and also the processing of concrete is energy-intensive because it takes place at temperatures between 1400 and 1500°C. So far unsurpassed way of achieving such high temperatures is the use of high-calorific fuels. Fossil fuels generate large amounts of carbon dioxide and they thus burden the environment. On the other hand, it must be appreciated that concrete is an environmentally compatible building material. Concrete as an alternative to natural stone is highly durable and it has a service life of up to hundreds of years. Mechanisms of concrete degradation are studied, followed by the development of protective treatment of concrete, which is also aimed at extending the concrete service life and thus reducing the need for concrete production in the future. It is from this point of view that different types of concrete can be considered as environmentally friendly products.

HEAT PASSAGE THROUGH A FLAT WALL

Flat wall can be considered the base structural element of a building, i.e. a slab with a constant surface S and a thickness d, the ends of which are maintained during the time interval τ at constant temperatures T_1, T_2; i.e. at a constant temperature difference $\Delta T = T_1 - T_2$ between the opposite walls of the slab (Figure 1).

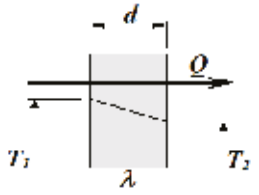

Figure 1. Diagram of heat conduction through a flat wall

The heat Q is conducted through the slab perpendicularly to the facial opposite surfaces of the slab according to the Q of the Fourier's law, in which the significant material parameter λ acts as the specific thermal conductivity of the slab.

The slab thermal resistance parameter is then derived as the ratio of the thickness d of the slab and its specific thermal conductivity. The parameter k for the slab heat transfer, which is in some cases used quite frequently, is defined as an inverted value of the thermal resistance of this slab (Ziman, 1972).

The overall thermal resistance parameter of the composite flat wall is given as an algebraic sum of the parameters of thermal resistances of the partial layers of the composite wall. The total parameter U of the composite wall heat transfer is given as an inverse value of the sum of the thermal resistances of the partial layers of the wall.

Specifically, for a flat wall composed of two different layers of specific thermal conductivities λ_1, λ_2 and different thicknesses d_1, d_2.

$$U = \frac{1}{\frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2}} \qquad (1)$$

The required value of the average heat-passage parameter of the dwelling building enclosure with a common indoor environment is 0.30 $W \cdot m^{-2}K^{-1}$ according to „Czech Technical Standard 73 0540-2: 2011 Thermal Protection of Buildings-Requirements".

The recommended value for a heavy wall is 0.25 $W \cdot m^{-2}K^{-1}$ and for the light wall it is 0.20 $W \cdot m^{-2} \cdot K^{-1}$. The recommended heat passage value for passive buildings is 0.18 to 0.12 $W \cdot m^{-2}K^{-1}$. Respecting this standard requires thermal insulation of the wall by a layer of thermal insulation.

However, facade insulation, for example with the use of polystyrene, means an increase of the building costingness, or requires the solution of related technological problems.

Reduction of requirements for insulation can be achieved by using new and innovative materials for load-bearing systems that exhibit reduced heat transfer.

From an economical point of view, it is most advantageous for energy-passive and low-energy buildings to choose such material for a building envelope that can provide sufficient thermal insulation functionality with the smallest overall thickness of the external wall.

MATERIALS AND METHODS

For the laboratory measurements**,** two measuring instruments were used: the commercial multifunctional device Isomet 2114, and a prototype device of a thermostatic calorimeter chamber with computerized touch probes (Kušnerová, 2012; 2014; 2016). On each studied concrete sample, a total of 40 direct measurements using Isomet 2114 and more than 150 direct measurements on the thermostatic calorimetric device were performed and evaluated. Three kinds of samples of the newly proposed concretes B 200, B 300, B 400 were examined (Gola, 2015), see recipes of the concretes B 200, B 300, B 400 (Table 1).

Table 1. Recipes of the concretes B 200, B 300, B 400

Concrete designation	Filler (0.063/4mm) [kg]	Cement CEM 42.5R [kg]	Water [kg]	Water parameter [-]	Super – plastizer [kg]
B 200	446.0	198.0	376.3	1.9	0.99
B 300	422.8	276.0	358.9	1.3	1.38
B 400	414.5	375.5	394.2	1.5	1.88

RESULTS AND DISCUSSIONS

Determination of parameters of heat transfer of samples made of concrete

The heat transfer parameters *k* of the samples made of the proposed thermally insulating concretes B 200, B 300*,* B 400 of identical geometric dimensions (0.15 m x 0.15 m x 0.15 m), but of different composition of their material according to the formulations declared in the publication (Gola, 2015) (Table 2), were determined. For the samples, the thermal insulation cladding was chosen with a comparable layer of expanded polystyrene (with geometric dimensions of 0.15 m x 0.15 m x 0.20 m and a specific thermal conductivity of 0.04 $W \cdot m^{-1}K^{-1}$).

Table 2. Newly tabulated heat transfer parameters *k* of the samples of heat insulating concretes and heat transfer parameters *U* of these samples, which had polystyrene insulation cladding

Concrete	λ $\left[\frac{W}{m \cdot K}\right]$	*d* [m]	*k* $\left[\frac{W}{m^2 \cdot K}\right]$	λ_P $\left[\frac{W}{m \cdot K}\right]$	*d* [m]	*U* $\left[\frac{W}{m^2 \cdot K}\right]$
B 200	0.1400	0.15	0.933	0.040	0.20	0.165
B 300	0.1625	0.15	1.083	0.040	0.20	0.169
B 400	0.1935	0.15	1.290	0.040	0.20	0.173

In all cases, the recommended value of the heat passage parameter through the wall of the energy-passive building was achieved.

Determination of parameters of heat transfer of comparative commercially used concretes

In order to compare the heat transfer parameters of the samples of proposed heat insulating concretes, the heat transfer parameters *k* of the samples of commercially used concretes were determined: B_H compact concrete, B_C brick concrete, B_C lightweight autoclaved non-reinforced porous sand concrete and B_A light autoclaved non-reinforced porous ash concrete of identical geometric dimensions (0.15 m x 0.15 m x 0.15 m) (Table 3).

For the samples, the insulation cladding was chosen with a comparable layer of expanded polystyrene (with geometric dimensions of 0.15 m x 0.15 m x 0.20 m and a specific thermal conductivity of 0.04 $W \cdot m^{-1} \cdot K^{-1}$). Only in the cases of the samples of thermally insulating concretes the recommended values of the heat passage through the wall of the energy-passive building was reached, and these values were higher than those of thermally insulating concretes B200, B300, B400.

Table 3. Comparatively declared heat transfer parameters *k* of the samples of concretes and heat transfer parameters *U* of heat transfer of these samples, which have thermal insulation cladding made of polystyrene

Concrete designation	λ $\left[\frac{W}{m \cdot K}\right]$	*d* [m]	*k* $\left[\frac{W}{m^2 \cdot K}\right]$	λ_P $\left[\frac{W}{m \cdot K}\right]$	*d* [m]	*U* $\left[\frac{W}{m^2 \cdot K}\right]$
B_H	1.30	0.15	8.667	0.040	0.20	0.195
B_C	0.63	0.15	4.200	0.040	0.20	0.191
B_S	0.21	0.15	1.400	0.040	0.20	0.175
B_A	0.20	0.15	1.333	0.040	0.20	0.174

The use of a concrete wall (made for example from thermal insulation concrete B 200) with polystyrene insulation cladding (thickness 0.2 m, specific thermal conductivity 0.04 $W \cdot m^{-1} \cdot K^{-1}$) instead of a brick wall (thickness 0.30 m, specific thermal conductivity 1.01 $W \cdot m^{-1} \cdot K^{-1}$) with the same polystyrene insulation cladding is very advantageous. With a comparable heat transfer parameter (0.169 $W^2 \cdot m^{-1} \cdot K^{-1}$), the total

thickness of this wall is 0.5 m. The difference between the two thicknesses of composite walls is 0.15 m. For the wall with geometric dimensions 4 m x 2.4 m, this saving of internal volume makes 1.44 m^3, for 4 walls this saving is 5.76 m^3. Savings in the living area of the room then make a considerable area of 2.4 m^2 (15%) of its living space.

CONCLUSIONS

The differences between the values of the heat passage parameters of the samples of concretes with thermal insulation cladding are not negligible because they represent a possible variability in the total thickness of the composite wall, in the thicknesses of the load bearing wall and of its thermal insulation layer. Especially with respect to the wall built from bricks, it represents considerable savings of the residential space of the building combined at the same time with an increase in the total energy intensity parameter of the house.

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BIOMETHANE POTENTIAL OF SAFFLOWER HARVEST RESIDUES

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Abstract

Residues from agricultural production are sources of raw material for biomass energy. Biogas technology allows organic waste/residues to be recovered. Safflower harvest residues (SHR) are resulted from safflower production. The purpose of this study is the assessment of the methane volume obtainable from SHR with dairy manure (DM) in the anaerobic fermentation process. Five mixtures of SHR and DM were prepared considering the mixing ratio (miR= SHR/(SHR+DM), dry basis, as 0.06, 0.27, 0.49, 0.74, and 1.0. Batch fermentation test was carried out in bioreactors made of eighteen 2-L flasks located in a temperature controlled water bath with a dimension of 80 x 60 x 20 cm. The mixing of each bioreactor was done by mechanical rotating mixers driven by motor coupled with 10 rpm output gearbox. During the experiment, methane (CH_4), carbon, nitrogen, pH, EC, dry matter, and organic matter were measured. The results were presented in the study.

Key words*: Biogas process, dairy manure, safflower harvest residues, biomethane potential.*

INTRODUCTION

The main determinants of economic growth, social development and quality of life for communities are energy and energy use. Today, energy needs due to emerging technologies and demographic and economic growth are rapidly increasing not only in the world but also in Turkey (Tuncer et al., 2006; Acaroglu, 2007; Akova, 2008; Yearling et al., 2010; Yilmaz, 2012; Aries and Şenel 2013, Aybek et al., 2015). Much of the energy demand in the world is covered by fossil sources (oil, coal and natural gas) (Onurbaş Avcıoğlu et al., 2011; Yılmaz, 2012).

Vast majority of energy needs are met by fossil fuels. Emissions from these fuels have a large share in global warming due to greenhouse effect leading to the shift of research into renewable energy sources (Koç and Şenel, 2013). Biomass has an important place under renewable energy resources. Biomass is defined as non-fossil organic matter of biological origin (Üçgül and Akgül, 2010; Yılmaz, 2012; Basu, 2010). Biomass energy is transformed into energy sources such as biodiesel, bioethanol, biogas by various technological methods (Akova, 2008; Öğüt, 2007). Organic materials with methanogenic bacteria can be converted to biogas in an anaerobic environment (by anaerobic fermentation). Biogas is formed as a product of anaerobic material degradation and contains 60-75% methane (CH_4), 23-38% carbon dioxide (CO_2), 2% hydrogen (H_2) and 2% hydrogen sulphide (H_2S) depending on the organic substance (Edelmann et al., 2005).

Biogas technology allows both the energy obtained as a result of organic origin waste and the waste to be imparted as an organic fertilizer throughout fermentation progresses.

Assessment of organic matter residues is important for environmental pollution and clean energy production. For this purpose, the most common source for use in developing countries is biomass. Approximately 15% of world energy consumption and about 43% of energy consumption in developing countries are provided with biomass (Başçetinçelik et al., 2007).

Turkey is an important agricultural country with high potential in terms of both crop and animal production. With the biogas technology and production, an economic input in terms of energy will be provided to rural development with the sustainable quality of the environment by reducing harmful wastes.

In 2016, there were also 14 223 million head of cattle in Turkey (TurkStat, 2016). In light of these data, Turkey's cattle manure potential is

approximately 611 589 tons per year. SHR exists after harvest of safflower in the field. This study aimed to determine biogas potential of SHR with DM at five different mixing ratios. The result of this study could help biogas designer/decision maker on the utilization of safflower stalk residues with dairy manure.

MATERIALS AND METHODS

This study was conducted at the Compost and Biogas laboratory Süleyman Demirel University (SDU). Research involves SHR and DM. DM was collected from Dairy Farm at Agricultural Application and Research Center at SDU. SHR was obtained from a farmer in Isparta. The anaerobic digestion test was carried out using a Biomethane Potential Test Unit. Batch fermentation test was carried out in bioreactors made of eighteen 2 L flasks located in a temperature controlled water bath with a dimension of 80 x 60 x 20 cm. It consists of a 1500 W electrical heater, circulation pump and water reservoir. The mixing of each bioreactor was done by mechanical rotating mixers driven by 12 V DC motor coupled with 10 rpm output gearbox.

During the study, the mixers were set to run with a cycle of 1 minute on - 29 minutes off. SHR was dried in the solar tunnel drier at Agricultural Machinery and Technology Engineering Department, Faculty of Agriculture at SDU. Dried SHR was milled with an industrial mill. Inoculum was obtained from previous experiment. The inoculum, a mixture of liquid+solid phase, was prepared in a 50 L tank at 37°C.

In the study, the grinded SHR samples were placed in 2 L glass bottles with 3 replicates at different mixing ratios and then placed in a water bath (37^{o}C). The bottles prepared at different mixing ratios were connected to 5 L biogas bags.

The mixing ratio (dry weight basis) was defined as miR = SHR/(SHR+DM). The selected miR values was 0.06, 0.27, 0.49, 0.74, and 1.0. Initial physical and chemical properties of feedstocks are given in Table 1. The amount of SHR, DM, and inoculum used in mixes (dry weight basis) and the resultant miR and C/N ratio are given in Table 2. Prepared samples were analyzed for dry matter content (DMC) (AOAC, 1990) and organic matter (OM) (AOAC, 1990). pH and EC of the fresh samples were extracted by shaking at 180 rpm for 20 min at a solid: water ratio of 1:10 (w/v), and measured using pH and EC meters (Models WTW pH 720 and WTW Multi 340i), respectively.

Total carbon (C) and nitrogen (N) of samples were analyzed using CN analyzer (Vario MACRO CN Elemental analyzer). The biogas volume was determined using a gas meter (Ritter, Bochum, Germany). Methane (CH_4) concentration was measured using a sensor (PIR 7200 Draeger).

After the measurements were made on 3, 5, 7, 11, 17, 25, 35, and 47 days, the experiment was terminated.

Table 1. Initial physical and chemical properties of feedstock's

Parameters	SHR	DM	Inoculum
DMC, %	90.83±0.10^{c}	18.17±0.60	6.99±0.52
OM, %	92.45±0.15	85.07±0.19	73.26±0.11
EC, µS/cm	3.18±0.01	7.43±0.03	11.60±0.21
pH	6.96±0.12	6.80±0.09	7.88±0.13
C, %	51.36±0.53	43.47±0.10	23.13±0.12
N, %	1.27±0.13	1.46±0.03	1.98±0.15

Table 2. Compositions of feedstock's used to formulate mixes

Mix	SHR	DM	Inoculum	miR	C/N ratio
	kg/kg	kg/kg	kg/kg	-	
Mix-1	0.561	0.000	0.439	1.00	24.66
Mix-2	0.433	0.154	0.413	0.74	22.75
Mix-3	0.303	0.310	0.387	0.49	20.83
Mix-4	0.171	0.469	0.360	0.27	18.92
Mix-5	0.006	0.629	0.333	0.06	17.00

RESULTS AND DISCUSSIONS

Initial and final values of DMC, OM, pH, and EC values were given in Table 3. In the starting mixtures; DMC was the highest in Mix-2 (8.97%) and Mix-5 (7.36%) was the lowest, OM was the highest in Mix-2 (87.02%), lowest in Mix-5 (83.97%), the pH value was the highest in Mix-2 (7.89) and the lowest in Mix-1 (6.97), and EC values were the lowest in Mix-4 (10.61 µS/cm). At the end of the experiment, DMC was the highest in Mix-5 (5.79%) and Mix-1 (5.24%) was the lowest, OM were the highest in Mix-2 (77.47%) and the lowest in Mix-1 (67.40%), the pH values were the highest in Mix-4 (7.73%) and the lowest in Mix-1 (6.97%), and EC values were the highest in Mix-4 (13.39 µS/cm) and the lowest in Mix-1 (10.57 µS/cm). The result showed that DMC, OM, and EC values of mixes increased at the end of the experiment. However, there was no clear trend in terms of pH (Table 3).

Table 3. Initial and final DMC, OM, pH and EC values of mixes

Mix	Initial DMC %	Final DMC %	Initial OM %	Final OM %	Initial pH	Final pH	Initial EC µS/cm	Final EC µS/cm
Mix-1	8.84	5.24	85.25	67.40	7.85	6.97	9.14	10.57
Mix-2	8.97	5.74	87.02	77.47	7.89	7.69	9.60	11.09
Mix-3	8.12	5.52	86.30	75.86	7.61	7.51	10.24	12.32
Mix-4	7.58	5.47	85.24	75.87	7.31	7.73	10.61	13.39
Mix-5	7.36	5.79	83.97	75.78	7.25	7.58	10.53	12.49

Methane measurement

CH_4 content (%) as a function of time could be divided into two phases (Figure 1). The first phase (day 0-3) was characterized by a rapid hydrolysis stage where low concentrations of CH_4 were detected since the phase was designed to decompose the principal constituents of the SHR and DM. Then, CH_4 content of biogas sharply increased to > 54% for all mixes.

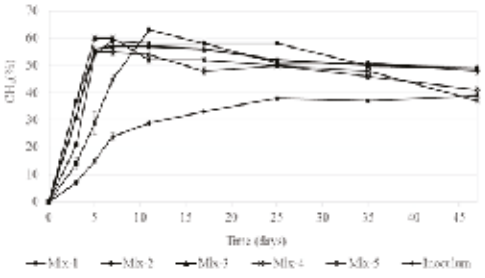

Figure1. Time - dependent methane ratios of mixtures

The level of CH_4 content for all mixes fluctuated between 37% and 60%. It could be said that the level of CH_4 measured for Mix-4 was always higher than the other mixes during the experiment.

Biogas and methane production

The time - dependent daily biogas and CH_4 production of the inoculum and the mixtures are given in Figure 2. The daily biogas and CH_4 production of the mixtures reached maximum values within 3-7 days, starting from day 1. The highest daily biogas and CH_4 production in mixtures were in Mix-5 between 4-6 days and Mix-4 between 4-5 days. The lowest daily biogas and CH_4 production in mixtures were in Mix-1 (Figure 2).

Cumulative biogas and CH_4 production of the mixture and inoculum over time are shown in Figure 3.

Cumulative biogas production was the average of 3 samples measured for each mixture. The gas production in the mixtures started on the first day and reached the maximum biogas and CH_4 production towards 47^{th} day.

The highest cumulative biogas production value was in Mix-2, and the lowest cumulative biogas production value was in Mix-1.

The highest cumulative methane production value was in Mix-2, and the lowest cumulative methane production value was in Mix-1 (Figure 3).

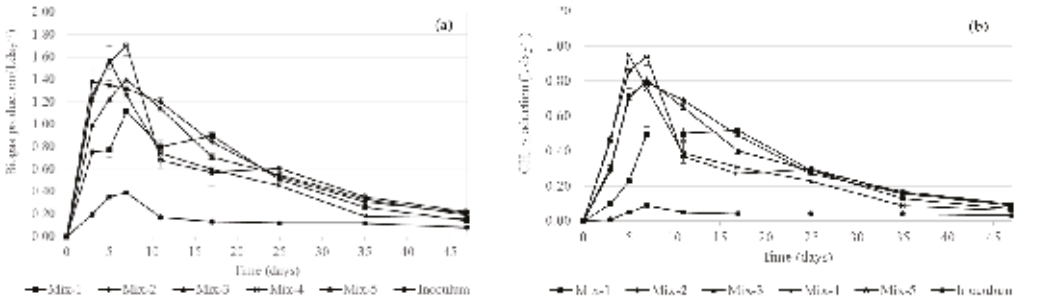

Figure 2. Daily biogas and CH_4 production as a function of time

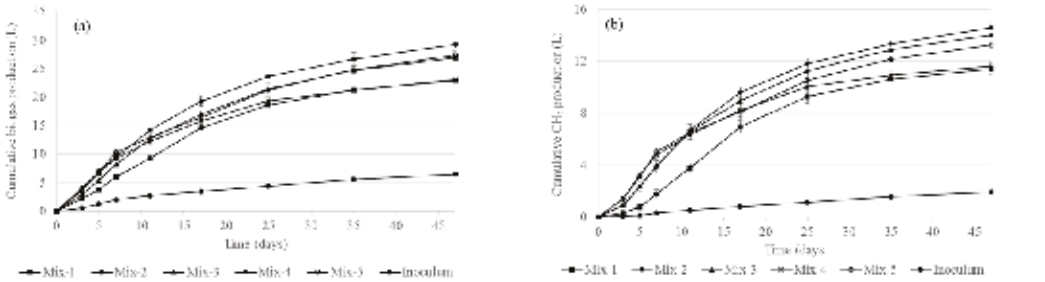

Figure 3. Cumulative biogas and CH_4 production as a function of time

The cumulative specific CH_4 production rates of mixtures after subtracting the contribution of inoculum is given in Figure 4.

The specific CH_4 productions were determined for Mix-1 through 5 as 205.31, 249.39, 218.22, 159.59, and 167.73 $NmLg^{-1}$ OM, respectively.

The reported range of specific CH_4 productions in this study are in agreement with those 167 mL/g OM (Amon et al., 2006), 125-166 mL/gOM (Amon et al., 2006), 317 mL/g OM (Zhang et al., 2013) and 271 mL/g OM (Frauke et al., 2015).

It should be noted that no pre-treatment were applied to initial material (substrates and digested dairy manure) for CH_4 production.

As a result of this study, the specific methane production values of SHR and DM mixtures are between 159.6-249.4 NmL/g OM.

In this study, methane production from DM (Mix-5) was found to be 167.7 NmL/g OM

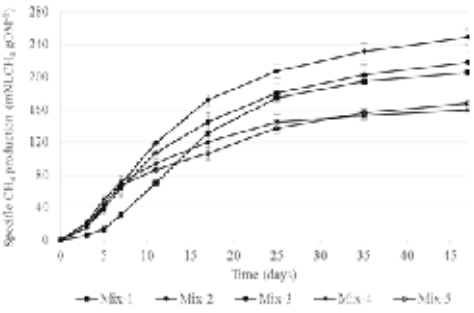

Figure 4. Cumulative specific methane production as function time for all mixes

Specific methane production ($CH_{4,cum}$) as a function of miR

In the study, a Gaussian model was used to determine the best mix of specific methane production ($CH_{4,cum}$) (Figure 5). Gaussian curve was applied to $CH_{4,cum}$ at different miRs. $CH_{4,cum}$ as a function of miR was correlated and the resultant equation with R^2=0.96 (Eq.1) showed that the highest $CH_{4,cum}$ occurred at the miR of 0.73 corresponding to Mix-2. $CH_{4,cum}$ as a function of miR is given in figure 5.

$$CH_{4,cum} = 160.28 + 92.04\, e^{-0.5\left[\frac{miR-0.73}{0.22}\right]^2} \quad (1)$$

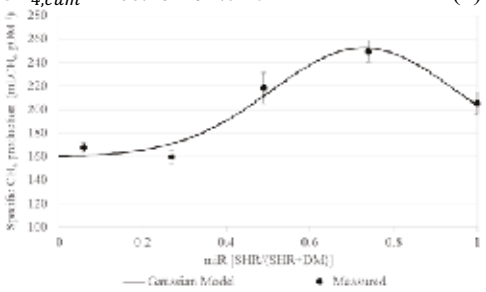

Figure 5. Gaussian model of specific methane production in mixtures

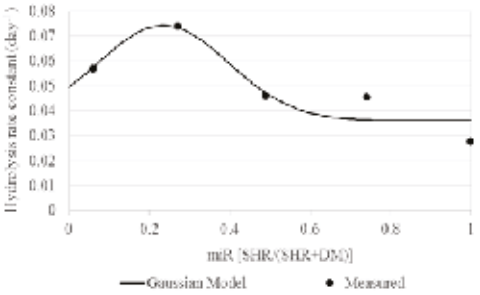

Figure 6. Hydrolysis rate constants of mixtures as a function of miR

Hydrolysis rate constant as a function of miR

The hydrolysis rate constant (K_h) of each mixes was determined using the first-order kinetic model of Eq. (2).

$$CH_{4,cum}(t) = M_{max}[(1 - \exp(-Kh.t)] \quad (2)$$

Where $CH_{4,cum}$ (t) is the specific methane production at digestion time t days (NmL g^{-1}OM), M_{max} is the potential maximum methane production at the end of digestion (NmL g^{-1}OM). Sigmaplot™ program was used to predict K_h and M_{max}.

The predicted K_h value for Mix-1 through 5 was 0.0279, 0.0455, 0.0461, 0.074, and 0.0571 day^{-1}, respectively. Gaussian curve was applied to K_h at different miR. K_h as functions of miR was correlated and the resultant equation with R_2=0.87 (Eq.3) showed that the highest K_h occurred when miR=0.24. K_h as functions of miR is given in Figure 6.

$$K_h = 0.036 + 0.038\, e^{-0.5\left[\frac{miR-0.24}{0.16}\right]^2} \quad (3)$$

The Gaussian model was used to determine the change in hydrolysis rate constant of the mixtures (Figure 6).

The modeling result shows that the mixture with the highest hydrolysis rate constant was in Mix-4 and the lowest hydrolysis rate constant was in Mix-1 (Figure 6).

CONCLUSIONS

The results obtained from this research for the experimental determination of the biogas production potential of dairy manure and safflower harvest residue can be summarized as follows:

1. At the end of the experiment; DMC, OM, decreased, EC increased;
2. Cumulative maximum biogas and methane production was in Mix-2, and minimal biogas and methane production was in Mix-1;
3. Specific maximum methane production was found in Mix-2 (249.4 NmL/g OM);
4. Daily biogas and methane productions of different types of dairy manure and safflower harvest residue prepared at different mixing ratios are different;
5. Methane ratios increased with time and then decreased;
6. In the study, it was found that the best mix ratio of the Gaussian model was Mix-2.

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BIODEGRADABLE WASTE IN THE CURRENT ECONOMIC CONTEXT OF ROMANIA - CHALLENGES AND SOLUTIONS

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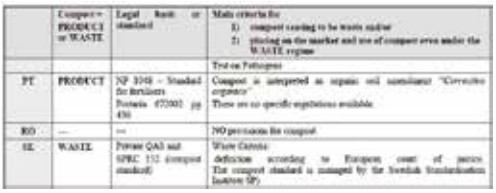
Abstract

Considering that, in the municipal waste composition, about 50% of the total is biodegradable waste and because there are also important quantities of other categories of organic waste such as: green waste, sludge from waste water treatment plants, animal waste, agricultural waste, etc., the problem of biodegradable waste in the current economic context of Romania is complex and vast. Agricultural land is continuously degrading, 95% of municipal waste goes directly to the landfill, a large number of existing composting facilities are not in use, lack of legislation (Romania is one of the only three countries in Europe that do not have composting legislation), and these are just a few examples of the challenges our country is facing today. To meet these challenges, our country needs to take urgent measures to address the issue of biodegradable waste. This article aims to highlight both the problems and the solutions that can solve these problems in correlation with the best available techniques as well as with the tendencies and the legislation at European level All these, adapted to the Romanian specifics.

Key words*: biodegradable waste, end of waste, circular economy.*

ACTUAL CONTEXT

Earth's population is growing exponentially. Primary resources are limited and become more and more difficult to obtain. Degraded land areas are growing at European and world level.
To address the growing demand for food, new approaches are needed to take into account the re-use of residual bio resources (co-products, by-products, organic waste, sewage sludge, etc.). Romania, unfortunately, not only makes no exception, it is even a negative example in terms of waste management in general and waste bio resources in particular.
Considering that, in the municipal waste composition, about 50% of the total is biodegradable waste and because there are also important quantities of other categories of organic waste such as: green waste, sludge from waste water treatment plants, animal waste, agricultural waste etc., the problem of biodegradable waste in the current economic context of Romania is complex and vast. Agricultural land is continuously degrading, 95% of municipal waste goes directly to the landfill, a large number of existing composting facilities are not in use, lack of legislation (Romania is one of the only three countries in Europe that do not have composting legislation), and these are just a few examples of the challenges our country is facing today.



	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) compost ceasing to be waste and/or 2) placing on the market and use of compost even under the WASTE regime
			Test on Pathogens
PT	PRODUCT	NP 3048 – Standard for fertilizers Portaria 672/2009 pp 436	Compost is interpreted as organic soil amendment "Corrective organico" There are no specific regulations available
RO	—	—	NO provisions for compost
SE	WASTE	Private QAS and SPBC 152 (compost standard)	Waste Criteria: definition according to European court of justice The compost standard is managed by the Swedish Standardisation Institute SIS

Figure 1. Waste and product approaches table extract

Addressing the issue of organic waste will help solving a lot of problems starting with decreasing of landfilling, a better organic waste management, closing the chain (circular economy), creating new markets for local products, creating jobs.
In this context, the paper aims to highlight both the problems and the solutions that can solve these problems in correlation with the best available techniques as well as with the tendencies and the legislation at European level.

CHALLENGES

In order to have a 360-degree image of the actual situation in Romania, we have to refer at each main organic waste category separately.

1. Municipal waste and similar waste

In the National Plan for Waste Management, issued on January 2018, data used refers to the 2010 – 2014 period.
Main data and information sources are: National Institutions having roles in waste area, National Institute of Statistics, EUROSTAT, JASPERS – waste related projects (Jaspers, 2012; Jaspers, 2013; Jaspers, 2016), information from County Councils, other actors in the waste area, terrain visits. According to this data, the annual generated quantities of waste are according to the table 1.
In the same time, domestic and similar waste collected by sanitation operator's waste composition is characterized by a high percentage of bio-waste, according to Figure 2. Regarding the composition of parks and garden waste, main fraction is represented by bio waste (in the analysed period, the percentage varies between 83.4% and 99.8% with an average of 93%.

Table 1. Generated municipal waste, 2010-2014

Types of municipal waste	Municipal waste quantities (ton/year)				
	2010	2011	2012	2013	2014
Municipal waste (mixed and separately collected)	3,367,325	2,955,517	2,654,525	2,817,947	2,900,695
Similar waste (mixed and separately collected)	1,176,870	917,794	852,591	874,591	902,144
Waste from parks and gardens	123,514	100,700	95,223	97,204	70,134
Markets waste	81,773	90,024	71,270	61,330	54,170
Street waste	343,550	294,478	313,823	391,168	340,948
Municipal waste (generated and uncollected)	1,250,112	857,650	1,056,687	828,564	687,985
Total municipal waste generated	6,343,144	5,216,162	5,044,121	*5,070,805*	*4,956,075*

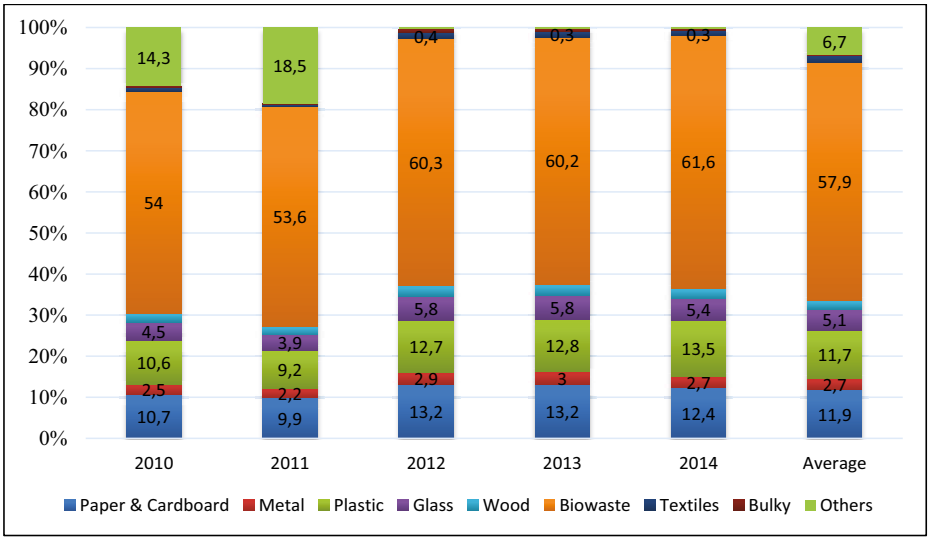


Figure 2. Composition of domestic and similar waste collected by sanitation operators, 2010-2014

Market waste composition is characterized by bio waste as main fraction too with 70%, the rest being recyclables.
Street waste contains less bio waste (in average 60%) and the rest being recyclables.

Regarding waste generation index, it shows lower values in the case of Romania compared with EU-28 according to EUROSTAT as shows Table 2 presented below.

Table 2. Waste generation index in Romania and EU-28

Waste generation index	2010	2011	2012	2013	2014
Romania (kg/year/capita)	313	259	251	254	249
EU-28 (kg/year/capita)	503	496	485	477	474

In accordance with the provisions of HG 349/2005 on the waste landfilling, biodegradable waste is defined as waste that undergoes anaerobic or aerobic decomposition, such as food or garden waste, paper and cardboard.
Thus, biodegradable municipal waste is found in all municipal waste categories, namely:

- Domestic waste and household waste - bio waste, paper and cardboard waste, wood waste and the biodegradable fraction of textile and bulk waste;
- Waste from gardens and parks - bio waste;
- Market waste - bio waste, paper and cardboard waste and wood waste.

Table 3. Biodegradable waste generation index in Romania

	Quantity (Million tonnes/year)				
	2010	2011	2012	2013	2014
Generated municipal waste	6.34	5.21	5.04	5.07	4.95
Generated municipal biodegradable waste	4.30	3.45	3.92	3.93	3.84

Taking into account the data presented above, we can see that over 60% of domestic and similar waste consists of biodegradable waste and, even if the total amount of municipal waste is decreasing, the percentage of biodegradable waste is increasing (from 68% in 2010 to 78% in 2012 and stays at quit the same value in 2013 and 2014).
In the same time, according to data form National Agency for Environment Protection, material recycling rate of the was about 5% from the total treated waste.

Because Romania has assumed that the recycling target by 2020 will be ten times higher (50%) relative to the total quantity (expressed in tonnes) generated in 1995 which was 4.8 million tonnes, we can conclude that, at this moment, Romania is in a difficult situation regarding municipal waste and the main problem for reaching the target is generated by the main fraction of municipal waste – biodegradable waste.
To deviate as much biodegradable waste as possible from landfilling, Romania is currently using three ways to treat it:

- Composting;
- Recovery by co-incineration;
- Mechanical-biological treatment.

As we can see, at present, no anaerobic digestion plant for municipal waste is in operation in Romania.
According to National Plan for Waste Management, composting is, currently, the most widely used method.

2. Sludge from Waste Water Treatment Plants

Due to the updating of the sewage treatment technology and the increase in the degree of connection of the population to the urban sewerage systems, there is a significant increase in the amount of sludge generated between 2010 and 2014, from 82,000 t dry matter in 2010 to 192,000 t dry matter.
According to data published by the National Institute of Statistics, about 6% of the total treated sludge in 2014 was used in agriculture, but the most important part (around 75%) was landfilled or stored on its own platforms.
So, these days, sludge is representing a big problem for our country. The lack of legislation on sludge (Ordinance 344/2004 on the use of sludge in agriculture is outdated) as well as for compost, low tariffs for wastewater treatment, the lack of reaction of operators of waste water treatment plants, the difficult implementation of financing programs in European or governmental funds have led to the accumulation of impressive amounts of sludge in recent years.
Certainly, sludge from waste water treatment plants has some agronomic value due to its loading with nutrients and microelements.

However, it should also be borne in mind that it also contains many other elements harmful to the environment (metals, pathogens, volatile organic compounds, weed seeds etc.) which make it unusable on land of any kind without being previously treated using the best available technologies.

3. Agricultural waste

Another important category of biodegradable waste is represented by agricultural waste. Every year, large amounts of waste are generated due to agricultural activity.
Whether it's vegetal waste, whether we're talking about manure, this waste is a real challenge for farmers.
Agriculture is a growing branch of the Romanian economy and, therefore, the amount of specific waste is increasing. Farmers around Romania are still using old methods for disposal of agriculture waste.
For Manure, legislation in force is transpose European Union legislation.
Regarding the environmental impact of manure landfills there are two European directives to be taken into account: the Council Directive 91/766 / EEC of 12 December 1991 on the protection of waters against pollution by nitrates from agricultural sources and the Council Directive 96/61 / EEC of 24 September 1996 on Integrated Pollution Prevention and Control.
Nowadays, manure is still applied directly to the land, situation that comes together with all the associated problems: VOC emissions, bad smell, pathogen contamination risk, weed seeds spreading etc.

OTHER CHALLENGES

Together with the technical, operational and financial challenges, Romania is facing some logistic problems such as: no data regarding financing sources of some projects mentioned in the National Waste Management Plan in force since January 2018 (we are talking about plans to build several AD plants), many facilities for waste management have no operators or have been poorly dimensioned etc.

A good example in this respect is the composting facilities designed to treat all kind of organic waste.
The Romanian Compost Association has conducted at the end of 2017 a study on composting capacities. The results are presented, in the figures 3 and 4.
Figure 3 shows in yellow existing facilities in operation, in red existing but not operational facilities (mainly due to lack of operators) and in blue the under-construction facilities.
As we can see in Figure 4, the situation of composting capacities in Romania is pretty bad. From a total capacity of about 1.4 Mt/y, only 8.7% (0.12 Mt/y) are in operation and a huge per cent are ready but currently are not in operation.

Figure 3. Composting facilities in Romania

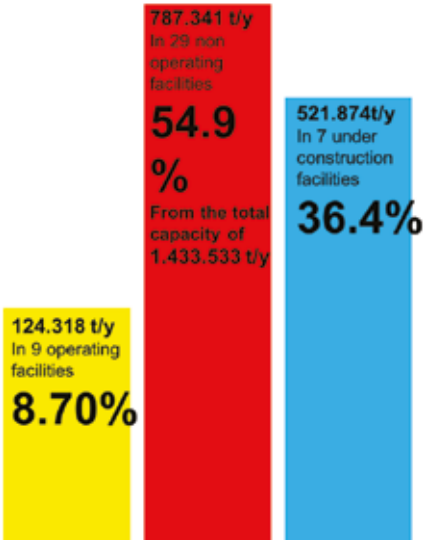


Figure 4. Composting capacities in Romania

SOLUTIONS

Taking into consideration all the aspects presented below, we can say that there is no solution that fits all the types of biodegradable waste and all the associated problems.
Every type of organic waste has its own problems and a mix of solutions must be taken into consideration in order to solve these problems.
For example, for sludge, a good solution is to use two different treatment solutions in order to transform this matter in something useful: first of all, an AD process to convert biosolids in biogas and digestate. Biogas will be used as fuel for CHP's. Digestate will be processed by composting for further reduction of pathogens, and to transform it in compost, a more stable form, with a lot of potential benefits for soils at minimum risks.
In a similar way the green waste can be easily composted and used as organic fertiliser on various soil types. When we are talking about biodegradable fraction of municipal solid waste, the situation is more complex.
The treatment of such kind of material involves some more operations and is more expensive compared with green waste for example: the waste must undergo a mechanical treatment to separate as much as possible biodegradable matter from the other contaminants followed by a biological treatment to stabilize, to sanitize and to dry the material for mass reduction.
In this case, the final product can be used as daily coverage material for landfills.
Sometime, with a good separation and an appropriate control of biological process, the resulting material can be classified as compost like output (CLO).
Another option is incineration or other thermal treatments such as pyrolysis and gasification. In any case, for every kind of option we chose, we have to think about environmental impact and the costs of treatment. The same situation is for biosolids.
A dedicated study conducted by an German Institute – BIFA Environmental in 2015, shows, in an interesting chart (Figure 5), the relation between environmental and financial impact of different treatment technologies for biodegradable waste treatment, currently available on the market (ecology-index<0 means environmental benefit; ecology-index > 0 means environmental burden; costs index: Scaling of the process-specific costs at the maximum value).

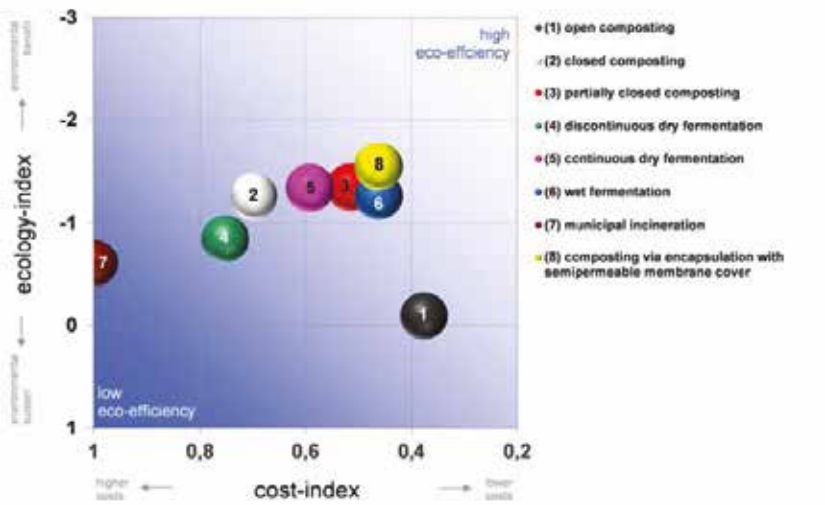


Figure 5. Eco-efficiency portfolio of different biomaterial treatment processes

According to this study, from far, the most expensive and with the highest environmental impact treatment solution are incineration and the most effective; with the lowest environmental impact are modern enclosed composting technologies with semipermeable

membranes. Beyond all this, we have to mention here the human factor. Even with the best technologies for waste collection and processing available on the market we cannot reach the targets without everybody's involvement.

For a successful biodegradable waste management, we have to run many programs to disseminate information for all the citizens. We have to constantly increase the landfilling tax, we have to implement solutions for separate collection and we have to implement adequate programs like "pay as you throw".

CONCLUSIONS

As long as biodegradable waste represents the main component of municipal waste, as long as biosolids and agricultural waste are increasing constantly, we can say a correct approach of related challenges will conduct to a successful story for Romania in terms of waste.

With a deep knowledge of the best available technologies and practices currently used by other countries and following the End of Waste criteria for biodegradable waste as they are stated by the European Commission, we can divert a big amount of biodegradable waste from landfilling to recycling in the spirit of circular economy, we can generate new business lines, new jobs, a better environment and a better life for everybody is living in Romania.

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THERMAL PROPERTIES OF PELLETS MADE OF PEACH PIT AND LIGNITE COAL DUST

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Abstract

Densification of biomass materials can be achieved through pelletization technology, which can be used to produce useful, high value added, and salable pellets. In this study, pellets were made using peach pit (PP) with Lignite Coal Dust - coal powder (CP) at specific ratios. Pelletization was performed by a pelletizing machine having flat die and roller with a capacity of 50-60 kg/h. The pellet die had an inlet hole diameter of 11 mm, an outlet hole diameter of 7 mm and a die height of 25 mm. The pellets were the mixture of PP and CP: 100% CP, 90%CP+10%PP, 75%CP+25%PP, 50%CP+50%PP, 25%CP+75%PP, 10%CP+90%PP, and 100%PP as dry weight basis. Proximate analyses and higher heating values of the pellets were determined. Thermogravimetric and differential thermogravimetric analysis were performed. The results were presented in the study.

Key words*: peach pit, lignite coal powder, pelletization, thermogravimetric analysis.*

INTRODUCTION

The energy requirement of the world is increasing due to the developing technology and the increasing human population. However, energy resources, especially oil, is gradually declining. In addition to the problem of diminishing energy resources, the greenhouse gases generated due to the burning of hydrocarbon resources make the world climate warmer. Alternatively, clean and renewable energy sources have become important due to factors such as decreasing energy sources, increasing energy demand and negative effects of greenhouse gases. Agricultural and other biomass wastes are an important resource for meeting energy needs, especially in developing countries, and in the majority of these countries, there is a large amount of waste existing every year. Since agricultural wastes are of low density and high moisture content, direct burning in houses and industrial areas is not very effective, direct use of these wastes causes transport, storage and processing problems and most importantly causes environmental pollution. One of the ways in which agricultural and other biomass waste can be used effectively is by their pelletization. Biomass fuel quality can be improved by pelletization process for example, increase in bulk density, uniformed shape and size (Li et al., 2012; Gil et al., 2010; Obernberger and Thek, 2004). Therefore, pellets can be utilized for many combustion applications such as grate furnace and gasification in fluidized bed furnace for residential and industrial operations. Although many studies concerned mechanical durability of biomass pellets while combustion behavior of the pellets has been seldom reported (Gil et al., 2010; Obernberger and Thek, 2004). This study aimed to determine some thermal properties of pellets made of peach pit (PP) and lignite coal dust-cool powder (CP). The results of this study could help the designer/decision makers on not only development of biomass utilization processes but also usage of these fuels with together for power generation.

MATERIALS AND METHODS

This study involved CP and PP. The PP was received from a company in Isparta province. CP was purchased from a coal retailer in Isparta. In the study, the seven different pellets were prepared using mixing ratios based on dry weight basis of the materials used for pellet production.

The pellets were named based on the proportions of raw materials added to the blend as (%) CP- (%) PP. For example, „10CP-90PP" means „(10%) CP-(90%) PP" as dry weight basis. 100PP and 100CP are the pellets where only raw material themselves were used for pellet production. Therefore, the properties of the pellets can be considered as those of raw materials.

The raw materials were dried at a constant temperature of 35˚C for 72 h. Pelletization was performed by a pelletizing machine having flat die and roller with a capacity of 50-60 kg/h. The pellet die has an inlet hole diameter of 11 mm, an outlet hole diameter of 7 mm and a die height of 25 mm. Then, the pellets were dried at the room condition.

The moisture content (MC) of the pellets was determined according to ASTM D 3173. The ash content (AC) of the pellets was determined according to the ISO 1171 standard. The volatile matter (VM) of the pellets was determined according to the ISO 562 standard. The fixed carbon (FC) of the pellets was obtained from the equation (ASTM D3172). Higher heating value (HHV) was calculated according to the equation HHV (MJ/kg) = 0.312 FC + 0.1534 VM, FC and VM were the percent of fixed carbon and volatile matter of the fuel, respectively (Baley, 1984).

Thermogravimetric analysis (TG) as well as derivative thermogravimetry (DTG) applied to investigate the combustion characteristics was performed by a thermogravimetric analyzer (Perkin Elmer Diamond TG/DTA model). All combustion experiments were conducted at atmospheric pressure, using temperature range from 25 to 900°C with a heating rate of 10°C/min and an air flux of 20 ml/min with N_2 gas.

RESULTS AND DISCUSSIONS

The proximate analyses of pellets are presented in Table 1. 100PP or PP had the lowest ash content (1.76%), while the 100CP or CP had the highest ash content. The addition of PP to the blend relatively decreased ash content of pellets. For example, addition of 10% PP to the blend (90CP-10PP) reduced the ash content of pellets from 18.95% to 18.58%. Reduced ash content indicates the improvement of fuel quality. Furthermore, increased fixed carbon content and elevated HHV indicate enhanced fuel quality (Liu et al., 2014). 100CP pellets had the highest fixed carbon content and HHV whereas 100PP had the opposite. Addition of PP to the blend reduced fixed carbon and HHV of the pellets. The fixed carbon ratios in all combustible carbon were 41.13% and 10.02% for 100CP and 100PP, respectively. For example, the addition of 10 and 25% PP to the blend (90CP-10PP and 75CP-25PP) reduced fixed carbon from 41.13% to 34.4% and 32.06%, respectively. As a result of the decreased fixed carbon ratios, the HHVs also decreased from 18.21 MJ/kg to 17.16 and 17.11 MJ/kg, respectively. The more PP in the blend, the less fixed carbon content and HHV. Therefore, the addition of PP should be optimized based on ash content, fixed carbon and HHV of the pellets.

Table 1. Proximate analysis and higher heating values of the pellets

Pellets	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)	HHV (MJ/kg)
100PP	8.72±0.51	1.76±0.35	79.49±0.25	10.02±0.6	15.32±0.15
10CP-90PP	8.24±0.29	3.02±0.49	73.83±0.24	14.91±0.72	15.98±0.19
25CP-75PP	7.92±0.66	7.31±0.66	64.01±1.27	20.77±1.93	16.3±0.41
50CP-50PP	6.80±0.75	11.34±0.32	57.37±0.25	24.5±0.06	16.44±0.06
75CP-25PP	5.71±0.15	15.9±0.31	46.32±0.11	32.06±0.20	17.11±0.08
90CP-10PP	5.10±0.43	18.58±0.81	41.91±0.92	34.4±0.13	17.16±0.1
100CP	4.88±0.21	18.95±0.23	35.02±0.76	41.13±0.53	18.21±0.05

In order to evaluate the effect of the amount and the type of raw material (CP and PP) on the combustion characteristics, the pellets were subjected to thermogravimetric analysis. The TG and DTG profiles of the pellets as a function of temperature for seven different pellets are shown in Figure 1a, b, c, d, e, f, and g with the temperature range of 20-900°C. TG curves from all pellets had four typical combustion stages, representing the dewatering

phase, the combustion of volatile matter, the combustion of fixed carbon and burnout (Jiang et al., 2014). While all the TG profiles for all the pellets are given in Figure 2a, all the DTG profiles are given in Figure 2b for comparison purpose. The characteristic combustion parameters were defined as T_{i1} and T_{f1}: initial and final combustion temperature (the primary devolatilization process (°C) (Vamvuka et al., 2003), T_{max1}: temperature at maximum weight loss rate (the primary devolatilization process) (°C), T_{i2} and T_{f2}: initial and final combustion temperature (°C), T_{max2}: temperature at maximum weight loss rate (°C) and r: maximum weight loss rate (%/min) corresponding the primary devolatilization process. The summary of characteristic combustion parameters for seven different pellets are given in Table 2.

It can be observed that the thermal decomposition of pellets starts at approximately T_{i1}, followed by a major loss of weight, where the main devolatilization occurs, and the thermal decomposition is essentially completed by T_{f1} (Figure 1 a, b, c and f) (Vamvuka et al., 2003). However, the combustion of 100CP, 90CP-10PP, and 75CP-25PP pellets occurred in two separated temperature ranges (163.45°C-379.99°C and 379.99°C-578.64°C), (161.06°C-412.88°C and 412.88°C-555.19°C), and 158.06°C-412.88°C and 412.88°C-552.90°C), respectively, caused by the big difference of the reactivities among different constituents (Figure 1d, e and g).

It can be concluded that increasing the ratio of PP in the blend led to decrease in T_{i1} and T_{max1} parameters. Furthermore, 50CP-50PP, 25CP-75PP, 10CP-90PP and 100PP had lower T_{i1} and T_{max1} than those of the rest of pellets (Table 2). The results are consistent with those reported by (Vamvuka et al. 2003).

The maximum weight loss rates (r) drastically increased with increasing PP in the blend. For example, addition of 10 % PP to the blend (from 100PP to 90CP-10PP) r increased from 0.7 to 1.34%/min (91.43%). There was no difference detected in terms of r between 90CP-10PP and 25CP-75PP. Adding more PP to the blend caused the dramatic increase in r. For example, 25CP-75PP and 10CP-90PP had the r values of 3.21 and 4.52, respectively. This indicates that there should be limit for the addition of biomass to coal blend. Likewise, Vamvuka et al. (2003) stated that 10% and 20 % biomass addition to coal/biomass blend are typical of co firing applications used in the European industry. Furthermore, Liu et al. (2014) and Obernberger and Thek (2004) stated that the increased final temperatures and the decreased maximum weight loss rates indicated that the pellets are combusted in a more moderate way. The continuous and elevated combustion temperature ranges coupled with significantly increased final temperatures suggests that the higher thermal efficiency can be achieved for combustion. Vamvuka et al. (2003) stated that the DTG peak height is directly proportional to the reactivity, while the temperature corresponding to peak height inversely proportional to the reactivity. Figure 2b shows DTG of all pellets indicating that pellets having high amount of PP in the blend for example, 100PP, 10CP-90PP, 25CP-75PP, and 50CP-50PP are more reactive than those having high amount of CP in the blend. This combustion behavior could be due to the fact that PP had higher volatile content than CP (Vamvuka et al. 2003; Liu et al., 2014; Jiang et al., 2014).

CP itself yielded 62.82% of residues after combustion (Table 2). The similar result was reported by Vamvuka et al. (2003). Addition of PP to the CP/PP blend reduced the percentage of residues. For example addition of 10% of PP to the blend reduced the residue from 62.82% to 53.70%.

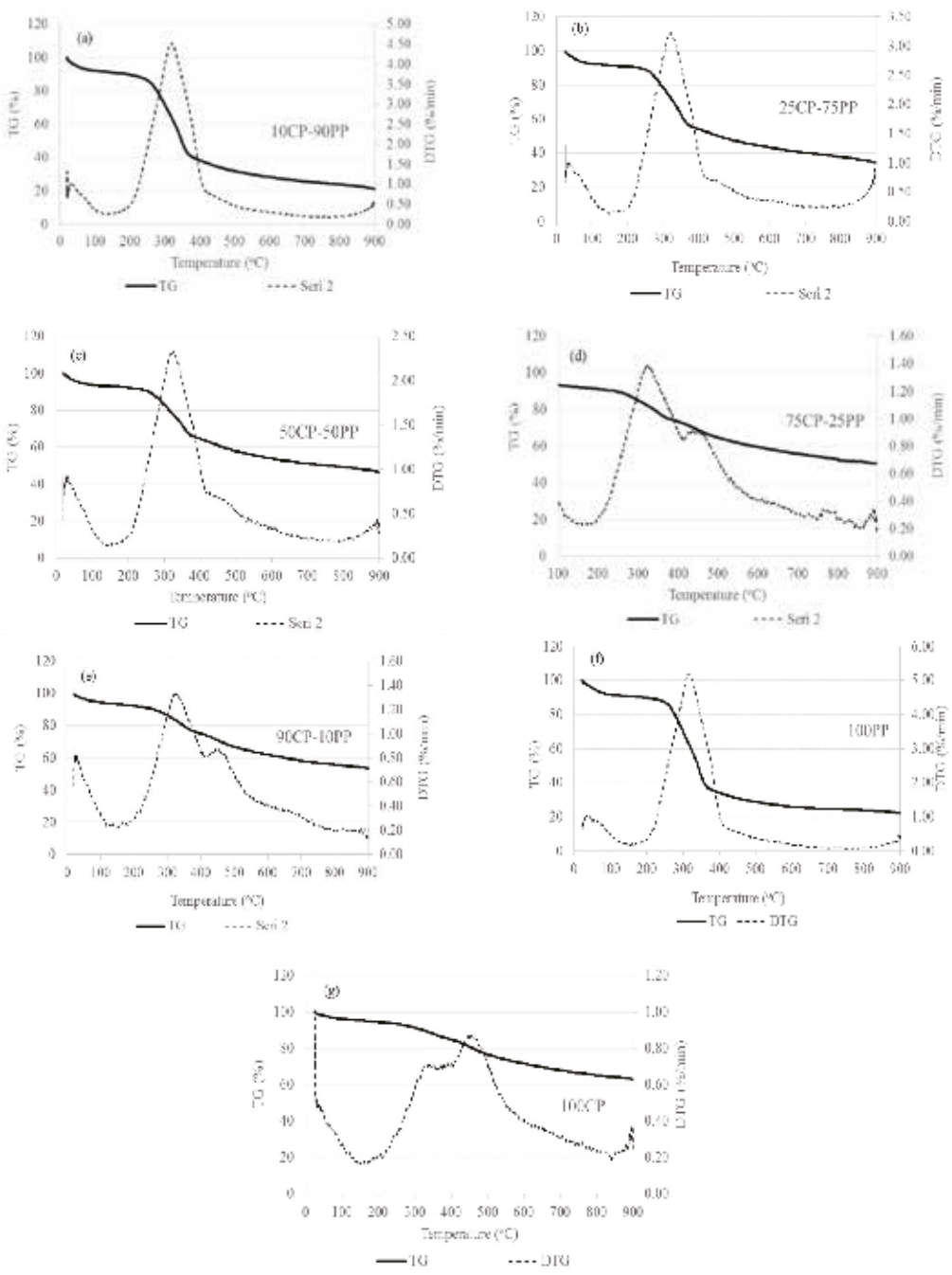

Figure 1. TG and DTG profiles for pellets

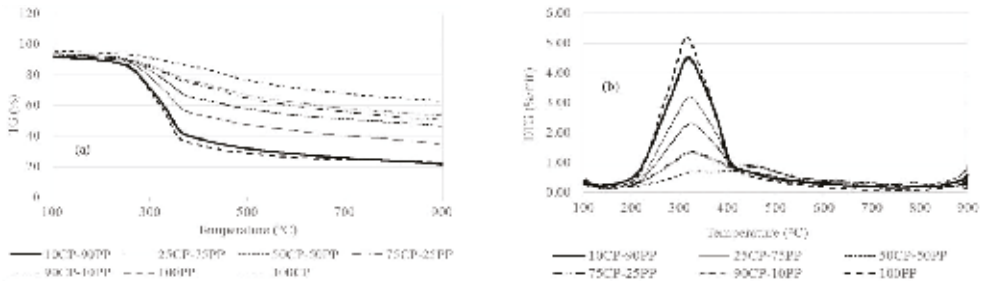

Figure 2. TG (a) and DTG (b) profiles as a function temperature for all pellets

Table 2. The characteristic combustion parameters for the pellets

Pellets	T_{i1} (°C)	T_{max1} (°C)	T_{f1} (°C)	T_{i2} (°C)	T_{max2} (°C)	T_{f2} (°C)	r (%/min)	Residue (%)
100CP	163.45	341.62	379.99	379.99	458.36	578.64	0.70	62.82
90CP-10PP	161.06	327.00	412.88	412.88	451.97	555.19	1.34	53.70
75CP-25PP	158.06	327.00	412.88	412.88	451.97	552.90	1.34	50.45
50CP-50PP	154.59	324.46	484.86	-	-	-	2.33	46.44
25CP-75PP	153.35	323.08	450.47	-	-	-	3.21	34.12
10CP-90PP	148.65	319.81	423.75	-	-	-	4.52	21.14
100PP	154.85	313.76	439.57	-	-	-	5.19	22.22

CONCLUSION

Seven different pellets were prepared using peach pit and lignite coal dust using pelletization machine.

Proximate analysis and higher heating values were performed.

Thermogravimetric analysis and derivative thermogravimetry were applied using thermogravimetric analyzer.

The results on proximate analysis and higher heating values of pellets showed that the more peach pit in the blend, the less fixed carbon content and HHV are.

Therefore, the addition of peach pit to pellet blend should be optimized based on ash content, fixed carbon and HHV of the pellets.

It was concluded that increasing the ratio of peach pit in the blend led to decrease in T_{i1} and T_{max1} parameters.

The maximum weight loss rates (r) of pellets drastically increased with increasing PP in blend. Addition of peach pit to the blend reduced the percentage of residues after combustion.

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THE CURRENT STATUS OF INTERMODAL NODES AND THEIR CAPACITY IN ORDER TO DEVELOP THE TEN-T NETWORK ON THE ROMANIAN SIDE OF THE ROMANIAN-BULGARIAN CROSS-BORDER REGION

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Abstract

The paper aims to present the ways to create a common mechanism to improve the transport systems between Romania and Bulgaria. The aim of is to have a well-connected region between the two countries. The paper will present the key areas, highlighted by simply analysing the flux of the transport, for construction and modernization the routes between Romania and Bulgaria

Key words*: transnational, Romania, Bulgaria, European funds, transport.*

INTRODUCTION

More than a third of EU citizens live and work in border regions of Europe. Borders have a direct and indirect impact on their lives.
European territorial cooperation has an important role in removing obstacles and stimulating cross-border cooperation.
Border Cooperation Programme between Romania and Bulgaria for the period 2014-2020 includes seven counties in eight districts in Bulgaria and Romania which are composed largely of municipalities (The Interreg V-A Romania-Bulgaria Programme, Application form, 2016).

Figure.1. Area of the Border Cooperation Programme between Romania and Bulgaria

The structure of the cross-border area Romania-Bulgaria is characterized by 7 counties with strategic character both in the cross-border area and in comparison with the Pan-European corridors.

MATERIALS AND METHODS

The eligible area of the programme is located in the north of Bulgaria and in the south of Romania along the border which extends between Serbia and the Black Sea. It consists of seven Romanian counties and eight Bulgarian districts, localised exactly near the national border.
There are three types of infrastructure to cross the border: waterway, road and air.
A major barrier against the cross-border cooperation is the lack of border crossing points (road crossing points). Along the 470 km of Danube River there are two bridges, both by road and by rail and several border crossing points by ferry:

- Vidin - Calafat (road bridge and rail bridge);
- Lom - Rast (ferryboat);
- Oriahovo - Bechet (ferryboat);
- Nicopole/Somovit - Turnu Magurele (ferryboat);

- Svishtov - Zimnicea (ferryboat);
- Ruse - Giurgiu (road and rail bridge);
- Tutrakan - Oltenita (ferryboat);
- Silistra - Calarasi (ferryboat).

Land border crossing points are near the Black Sea coast:

- Kardam - Negru Voda;
- Durankulak - Vama Veche, as well as in the south of the Danube, between Silistra and Ostrov.

In the border area two international civil airports are localized:

- Constanta – Mihail Kogalniceanu International Airport, managed and financed from the Romanian budget through the Ministry of Transportation;
- Craiova, International airport, of which management was assigned to Dolj County Council. Currently, there are regulated flights on this airport to many destinations in Europe.

The number related to the movement of passengers and the frequency at the border crossing points show modest levels, as well as less than 61% of the total of passengers crossing the border are or Romanian and Bulgarian origin. (Romanian Ministry of Transport, Statistical data, 2014-2018).

The exceptions are found at Ruse-Giurgiu Bridge and Calafat–Vidin Bridge over the Danube, which are the most used border crossing points, with Romanian, Bulgarian and international traffic.

Despite naming it major artery of European transport, the Danube River has a reduced importance in the economy of transports in the region than would be expected, being used only 10-15% in terms of its transport capacity.

The Rhine/Meuse-Main-Danube interior fluvial transport axis (Priority Axis TEN-T) is a major route of transport of goods which connects Rotterdam Port from the North Sea with the Black Sea (especially Constanta and the Bulgarian ports), as well as the fluvial ports located on the two great waterways.

The total length of the roads in the cooperation area is of 16.511 km including county and communal roads. (Directorate for Driving and Vehicle Registration, Statistics Data, 2014-2018). The total density of public roads is of 22.95 km/100 km^2, which is so small, compared to the average of EU25 of 110 km/100 km^2. The density of roads along the Danube is much inferior to the national levels.

Many roads have an insufficient capacity, which lead to the congestion and, consequently, to travel times, costs for the functioning of the vehicles, accidents and increased prejudices of the environment.

The density of operational railway lines is of about 46.1 km^2 to 1000 km^2 in Romania and 38.9 km^2 to 1000 km^2 in Bulgaria, being under the average of the EU countries (65 km^2/1000 km^2).

RESULTS AND DISCUSSIONS

„Central Network Corridors" were introduced to facilitate the coordinated implementation of the central network. These reunite public and private resources and focus the EU support from CEF especially to:

- removing bottlenecks;
- build missing cross-border connections;
- promote modal integration and interoperability.

They also aim at:

- integrating (as on going modal measure, these corridors shall be integrated into the multi-modal TEN-T) rail freight corridors;
- promoting clean fuel and other innovative transport solutions;
- advancing telematics applications for efficient infrastructure use;
- integrating urban areas into the TEN-T;
- enhancing safety.

Nine core network corridors are identified in the annex to the CEF Regulation, which includes a list of projects pre-identified for possible EU funding during the period 2014 - 2020, based on their added value for TEN-T development and their maturity status.

In terms of the networks Central TEN-T and Extended TEN-T, this sub-criterion reflects that the transport policies both from Romania and EU have the role to improve the quality of the most important routes on the Romanian territory.

The main roads have been maintained and rebuilt lately (several National Road Rehabilitation Programs funded by various Banks) and offer adequate access to the main cities in the area. National rehabilitation

programs had a clear impact on the improvement of the road network in the Program area. (Centre for Road Engineering and Computer Science - The National Road Traffic Management Company).
An example is the extension to four lanes of sections of the national road from Bucharest to Giurgiu. Local road infrastructure has been significantly improved between 1999 and 2004. The approach has been focused on the rehabilitation of roads that increased fluency to border crossings, in a coordinated and complementary way across the two sides of the border.
While the vast majority of large settlements are easily accessible from the main roads, many of the small rural settlements are characterized by low accessibility. Also, private road passenger and freight transport services are available only in the main urban areas and not in areas with a pronounced rural character.
Existing roads and public transport services for both passengers and freight are insufficient to generate that "network" of connections necessary for a fully functional cross-border economic activity.

CONCLUSIONS

Despite of the investments made in the last years, bottlenecks – especially for roads and ferryboat – continue to affect the peripheral areas of the cross-border area in terms of access. Infrastructure of cross-border transport and the modalities of communication which need urgent improvements still represent a barrier in the development of economic and social networks and cross-border exchanges.
Both Bulgaria and Romania could benefit from the East-West waterway and in this sense both countries should develop common work orientations on the common part of the Danube and to prepare an adequate structure at national level in this sense.
The rehabilitation projects must be agreed and coordinated by both countries and implemented at the same time.
Once this axis is completed, the travel times between the localities in the cross-border region and the centre, respectively south-eastern Europe, will be much smaller, contributing to the development of tourism and trade. (University of Craiova, The Ecological Initiative and Sustainable Development Group, Preliminary study on the current stage of intermodal nodes and their capacity to develop the TEN-T network in the Romanian side of the cross-border region Romania-Bulgaria, Project INTERREG V-A Romania-Bulgaria Programme „Investigation of opportunities for reducing the TEN-T network use within the cross-border region Romania-Bulgaria through optimization of the freight and passenger transport and the development of a joint mechanism for support of the intermodal connections", 2016 – 2018).
This strategy should articulate around a thematic approach and more targeted surveillance of each country. The basis of this strategy is the strength of existing coordination tools already in place, namely:

- thematic approach, the main instrument being the Europe 2020 program and its flagship initiatives, which require action both at EU level and at Member State level. The thematic approach reflects the EU dimension, clearly shows the interdependence of the economies of the Member States and allows a greater degree of selectivity in the choice of concrete initiatives supporting the strategy and contributes to the achievement of the main EU and national objectives;
- country reports would help meet the objectives of the Europe 2020 strategy by helping Member States to define and implement crisis exit strategies, restore macroeconomic stability, identify bottlenecks at national level, return to economic growth, sustainability and regain the sustainability of public finances.

These reports will not only include fiscal policy but also key macroeconomic issues related to growth and competitiveness (macroeconomic imbalances) and will need to ensure an integrated approach to policy design and implementation, which is essential to supporting the choices they will need To make them Member States, given the constraints to which they are subject in terms of public finances. Particular attention will be paid to the

functioning of the euro area and the interdependence of the Member States.

As members of the European Union for Romania and Bulgaria, solving the problems of subcontracting tends to become a very important one in the context of the current economic crisis and the requirements set out in the Europe 2020 strategy. Thus, more than ever, policies adopted at tertiary level must Allow network optimization across the border region. For policies to be effective, a complex analysis of both key economic development indicators and analyses based on link points with other relevant indicators is needed in areas such as demography, budget execution or inclusion / Social exclusion.

Although Romania enjoys openness to all types of transport: road, river, sea and air, the lack of a transport policy development strategy in recent decades has seen more decline than development.

That is why our country to align itself with the TEN-T initiative must prioritize the development of railway, road, naval, air and intermodal infrastructure.

The Danube, the longest river in the European Union, has a huge potential for economic, cultural and ecological development. Crossing ten countries: Germany, Austria, Slovakia, Hungary, Serbia, Romania, Croatia, Bulgaria, Moldova and Ukraine, it provides a direct link between the North Sea and the Black Sea through the Rhine-Danube Corridor. At the same time, the area is also a recognized territory for its biodiversity. The development of the Danube region will help to improve interregional, cross-border and transnational cooperation and will create a genuine dialogue platform between states to facilitate the development of projects with national, regional or local impact.

By encouraging sustainable tourism and structuring an integrated vision on the river transport system, the Danube macro-region generates immediate opportunities for riparian local communities.

Local communities should be involved in the rehabilitation of ports, in order to update the tourist potential by increasing the tourist capacity that is insufficient at present (infrastructure, accommodation, services, etc.) and modernization of the transport infrastructure.

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DIFFERENCES IN VEGETATION AND SOIL PROPERTIES OF THE HIGHLAND RANGELANDS GRAZED WITH SINGLE CATTLE HERD AND CATTLE+SHEEP HERDS

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Abstract

The effect of grazers on vegetation and soil properties changes depending on their foraging behaviour and hoof pressure. In general, cattle prefer grasses while sheep prefer considerably forbs and goat skilfully browse during feeding. These differences in feeding preferences herbivore effects species composition and consequently alter vegetation structure on the area. The aim of this study was to determine the effects of single cattle herd and cattle+sheep herds grazing on vegetation composition and soil properties in highlands rangelands. For this aim, four rangeland sites in two locations were selected two site in each location grazed with single cattle herds and the other sites have been grazed with cattle + sheep mixing herds for least 20 years. To compare the effect of grazer differences on vegetation and soil properties, redundancy analysis (RDA) was chosen as the most appropriate constrained ordination technique. Species data were transformed to provide have normality of data. Statistical tests of the significance of the relationship soil properties used Monte Carlo permutation test within CANOCO. Species distribution in the vegetation and some soil properties such clay, silt, sand, organic matter, pH, P, CaCO3, showed a significant correlation related to herd type. These results indicated that animal types have an important role on distribution of plant species and soil properties in the highland short grass steppe rangelands. It can be suggested that cattle and sheep are grazed together to enhance biological diversity and sustainable use of highland short grass steppe rangelands.

Key words*: cattle, mixed grazing, rangeland, soil properties.*

INTRODUCTION

Rangelands have been an important component of farming systems in the Eastern Anatolia region of Turkey for centuries. Both big and small ruminants obtains significant part of their feeds from rangelands, hence, rangeland depended animal husbandry has crucial role in the Eastern Anatolia agricultural production (Koc et al., 2014). Grazing by livestock is a widely used management tool in rangeland, and is known to preserve and enhance plant diversity particularly in wetlands (Gordon et al., 1990), but has a great impact on plant species in low productive rangelands because of foraging selectivity and food quality requirements depend on herbivore size (Bakker and Olff, 2003). Plants species can decrease or increase abundance on the rangelands depends on grazing behaviour of animals especially selective grazing. Because cattle tend to graze grasses, sheep prefer forbs especially legume forb whereas goat willing to consume shrubs (Lemus, 2012; Rose et al., 2012). As a result of differences in grazing behaviour of animal types, dispersal and recruitment of plant species are affected. Consequently, vegetation structure and composition alters depending on changing competition condition (Tilman, 1982). Furthermore, the effect of animal type on seed dispersal may depend on animal size. Big animal has a strong effect on seed dispersal because of consume large amounts of seeds and move over long distances (Haskell et al., 2002). Grazing animals impact vegetation and soil properties direct or indirect. Direct effects of grazing are trampling, treading and excretal, while indirect effects are mediated by changes vegetation (Greenwood and McKenzie, 2001). Disintegration forces of soil are due to animal treading and trampling, and their impact depends on animal type, soil bearing capacity, vegetation, and grazing system. The mechanical impact of animal hooves on soil surface can be a severe disturbance on topsoil structure by treading and trampling (Greenwood and McKenzie, 2001). This mechanical impact changes the form and

stability of soil aggregates, bulk density, pore size distribution, and other soil properties. The pressure exerted by grazing animals on soil is a function of the animal's size for example the pressures exerted by a standing sheep and cattle are average 66 kPa and 138 kPa, respectively (Li et al., 2008; Taboada et al., 2011). While trampling causes compaction in wet soils, it causes structural degradation in aggregate and finally crushing occurs in this condition.

The aim of this study was to determine the effects of single cattle or cattle+sheep mixed grazing on species composition and soil properties in highlands rangelands. For this aim, four rangeland sites in two locations were selected two sites; in each location grazed with single cattle herds and the other sites have been grazed with cattle and sheep mixed herds for least 20 years.

MATERIALS AND METHODS

The study was conducted in the year of 2010 at the Muratgeldi, Kirmizitas, Kosk and Umudum villages in Erzurum, the eastern Anatolia Region of Turkey. Four range sites were selected while two of them have been grazed by single cattle herd (Muratgeldi and Kirmizitas) and the others have been grazed by cattle and sheep mixed herds (Kosk and Umudum) for more two decades.

The study area is characterized by harsh climatic condition with long and extremely cold winter and cool, short and dry summer. The long-term average annual temperature is 5.7^{o} C, average total annual precipitation is 450 mm. The precipitation is generally fall from autumn to the late spring. Soil analysis performed according to Soil Survey Laboratory Staff (1992) procedures revealed that the sites soils textures changed sandy-loam among the sites, organic matter content ranged from 0.5 to 2.5 %, pH ranged from 5.73 to 7.91. The soils of all sites were poor in lime and phosphorus but rich in potassium.

Botanical composition and canopy coverage were measured when common species reach the flowering (late June) stage using modified wheel point method (Koc and Cakal, 2004) on ten transects lines. Every line had 20 m interval and 100 m length (100 point with 1 m interval were recorded).

The relationships between vegetation and environmental variables (soil properties and grazed animal type) were analysed by ordination techniques. Redundancy analysis (RDA) was chosen as the most appropriate constrained ordination technique. Rare species are represented lower than 1% in the botanical composition was removed from the dataset before analysis. Redundancy analysis (RDA) was used to examine the relationships of floristic composition to the measured environmental variables at sites grazed by different animal type. Species data were transformed because the data contained many zeros using the transformation ln (10 x X + 1), where X= species number in species record in transect (ter Braak and Smilauer, 2002). Automatically selection was used to determine the variance explained by individual variables. Monte Carlo permutation tests were used to test the significance of each variable. The relationships between plant distribution and environmental factors were performed using the CANOCO 4.5 software (Ter Braak and Smilauer, 2002).

RESULTS AND DISCUSSIONS

The correlations of soil variables with the four RDA vegetation axes are given Figure 1 and Table 1. The Monte Carlo permutation test results indicated that all canonical axes were significant ($p<0.05$). The plant species distribution showed clear differences on the ordination diagrams depending on grazing animal type. There was significantly relation between species distribution and some soil properties such as pH, lime and clay on the rangeland site grazed by only cattle herd. Although the effects of herd types were significant, botanical composition and species distribution was mostly controlled by environmental factors. The effects of selected variables on plant composition defined. The RDA correlation variance of botanical composition showed distinct separation with species environment correlations 0.999, 0.906, 0.716 and 0.475 and cumulative percentage variance of species-environment relation are 47.6, 72.0, 84.2 and 89.7. Eigen values changed between 0.023 and 0.196, and sum of canonical eigenvalues determined is as 0.411 (Table 1).

In general, soil of site grazed by mixed herd had higher lime, pH and clay content but soil of site grazed by cattle had higher P and silt (Figure 1). LOTCOR *Lotus cornuculatus,* SCUORI *Scutelleria orientalis,* FESOVI *Festuca ovina,* AGRINT *Agropyron intermedium* and THYPAR *Thymus parviflorus* were found to significantly higher in the sites grazed by single cattle herd than the other site. Whereas, BROTOM *Bromus tomentollus,* GALVER *Galium verum,* CREARM *Crepis armena,* KOECRI *Koeleria cristata* and SIDMON *Sideritis montana* were significantly higher in the site grazed by mixed herd. Some plant species such as ERYCAM *Eryngium campestre* and VERSPP *Verbascum* sp. where not affected by distinctively by herd type.

Table 1. The results of RDA of species and soil properties

Axes	1	2	3	4
Eigenvalues	0.196	0.100	0.050	0.023
Species-environment correlations	0.909	0.906	0.716	0.475
Cumulative percentage variance of species data	19.6	29.6	34.6	36.9
Cumulative percentage variance of Species-environment relation	47.6	72.0	84.2	89.7
Sum of canonical eigenvalues	0.411			

The results revealed that herd type and some soil properties affected deeply spatial distribution of plant species. Plant species distribution showed distinct differences on ordination diagram depending on grazing animal type application. Grazer type plays a key role in shaping plant distribution together the environmental factors (Lemus, 2012; Rose et al., 2012). Single species grazing can affect botanical composition due to animal grazing behaviour. As it well known, mixed herd grazing could be an alternative to reducing undesired plant populations. If done right, studies have shown that mixed grazing, not only make good use of land and forage resources, but also results in higher animal production per unit area. Mixture grazing can improve utilization of rangeland, increase forage quality, and carrying capacity also it can control weeds (Erkovan et al., 2016).

There is a positive relation between grazing animal type and plant species distribution in the experiment results. While soil properties such as organic matter, sand, phosphorus, silt were positively related with plant species (ASTSPP *Astragalus* sp.; LOTCOR *Lotus cornuculatus*; SCUORI *Scutelleria orientalis*; TANABR *Tanacetum abrotanifolium*; VERSPP *Verbascum* sp.) in the plot grazed by mixed herd, there were relation between clay, pH, lime and BRMTOM *Bromus tomentollus*; KOECRI *Koeleria cristata*; CREARM *Crepis armena*; FALVUR *Falcaria vulgaris*; GLOTRI *Globularia trichosantha*; SIDMON *Sideritis montana* in the plots grazed by single cattle in experiment. Forb plant species in the botanical composition have higher cattle grazed area compared to mixed herd grazed area. These decreases in forb abundance in the site grazed with mixed herd must be related to sheep grazing preferences because sheep prefer to graze forbs. It is well known that forbs never resist to grazing as much as grasses (Holechek et al., 2004). Also similar research showed that plant species and soil properties are affected by grazing animal type (Bakker and Olff, 2003; Yunusbaev et al., 2003; Li et al., 2008; Taboada et al., 2011).

Some soil characteristics have significantly role on species distribution on the rangelands in semi-arid ecosystems, also grazing animal type have an important role soil properties (Tessema et al., 2011; Haftay, 2017). Animals have important mechanical effect on soil properties depending on size. The sheep decreases stubble height due to grazing ability and on the other hand, drags its back foot during the grazing, which break soil aggregates. These factors encourage erosion. Consequently silt move easily by erosive power.

This mechanical impact changes the form and stability of soil aggregates, bulk density, pore size distribution, and soil other properties. As a result of this effect soil properties can change grazing due to animal type.

While clay, pH, lime were positively related with mixed herd grazing, organic matter, sand, phosphorus, silt were related with mixed herd

grazing. Similar results also reported the other studies conducted on different places on the world (Greenwood and McKenzie, 2001; Haskell et al., 2002; Li et al., 2008; Taboada et al., 2011).

In conclusion, according to RDA, cattle grazing had the most adverse effect on grasses species in the botanical composition than mixed grazing on in high altitude rangelands. It is important to use correct animal herd that efficiently using land and forage type for sustainable use of grazing lands.

Mixed herd grazing can improve grazed area increasing quality and carrying capacity decreasing or controlling weed invasion.

Mixed animal grazing management has a harmony with soil properties and plant species, enabling grasses and legumes to proliferate can increase carrying capacity and decreasing detrimental effect of grazing.

But correct grazing capacity performing has crucial importance to obtain this positive effect of mixed grazing.

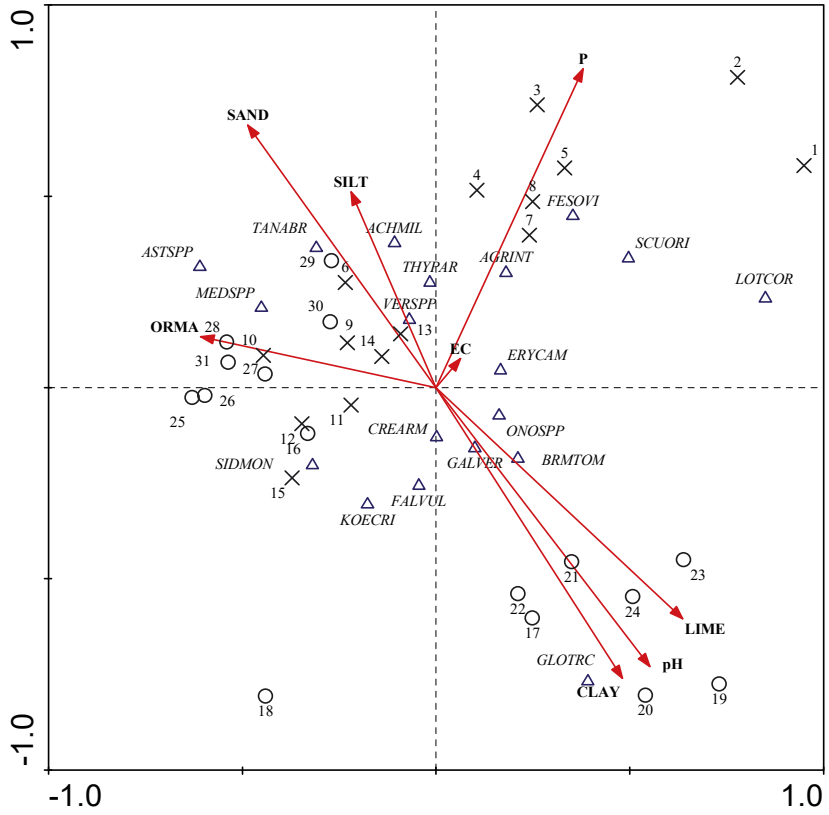

Figure 1. Triplot RDA ordination diagram rangeland vegetation composition with environmental variables

Key to abbreviations: x-mark represent grazed by single cattle samples and non-filled circle represent grazed by cattle and sheep mixed herds. pH, ORMA organic matter, LIME, P phosphorus, SUND, SILT, CLAY. AGRINT *Agropyron intermedium*; BRMTOM *Bromus tomentollus*; FESOVI *Festuca ovina*; KOECRI *Koeleria cristata*; ASTSPP *Astragalus* sp.; LOTCOR *Lotus cornuculatus*; MEDSPP *Medicago* sp.; ONOSPP *Onobrychis* sp.; ACHMIL *Achilla millefolium*; CREARM *Crepis armena*; ERYCAM *Eryngium campestre*; FALVUR *Falcaria vulgaris*; GALVER *Galium verum*; GLOTRI *Globularia trichosantha*; SCUORI *Scutelleria orientalis*; SIDMON *Sideritis montana*; TANABR *Tanacetum abrotanifolium*; THYPAR *Thymus parviflorus*; VERSPP *Verbascum* sp.

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DESIGN AND EXECUTION OF AN ANTIMONY SENSOR USED FOR MONITORING OF SOIL pH

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Abstract

The current paper presents the method that designs, manufactures and tests antimony based pH sensor used for monitoring of soil pH. In the first stage of this work the method of manufacturing the sensitive antimony elements is presented. These sensitive elements are casted into different forms (conical and cylindrical). These are subjected to a series of analysis in order to determine the chemical composition of the material used 99.73% Sb, 0.27% Ti (EDX), the morphology of the structure (SEM) and the characteristics of the oxide layer (XRD). The second part of this paper explains the method of testing the manufactured antimony sensors in the reference pH solutions. Finally, the sensors are used for measurements and are tested, alternatively, in pairs, with a reference Ag/AgCl sensors found in commerce. The results of these measurements show values approximately identical at both manufactured sensors. The adapted sensor that was obtained shows a relatively fast and stable response to pH changes in aqueous solutions. Its potential has a linear relation with pH solutions and a slope of 50.95 mV/pH.

Key words*:antimony, monitoring, pH, sensor, soil.*

INTRODUCTION

The pH of the soil is one of the most used indicators in order to observe and to analyse the processes that are taking place into the soil. The monitoring of soil' pH is done when different type of analyses are required to be done in the soil, or during a certain treatment process, in order to observe the variations (Matei et al., 2011; Predescu et al., 2017).

When making a monitoring of the soil pH, one of the most important things is the pH sensor (Hayat et al., 2014). Due to the fact that not all sensors found on the market are adequate, it is necessary to adapt some of them.

The most used sensors for pH measurements are the ones with glass membrane (Norman et al., 2000), but they are difficult to miniaturize, have mechanical fragility and chemical instability in corrosive systems. Studying the scientific literature we can observe that potentiometric metal oxide electrodes, specifically antimony electrodes, are common in soil pH measurements (Schirrman et al., 2011).

For ease of experimental measurements in a laboratory model, a pH sensor was built with indicator electrode and comparison electrode of the same material, antimony. The use of a pair of electrodes of the same material for the construction of pH sensors was presented by Jovanović et al., (1969) in their paper.

pH is one of the most commonly used indicators to have an overview of the processes occurring in the soil. Several methods for the characterization of soil pH were described by Thomas et al., (1996). Some researchers have focused on water pores from the soil and they used wells or piezometers for waterlogged soils or suction samplers that allow sampling water from soil pores (Elberling et al., 2007).

Currently, commercial glass electrode is the most used for measuring the pH, due to reliability and comfort of the measurements performed with it. In addition to the general requirements, including rapid response, high sensitivity, long term stability, and ensuring reproducibility of pH measurements, the pH electrode should be easy to be manufactured in a proper shape and size without losing its mechanical strength [da Silva et al., 2008; Ha and Wang, 2006).

The glass sensor disadvantages focused our attention to metal-metal oxide electrodes, a

study that was presented in Stoica and Micle, 2011. Many bibliographic sources present the usage of antimony sensor to measure soil pH between plant roots (Baghdady and Sommer, 1987), for mapping soil pH (Schirrman et al., 2011), or in other areas, for measuring dental plaque pH (Ro et al., 2008), for continuous potentiometric determinations of acetic acid from vinegar (Capelato et al., 1996). This shows that on-line monitoring of pH using antimony electrodes is proved to be a success.

Luca (1973) presents an electrode manufacturing as simple casting in the desired shapes or by molten antimony being absorbed into a glass capillary tube – „the method of the capillary absorbed smelt".

Sheng et al. (2013) demonstrated in their experiments that the double membrane modified antimony pH electrode testing instrument would be suitable for *in situ* and continuous pH measurement in many applications.

Boyes (2003) showed that the antimony electrode is a simple piece of pure antimony rod (~12 mm diameter, 140 mm length), placed in a plastic body with a protective role, which is resistant to acids attack. When immersed in a solution containing dissolved oxygen, the antimony rod prominence will be covered with antimony trioxide - Sb_2O_3.

For the execution of the electrode, antimony was strongly heated in a crucible until melted. The smelt was casted in a thin glass tube where it was left for solidification, thus obtaining a metal (antimony) rod with internal dimensions of the tube (Caflisch et al., 1978).

In his study, Luca (1973) was schematically showing the construction of an antimony electrode consisting of a cast rod of antimony, fixed in a hard rubber, glass or plastic body with an epoxy resin, a wire being attached as a connection element. Since no special precautions are taken, the metal electrode surface is covered, in moist air or in aqueous solutions with a thin film of antimony trioxide.

The aim of this paper is the design, execution and testing of antimony manufactured pH sensor used in soil monitoring.

EXPERIMENTAL

Construction of the sensors

The sensitive elements of the pH sensor such as the measure and reference sensors head were realised by melting antimony in a crucible at the temperature of 750°C and casting in moulds, in order to obtain a pH sensor (Figure 1a). The heads were adjusted to the desired dimensions and two sensitive antimony elements were obtained:

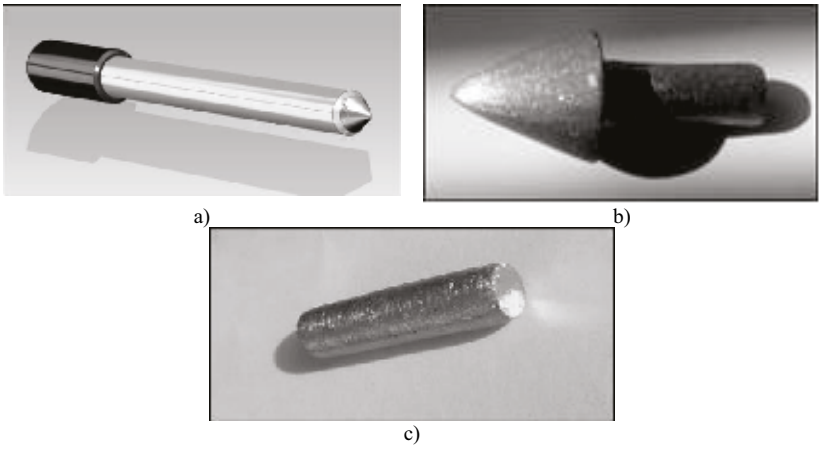


Figure 1. Antimony pH sensor design and sensitive elements executed:
a) designed version of the antimony pH sensor; b) conical sensitive element;
c) cylindrical sensitive element

1. ***conical*** shape element (Figure 1b) with the total length of 15 mm (from which 10 mm is the length of the conical part), the diameter of the conical part of 10 mm and the diameter of cylindrical part of 4 mm;
2. ***cylindrical*** shape element (Figure 1c) with a diameter of 2 mm and a length of 10 mm.

The sensitive elements are assembled in order to obtain a pH sensor which can be used to monitor the soil pH. The two elements are introduced into a body made of plastic and glass.

Characterization of the sensitive elements

The sensitive elements were analyzed by: Energy dispersive X-ray Spectroscopy (EDX), Scanning Electron Microscopy (SEM) in order to determine the morphology of the structure of the sensitive element and X-ray diffraction (XRD) for the characterization of the oxide thin layer on the surface of the sensitive element.

Testing of the manufactured electrodes

The manufactured electrodes were subjected to a series of measurements in acid and alkaline medium (reference pH buffered solutions) purchased from commerce. Using a reference electrode Ag/AgCl which exists on the market, in pair with the electrodes manufactured, we obtain comparable measurements with all antimony electrodes existing on the market.

Testing of the manufactured sensor

The manufactured sensor was subjected to a series of measurements in acid and alkaline medium (pH 2 to 10) - reference pH buffered solutions. For measurements, it was prepared in the laboratory a mix of phosphoric acid, acetic and boric, each of them in concentration 0.04 M. For obtaining of buffering solution with desired pH, there was added at 100 ml of mixing X-ml indicated solution NaOH 0.2 n (Lurie, 1970).

All measurements of tested antimony sensor were compared with a glass sensor commercially available.

For the last test measurements, the antimony sensor and the commercial glass sensor were put in buffering solution commercially available.

RESULTS AND DISCUSSIONS

Construction of the sensor

The main components of antimony pH sensor are: antimony element head (the sensitive H+ part), plastic body, reference electrode with antimony head and glass body (positioned inside of plastic body), ceramic junction which makes contact with medium, metallic conductors (realized from electrical contacts), plastic cover and cable for connection.

If the components (head, body, metallic conductors, and cable for connection) are assembled in order, we can obtain pH electrodes: in this case, conical and cylindrical shape. The conical sensitive element was equipped with a plastic body and the cylindrical one with a glass body.

The plastic body has a length of 140 mm, outside diameter of 14 mm and 12 mm interior diameter - in this form, it can be used as electrode body. It is threaded on one end and drilled in two places, resulting in a slot that can be used for filling with electrolyte and a slot in which the ceramic junction was mounted - in this form it can be used as body sensor. The pH sensor produced (Figure 2) has a length of 180 mm (without considering the cable), out of which the length has 40 mm and the cover has 16 mm – with the possibility of 10 mm threading on the plastic body.

The glass body has a length of 50 mm and a diameter of 2 mm. The cylindrical shaped sensitive element has on one end tinned a copper metallic conductor which is continued within the cable, then the subassembly is introduced in the glass body and the other end is sealed with an epoxy resin (Figure 3).

To obtain a sensor, the metallic conductor elements of each electrode were connected to a cable and then protected with the plastic cover.

Characterization of the sensitive elements

The chemical analysis (EDX) of the sensitive element (Figure 4) consists of 99.73% antimony (Sb) and 0.27% titanium (Ti).

The nested nature of metallic antimony (Figure 5) existing under an oxide layer grown on the surface of the sensing element can easily be observed by the scanning electron microscope (SEM).

In a cross-section (Figure 6) through the sensitive element, it can be observed the thickness of the oxide layer. Metal surface (B) is covered with porous oxide layer (A) which protects the metal.

In order to determine the crystalline phase of the oxide, powder was taken from the electrode surface and it was examined using X-ray diffraction (XRD).

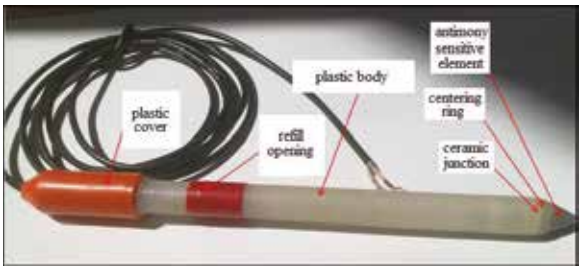
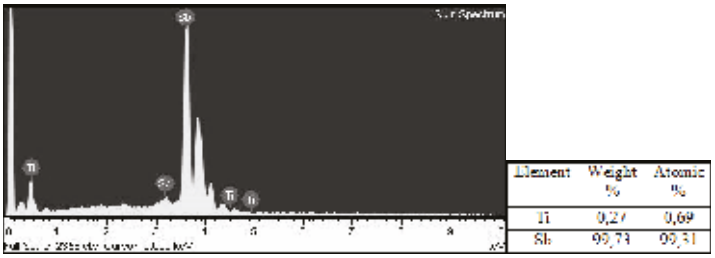


Figure 2. Plastic body antimony conical element

Figure 3. Glass body antimony cylindrical element



Element	Weight %	Atomic %
Ti	0,27	0,69
Sb	99,73	99,31

Figure 4. Chemical analysis of the sensitive element

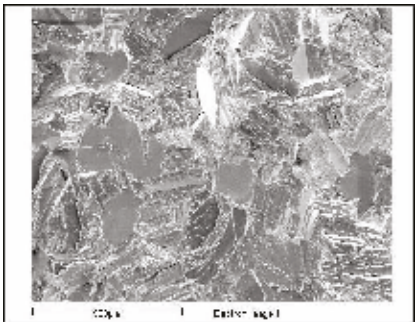


Figure 5. The morphology of the casted sensitive antimony element (SEM)

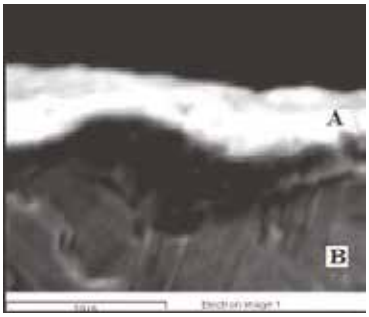


Figure 6. Section through the sensitive element observed using SEM: A) oxide layer; B) antimony metal

Peaks, identified in the Figure 7, match the pattern combination Sb_2O_3 and the Sb metal. The existence of Sb metal can be attributed to the fact that at the time of sampling (by scraping) for XRD, the very thin oxide layer of the metal was also sampled with it.

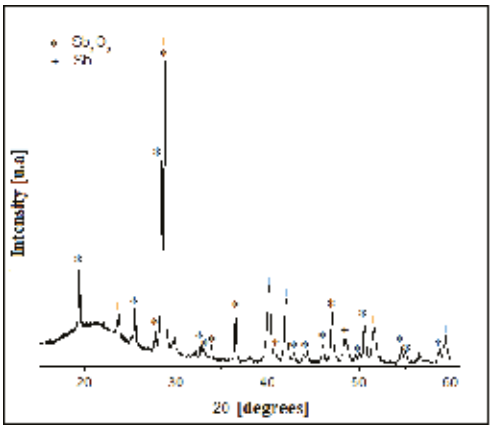


Figure 7. XRD result of antimony oxide powder scraped from the oxidized element surface

Testing of the manufactured electrodes in similar applicability medium conditions

Manufactured electrodes were tested in acidic and alkaline mediums which were established using pH standard solutions existing on the market in working temperature of 25°C. The potentials were measured by a mili-voltmeter of high precision ± 0.01 mV. Constant temperature of 25°C was maintained with help of circulated heated bay device.

Operational characteristics of antimony electrodes with plastic and glass body were established in standard pH solutions, in the range of 2 – 10. For these tests, it was used a commercial Ag/AgCl reference electrode, in pair with each laboratory-made electrode.

The electrodes response is presented in Figure 8. Both sensors presented a stable and rapid response to pH changes in different aqueous solutions. There is not a big response difference between antimony sensors and commerce glass ones. Potentials of antimony electrodes present a linearity relationship with the solution pH in which they were immersed. The determination coefficient was R^2=0.9972 for plastic body sensor, R^2=0.9969 for glass body sensors and sensitivity was 47.95 mV/pH, respectively 48.60 mV/pH.

As a result of multiple trials, the following functional characteristics were established:

- Operational linear domain: 2 - 10;
- Temperature range: 10 - 60 °C;
- Sensitivity: 50 ± 3 mV/pH;
- Frequency: ± 3 mV;
- Precision: 0.1 pH;
- Response time: less than 60 seconds;
- Fiability: high.

The disadvantage of using electrodes with antimony measurement sensitive element in pair with Ag/AgCl reference is the fact that for direct reading of the pH, special pH-meters are needed, different from those used in measuring the pH with glass sensor.

The glass sensors manage to compensate an asymmetry of potential of approximately -370 mV. Using a pair of sensors of antimony measuring element and antimony reference sensors proved to be the solution to eliminate this inconvenient. This fact is proved in the following experiment, where were used: the two manufactured electrodes (measurement electrodes: one with conical sensitive element (Figure 2) and one with cylindrical sensitive element (Figure 3), a manufactured antimony reference electrode – cylindrical shape (having a KCl solution as electrolyte) and an Ag/AgCl reference electrode (purchased from commerce).

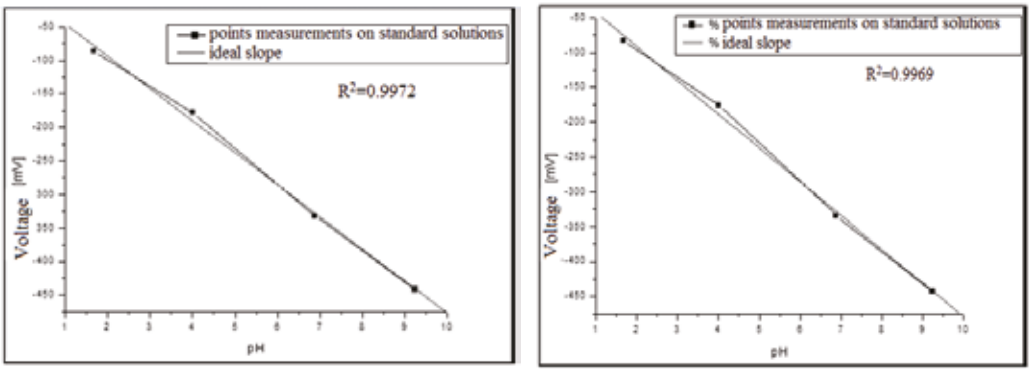
Analyzing the results presented in Table 1, it can be seen that there were obtained values almost identical for both sensors used. The results of the tests show that in the case of using antimony electrode with antimony reference, it is no longer necessary to use a special pH-meter to compensate the asymmetry of potential.

Testing of the manufactured sensors in similar applicability medium conditions

The antimony sensitive sensor's performances are presented in Figure 9 for the pH interval from 2 to 10.

It has a relatively fast and stable response to changes in pH in aqueous solutions. Its potential has a linear relationship with solutions pH (determination coefficient R^2=0.9997) and sensibility of 50.95 mV/pH.

The time for one performed measurement of the sensor is between 7 and 25 seconds.



a) b)

Figure 8. Response curve for electrode at 25°C: a) plastic body; b) glass body

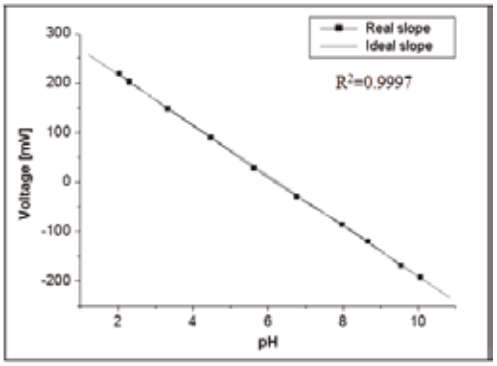


Figure 9. Antimony sensor response on pH range 2 to 10

Table 1. Comparison between measurements performed by indicator antimony sensors and indicator Ag/AgCl sensors

Open circuit potential obtained using measurement electrode and E_{RefSb}/ E_{Ref}	***pH***	6.88	4.01	9.23	ΔE
Plastic body – conical Sb element and E_{RefSb}	***Sb / E_{RefSb}[mV]***	-26	+138	-127	265
Plastic body – conical Sb element and E_{Ref}	***Sb / E_{Ref}[mV]***	-329	-168	-435	267
Glass body – cylindrical Sb element and E_{RefSb}	***Sb / E_{RefSb}[mV]***	-25	+143	-124	267
Glass body – cylindrical Sb element and E_{Ref}	***Sb / E_{Ref}[mV]***	-329	-170	-436	266

Note: E_{RefSb} –Sb reference sensor
E_{Ref} - Ag/AgCl reference sensor

CONCLUSIONS

The functionality of the manufactured sensor was proved by verifying the accuracy of the information acquired by a number of other sensors and other equipment purchased commercially.

The antimony sensor shows a linear response in 2 - 10 pH intervals, being resistant from mechanical point of view and can be used in

corrosive medium which contains hydrofluoric acid.

The responses of the manufactured sensor were compared with the responses of a glass pH sensor. The experiments demonstrated that the manufactured sensor measurements were correct, with an error of ± 0.2 pH units.

The drawback of using pH meters of a special construction was removed by using in the construction of the sensor a pair made of antimony, indicator and comparison.

The difference between this sensor in comparison with other types of sensors existing on the market is related to the shape of the element head that can be easily inserted into the soil.

The antimony sensor manufactured is showing a relatively fast response and stable to the pH changes in aqueous solutions. Its potential has a linear relation with the solutions' pH (determination coefficient R^2=0.9997) and a slope of 50.95 mV/pH.

It can also be seen that the shape and dimensions of the sensitive elements do not influence the measurements.

As a result of designing, manufacturing and testing the pH sensors, we can conclude that the manufactured sensor presented in this paper can be successfully put into practice.

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STUDIES REGARDING PHOTOCATALYTIC DEGRADATION OF TWO DIFFERENT ORGANIC COMPOUNDS

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Abstract

Water has the most importance to human life, but the quality is very important. Due to rapid development of industrial activities, it has been contaminated with many organic compounds, which is a great concern for environmental quality and human health. Nowadays, the reduction of pollutants in water has attracted a great interest leading to development of Advanced Oxidation Processes (AOPs), among which TiO_2 heterogeneous photocatalysis, as a green and sustainable technology, is one of the most emerging and promising method. TiO_2 photocatalyst is known for its excellent ability of degradation and mineralization of organic pollutants.
In this work, it was studied the degradation process of Levetiracetam and 2,4,6, trichlorophenol in aqueous solution, by heterogeneous photocatalysis, in the presence of TiO_2 Aeroxide® P25, confirming its effectiveness. For Levetiracetam at 150 min degradation was about 80%, while 2,4,6, trichlorophenol was total mineralization.

Key words*: 2,4,6 trichlorphenol degradation, Levetiracetam degradation, photocatalysis, titanium dioxide.*

INTRODUCTION

Over the last decades, water contamination with organic compounds has become an emerging environmental problem due to their continuous persistence in aquatic ecosystem (Ciobanu et al., 2013; 2014; Kadmi et al., 2015; Klavarioti et al., 2009; Rusu et al., 2014). Organic compounds discharged in the environment may impose toxicity on every rank of biological hierarchy. Apart from toxic effects, some of them may cause irreversible changes to the micro-organisms genome, making them resistant in their presence, even at low concentrations (Harja et al., 2011; Klavarioti et al., 2009). Some pollutants cannot be susceptible to biological treatments used in the wastewater treatment process because of their high chemical stability and low biodegradability.
Levetiracetam (LEV) is a tetrahydropyrrole with anticonvulsant activity and it shows good bioavailability (Schachter, 2000), linear pharmacokinetics, irrelevant protein binding, rapid achievement of steady-state concentrations (Patsalos, 2000; Perucca and Bialer, 1996), but the most important advantage of LEV is that presents no interaction with other antiepileptic drugs even at high dosage (Klitgaard et al., 1998).
2,4,6 trichlorophenol (2,4,6-TCP) is a chlorinated phenol, widely used in production of paper, pesticides, herbicide and wood preservatives (Noestheden et al., 2012). Their applications and releasing in water affects environmental quality and represent a great concern for human health.
One of the most efficient technologies in treatment of aqueous solutions for organic pollutants degradation is advanced oxidation processes (AOPs). In the last decades they have been applied for many organic compounds. AOPs such as ozonation, Fenton, photo-Fenton, ultrasound waves, sonochemical, photo-sonochemical processes, ultraviolet irradiation and sulfate radical-based oxidation (Krishnan et al., 2017; Safari et al., 2015). They are based on highly reactive transitory species such as H_2O_2, $OH^{\cdot}$, O_2^{-}, O_3 for the complete mineralization of organic pollutants, pathogens and disinfection by-products. Among semiconductor catalysts TiO_2, ZnO, Fe_2O_3, CdS, GaP and ZnS have the large efficiency in degrading (Chong et al., 2010).

Compared to conventional technologies, titanium dioxide (TiO_2) photocatalytic process the most emerging and promising (Dorian et al., 2011; Gómez de Castro et al., 2017). The advantages are ambient operating conditions, lack of mass transfer limitations, low operating costs and complete mineralization (Safari et al., 2015). TiO_2 photocatalyst is used in a large range of ambiguous refractory organic pollutants (Liu and Bi, 2017; Madjene et al., 2013). The organic substances are reduced to CO_2, H_2O and inorganic ions, all of them harmless for the ecosystem (Pourmoslemi et al., 2016). On the surface of TiO_2 photocatalyst are induced reductive and oxidative reactions (Atitar et al., 2015; Nutescu Duduman et al., 2018).

The objective of this work was to investigate the potential of TiO_2 heterogeneous photocatalysis for the removal of two different category of refractory pollutant: LEV and 2,4,6 – TCP.

MATERIALS AND METHODS

Chemicals

2,4,6-trichlorophenol (99%) and levetiracetam (≥98%) were purchased from Sigma-Aldrich Co and used without further purification.

Titanium dioxide, Degussa P25 (80% anatase, 20% rutile; Sigma Aldrich, France) was used as photocatalyst for this study.

Solutions were prepared using ultra-pure water.

Table 1. Pollutant characterization

Pollutant	Molecular formula	Molecular weight (g/mol)	Log $K_{o/w}$	pKa
2,4,6 Trichloro-phenol	$C_6H_2Cl_3OH$/ $C_6H_3Cl_3O$	197.45	3.69	6.19
Levetiracetam	$C_8H_{14}N_2O_2$	170.21	-0.49 (est)	16.09

Methods

Experiments for the degradation of LEV were conducted in a batch reactor (a glass beaker), mechanistically stirred by using a mechanic stirrer with four blades and adjustable speed, with external irradiation by two outer low-pressure fluorescent lamps (Philips PL-S 9W/10/2P lamps) whose main emission peak was the UV region (λ=365 nm). The radiation intensity was measured by a radiometer Delta Ohm DO9721 with an UVA probe.

The system employed in this work for studying the degradation of LEV consist of a rectangular enclosure, with a length of 100.2 cm and a width of 40.2 cm (Favier et al., 2015).

The tests were carried out at room temperature and at solution natural pH.

The experiments for the photodegradation of 2,4,6-TCP were conducted in a cylindrical borosilicate glass reactor. A mercury vapour lamp, which maximal emission was at 365 nm (Philips PL-S 9W/10/4P) was used as UV light source, placed in a Pyrex tube and disposed axially inside the reactor. Experiments were conducted at room temperature (20 ± 2°C) and at natural pH. The aqueous solution was magnetically stirred before and during irradiation for the catalyst suspension. The incident light intensity for the photodegradation assays was measured by VLX-3W radiometer (Vilber Lourmat, France).

The aqueous solutions were prepared by dissolving a well-known amount of compound in ultrapure water, without adjusting the pH before and during the degradation process. Subsequently, a specific amount of TiO_2 was dispersed in the solution. Before the irradiation, the suspension was stirred in the dark for 30 min to achieve the adsorption-desorption equilibrium. For the photocatalytic experiments, was considered an irradiation time of 140 and 160 minutes for the degradation of LEV and 2,4,6-TCP, respectively. Samples were taken at regular time intervals and filtered through a polymer syringe filter (Minisart/Sartorius) of 0.45 μm of porosity to separate the photocatalyst (Favier et al., 2016).

Pollutant concentration was measured by high performance liquid chromatography (HPLC), using a WATERS ACQUITY UPLC® system equipped with a diode array detector. A Waters Symmetry® C18 Column (250 x 4.6 mm, 5 μm) was used for analyte separation. The mobile phase was a mixture of acetonitrile/water/formic acid (60/40/0.1 for 2,4,6-TCP and 10/90/0.1 for LEV, respectively). Analysis was carried out under isocratic mode with a flow rate of 1 ml/min and a injected volume of 50 μL. 2,4,6-TCP was detected at 285.8 nm; its retention time was of 9.5 minutes. LEV was detected at 210.2 nm and the retention time was 8.3 minutes.

RESULTS AND DISCUSSIONS

The initial pollutant concentration (C_0) has a major influence in the photocatalytic degradation. The effect of initial LEV concentration was studied by varying the initial LEV concentration in the range 4.5 - 18 mg/L at 1 g/L TiO_2 loading, at ambient temperature, maximal irradiation flux and a stirring rate of 555 rpm, with an irradiation time of 150 min. The results showed that with increasing the pollutant concentration, degradation rate decreases. Degradation profile indicates that the optimal removal of LEV it's at 4.5 mg/L. The degradation efficiency at 150 min decreased from 99% to 76% with increasing LEV concentration from 4.5 to 18 mg/L.

A possible explanation for this behavior can be that the path length of photons entering the solution decreases with increasing the initial concentration of pollutant. The reverse effect is observed in low concentration, thus increasing the number of photon absorption by the TiO_2 in lower concentration, in accord with literature (Lutic et al., 2017; Tayade, 2009).

The effect of initial 2,4,6-TCP concentration on the degradation reaction was tested in same conditions with LEV. All experiments were realized without pH regulation and an irradiance of 59.6 W/m^2.

The catalyst efficiency is strongly affected by 2,4,6-TCP initial concentration. Thoroughly, a degradation yield of 81.5% was obtained for an initial pollutant concentration of 2 mg/L after 15 minutes of UV irradiation, compared to only 33.4 % for a concentration of 18 mg/L (Figure 1). Similar results were reported by Dionysiou et al. (2000) for the photodegradation of 2,4,6-TCP using a bench-scale TiO_2 rotating disk reactor.

A explanation for this comportment can be that when pollutant concentration increases, the vacant sites on TiO_2 surface is reduced by the organic surface adsorption on the catalyst surface, leading to an obstruction of the light penetration having an arousing effect on hydroxyl radicals generation and target pollutant oxidation. Therefore, this persuade to a decrease in pollutant degradation (Renata et al., 2005).

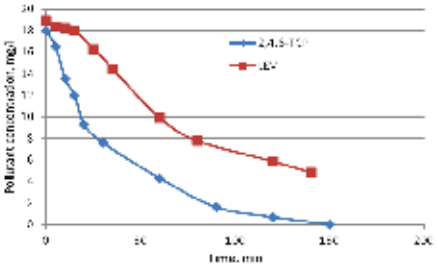

Figure 1. Degradation efficiency of 2,4,6-TCP and LEV in aqueous solution with TiO_2 P25 (1 g/L), natural pH and UV irradiance

CONCLUSIONS

In this paper was investigated the efficiency of TiO_2 photocatalyst on degradation of organic compound 2,4,6-TCP and LEV. The experiments were conducted at laboratory scale, in batch reactors using TiO_2 Aeroxide P25 as photocatalyst. The results shown that titanium dioxide photocatalytic process is a very promising method for the removal of refractory organic pollutants (giving their high chemical stability) and confirms the applicability of heterogeneous photocatalysis on environmental pollution issues.

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APPLICATION OF SOL-GEL METHOD FOR SYNTHESIS OF $Ni(OH)_2$ AND NiO NANOPARTICLES

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Abstract

The sol-gel method was used for obtaining $Ni(OH)_2$ and NiO. For structural characterization of the material we used X-Ray Diffraction (XRD). Morphological structures and chemical composition were examined by scanning electron microscopy (SEM.). The results obtained, it was found that the average particle size of the $Ni(OH)_2$ is about 15.8 nm and the thermal treatment for calcination at 350° C obtain NiO particle size is 48.5 nm. The result of DSC analysis of the precursor product showed that the proper calcination temperature was 350°C.

Key words*: characterization, sol-gel method, nickel oxide, synthesis.*

INTRODUCTION

Synthesis and characterization of new nanomaterials have a significant importance because of their essential role in fundamental research and its technological applications (Ciobanu et al., 2013, 2014a; Harja et al., 2016).

In the last decades, nanomaterials have been used in various applications due to their properties: chemical, optical, mechanical, magnetic, thermal etc. (Muneeret et al., 2015). Those properties determine for nano materials a different application ssuch as adsorption, photocatalysis, supercapacitors, batteries, sensors, solarcells etc.(Ciobanu et al., 2014b; Harja and Ciobanu, 2017 and 2018; Warnan et al., 2014).

An important p-type semiconductor is NiO, it is study recently due to extensive and attractive application in various fields: sensors, photo catalysis (Zouet al., 2006), electro catalytic (Zayimet al., 2008), magnetic area (Karthiet al., 2011) and catalysis materials (Kobayashi et al., 2011). Moreover, due to the high surface area of NiO, it is promising in the field of super capacitors and gas sensors. On the other hand, $Ni(OH)_2$ is most widely used in battery, storage for it high-power density, high proton diffusion coefficient and low toxicity (Khan et al., 2011).It is also reported that metal coating or doping on NiO can enhance the super capacitor performance. Cu-doping NiO, Fe-doped NiO hollows pheresand Au nanoparticles coating on NiO have reported (Zhao et al., 2011). Owing toth eexcellent conductive capacity and huge specific are as of Ag nanospheres, the capacitance performance of Ag doped NiO nanocomposites can be enhance defectively (Wu et al., 2007).

In the last decade were developed different methods for the synthesis of nano-NiO (Wang and Su, 2016).

The main methods for nano-NiO synthesis are: sol–gel (Nutescu Duduman et al., 2016; Ba-Abbad; Wu et al., 2007), solvothermal methods (Pan et al., 2012) micro-emulsion precipitation (Han et al., 2004; Lopez-Quintela, 2003) chemical vapor deposition (Sasi and Gopchandran, 2007; Ohta et al., 2003), sputtering (Chen et al., 2005) and liquid-control precipitation.

The more used methods for obtaining NiO are at high temperatures (Zanella et al., 2012), other techniques are complicated because is difficult to removing of templates (Zheng et al., 2005). So it is full of challenge to develop novel procedures to synthesize NiO

nanomaterials without any template. In this paper was synthesized, by facile method, $Ni(OH)_2$ and NiO that were characterized.

MATERIALS AND METHODS

For the experiment were used: Nickel Sulfate Hexahydrate ($NiSO_4 \cdot 6H_2O$) solution 0.5 M, sodium hydroxide (NaOH) solution 1M by Panreac. Morphological structure and chemical composition was examined by SEM - JEOL 6400 with an Oxford Link EDX microanalyser and Pentafet light sensing. For structural material characterization XRD method was used - Philips model X`Pert PDP3040 with a source Ka1 Cua, 40 kV and 40 mA. The program which was used for the analysis of the diffraction patterns is X`PertHihgScorePlusPANalytical (version 2.0).
The crystallite size of the prepared materials is calculated according to Scherrer equation:

$$d=0.94 \lambda / ß \cos \theta \quad (1)$$

where λ is the X-ray wavelength, ß is full width at half maxim um value, and θ is the diffraction angle
DSC analysis was performed with Controler DSC, Mettler Toledo.
The $NiSO_4$0.5 Msolution and NaOH1M solution were contacted slowly and pH value was monitoring. Figure 1 shows samples at different pH values.

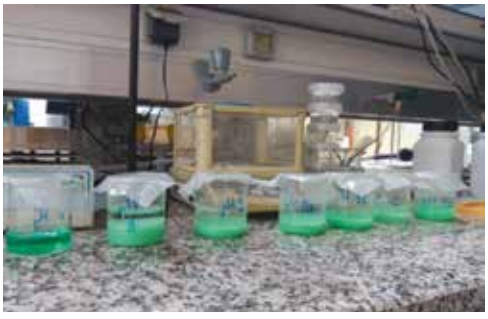

Figure 1. Samples at different pH

By adding sodium hydroxide size of synthetized materials may be controlled, in order to obtain the nanoparticles, and also leads to neutralization of reaction mass.
The solution was stirred for 2-3 hours at a temperature of 25°C, decanted for 24 hours to achieve complete phase separation. After this solid was filtered, wash with deionized water at neutral pH.
The synthetized materials were dry it in the oven at 100°C, these samples have been calcined for 2 h at 350°C.

RESULTS AND DISCUSSIONS

Figure 2 presents SEM images we can see the small powder agglomerates and EDX analysis confirms nickel, oxygen and hydrogen.
The XRD diffractogram (Figure 3) corresponds (JCPDS No. 14-17) to the major phase is the ophrastite with hexagonal structure and, to a lesser extent - $Ni(OH)_2$ and β-$Ni(OH)_2$.

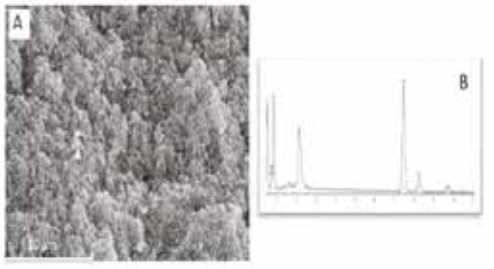

Figure 2. SEM micrographs and EDX of sample $Ni(OH)_2$.

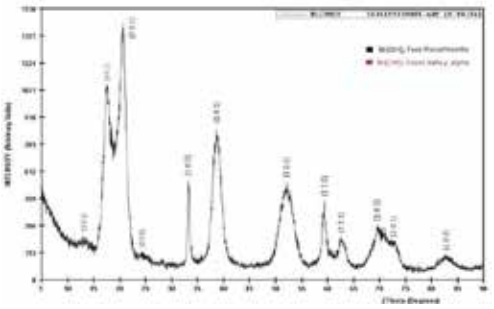

Figure 3. XRD patterns of sample $Ni(OH)_2$

The peaks have been detected and belong to the crystallographic plans (001), (100), (101), (102), (110), (111), (103), (201) and (202). After calcination in the figure 4 agglomerates with larger nanoparticles are observed and EDX analysis confirms oxygen, nickel and gold those are used to prepare the samples.

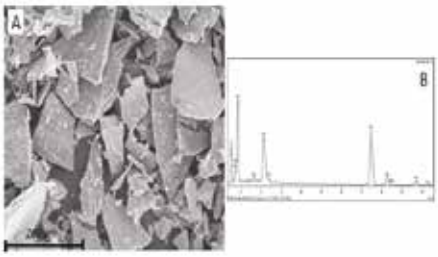

Figure 4. SEM micrographs and EDX of sample NiO

XRD diffractograms confirms the cubic structure of NiO (JCPDS No. 78-0643) and observes the crystallographic planes (111), (200), (220), (311), (222) (Figure 5).

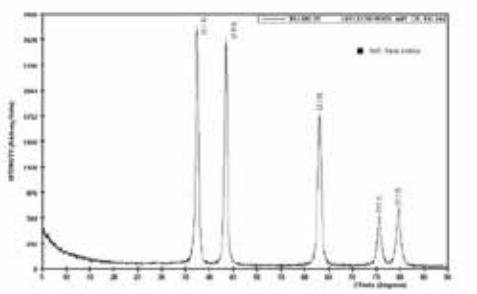

Figure 5. XRD patterns of sample NiO

Considering the results obtained, table 1 it was found that the average particle size of the $Ni(OH)_2$ is 15.8 nm and by the calcination at 650° C was obtained NiO particles, with 48.5 nm size.

Table 1. Average size of the nanoparticles calculated by the Scherrer equation

	$Ni(OH)_2$			NiO		
peak	001	101	102	111	200	220
β	0.008	0.007	0.012	0.003	0.002	0.003
θ	0.168	0.336	0.454	0.325	0.378	0.549
d (nm)	16.1	18.7	12.6	42.0	57.0	46
media(nm)	15.8			48.5		

DSC analysis, figure 6, shows the existence of two endothermic peaks. The first one (A), about 100ºC, corresponds to the water loss the sample might contain. The second peak, centered at 300°C (B), which starts at 230°C and terminating at 325°C is the transformation of nickel hydroxide to nickel oxide.

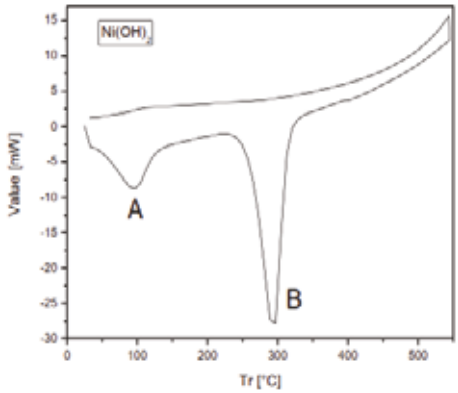

Figure 6. DSC initial sample - $Ni(OH)_2$

DSC analysis for calcined materials, figure 7, demonstrated stability of NiO.

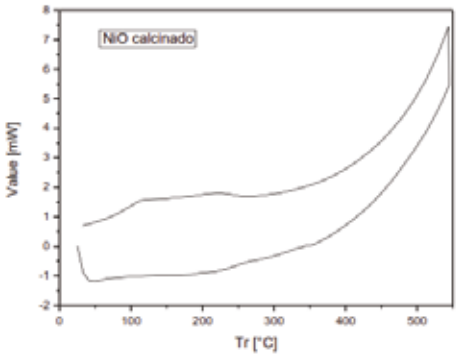

Figure 7. DSC calcined sample

After calcination at 350°C and after NiO formation, other transformations aren't observed. It is noticed that $Ni(OH)_2$ was irreversibly transformed into NiO.

CONCLUSIONS

$Ni(OH)_2$ and NiO nanoparticles were synthesized by sol-gel method. Synthesized nanoparticles were characterized by XRD, SEM, EDX and DSC. The results obtained, it was found that the average particle size of the $Ni(OH)_2$was about 15.8 nm and by the thermal treatment NiO particle obtained had 48.5 nm size. The result of DSC analysis of the precursor product showed that the proper calcination temperature was 350°C.

The synthetized nano $Ni(OH)_2$ was used to prepare nanosized NiO in a very simple and rapid procedure.

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DIFFERENT METHODS OF EXTRACTION, REDUCTION AND PURIFICATION OF AROMATIC AMINES FROM TEXTILE MATERIALS

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Abstract

Chemicals safety control and eco-properties have become a priority for the textile industry to avoid the negative effects on humans and environment. The European regulations limit the presence of 24 listed carcinogenic aromatic amines by 30 mg/kg of textile material.
The paper aims to present a comparison between different parameters of procedures for the extraction, reduction and purification of the amines obtained by the reductive cleavage of azo dyes in order to choose the optimal method. In order to test the amine extracts obtained, the 8-point calibration curve was performed for the mixture of the 24 standard amines and the solutions obtained from the extraction of the dyestuffs from the textile samples were analysed. Their testing was performed by liquid chromatography and the results were confirmed by the gas chromatography method.

Key words*: aromatic amines, textile ecology, azo dye, carcinogenic effect.*

INTRODUCTION

The key factor in textile ecology is the use of chemical substances and their effect on human health and environment. Beginning with fiber cultivation but extending to the production of yarns and fabrics, the tanning of leather, and including operations as dying, printing, finishing and surfacing, in every step the choice to be made is between hazardous and harmless chemicals. There is a logical connection between the use of chemicals in production and the health threatening substances found in textile products. Many toxins can be removed during the production processes but, unfortunately, not all. Detergents or sweat can leach these toxins out of fibers or leather. They can then enter the body through the skin. Or they can leak into the environment through washing and do their damage there. (International Association of Natural Textile Industry).
Chemicals as azo colourants are used to colour textile fibres, leather, plastics, papers, hair, mineral oils, waxes, foodstuffs and cosmetics (Lavandeira et al., 2010; Hunger, 2003). The word 'Azo' signifies the presence of a chemical azo group (-N=N-) in the dye. A unique feature of azo dyes is that the nature does not produce analogous coloured substances (Nadiger, 2001).
The biggest concern regarding azo dyes is their toxic effect; it was stated that azo dyes, after cleavage, present the capacity to release aromatic amines considered as carcinogenic. Three different mechanisms for azo dye carcinogenicity were identified; all involving metabolic activation to reactive electrophilic intermediates that covalently bind DNA. These mechanisms are:
1. Azo dyes that is toxic only after reduction and cleavage of the azo linkage to give aromatic amines, mostly via intestinal anaerobic bacteria. The aromatic amines are metabolically oxidized to reactive electrophilic species that covalently bind DNA.
2. Azo dyes with structures containing free aromatic amine groups that can be metabolically oxidized without azo reduction.
3. Azo dyes that may be activated via direct oxidation of the azo linkage to highly reactive electrophilic diazonium salts.
Each mechanism may be compound specific, thus azo toxicity is probably caused by more than one mechanism. Although it is not possible to predict azo dye carcinogenicity with

absolute certainty, it is possible to establish certain guidelines (Brown, 1993).
The European Union, by the Directive 2002/61/EC, reformulated by the Directive 2004/21/CE, has banned the use of these dyes used in the production of textile articles that enter in contact with skin or mouth. These Directives also establish that the referred textile articles cannot contain the 22 amines listed in the legislation, in a concentration higher than 30 ppm and, if the articles are made of recycled fibres, they cannot contain more than 70 ppm (Policy Research Canter for Environment and Economy, 1999; ETAD, 2007).

MATERIALS AND METHODS

Reagents and standards

- Acetonitrile and methanol gradient grade from Merck KGaA (Germany), water for chromatography (resistivity min. 18.2 MΩ x cm, TOC max. 50 ppb).
- Analytical standards of 24 aromatic amines from Sigma-Aldrich and Dr. Ehrenstorfer GmbH (Germany).

Instrumentation

- HPLC separation was performed on Agilent 1100 LC System using Agilent Zorbax Eclipse XDB C18 column and MWD detector.
- GC separation was performed on Agilent 6890 GC System coupled with Agilent 5973N transmission quadrupole mass spectrometer (Table 1).

Table 1. Operating condition

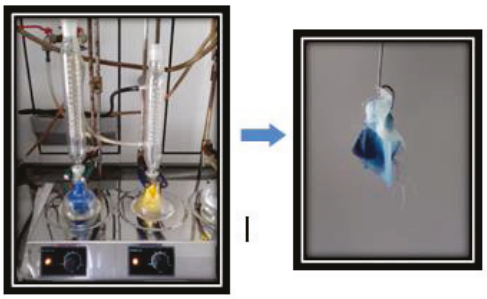
Agilent 6890 GC/5973N MS Operating Conditions	
Capillary Column	DB-35MS (J&W), 35 m x 0.25 mm x 0.25 µm;
Injector System	splitless
Injector Temp.	260 °C
Carrier gas	helium
Flow (mL/min)	1 mL/min
Temp. programme	100°C (2 min), 100°C - 310°C (15°C/min), 310°C (2 min)
Injection Volume	1.0 µl
Detection	MS / Full Scan
Acquisition Parameters	EI Positive Ion Mode, 70 eV

Agilent 1100 HPLC/MWD Operating Conditions		
Analytical Column	Zorbax Eclipse XDB C18 150 mm x 4,6 mm x 3.5µm	
Column Temp.	32°C	
Injection Volume	5.0 µl	
Mobile Phase	Eluent 1: methanol	
	Eluent 2: 0.68 g potassium dihydrogen phosphate in 1000 mL water, 150 mL methanol	
Run time	35 min	
Flow rate	0.6 - 2,0 mL/min (gradient)	
Quantification	at 240 nm, 280 nm, 305 nm and 380 nm	
Gradient profile	Time (minutes)	Gradient (% Eluent 1)
	0.00	10.0
	22.50	55.0
	27.50	100.0
	28.50	100.0
	28.51	100.0
	29.00	100.0
	29.01	10.0
	31.0	10.0
	35.00	10.0

RESULTS AND DISCUSSIONS

Procedures for extraction of azo dyes from textile materials

To perform procedures for the extraction and purification of azo dyes from painted textiles, we used the standardized method described in ISO/DIS 14362-1:2017.
We used one textile material made of cotton, dyed with Direct Blue 6.
The textile samples were cut in the form of narrow strips and weighed so as to obtain about 1g of material; then hooked with an inert thread and placed into 50 mL round bottom flasks; the painted textile samples were kept in an reflux apparatus over a volume of 25 mL boiling solvent (xylene/methylene chloride) for 40 min; after this time the drops from the textile material became colorless (Scheme 1).
The extract of the dye in the organic extraction solvent was allowed to cool to room temperature and then the solvent was evaporated to concentrate the extract in a rotary evaporator (Figure 1).



Scheme 1. Reflux condenser
for extraction of dyes

Figure 1. Rotary evaporator used
for evaporation of extraction solvent

In Table 2 below are synthesized factors which were varied for the extraction procedure: the extraction solvent (xylene respectively methylene chloride) and the volume of extraction solvent (25 mL and 50 mL), and two of the samples were carried out in duplicate: 1A, duplicate sample 1A ' for reproducibility of results.

Table 2. Extraction parameters

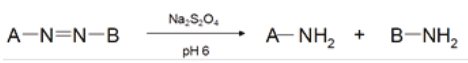
Sample	Solvent [mL]		Sample mass [g]
	Xylene	Methylene chloride	
1 A	25	-	1.0463
1 A'	25	-	1.0578
2 A	50	-	0.9870
3 A	-	25	1.0150

Procedures for reducing azo dyes to aromatic amines

In order for the aromatic amines to be detected from the textile materials, must be performed reductive cleavage of the azo dyes.

This is generally accomplished with sodium dithionite solution, which results in the breakage of the azo -N = N- bond, with the formation of two amine groups, $-NH_2$.

The reductive cleavage reaction of the dyes is shown schematically below:



azoic dye aromatic amines

The selective reduction was carried out as follows: a volume (15 and 20 mL) of an oxidizing agent - citrate buffer/sodium hydroxide solution preheated to 70°C was added to a reaction vessel, which was kept on the plate at 70°C (± 2°C) for 30 minutes (± 1 min); Subsequently, a volume of sodium dithionite reducing agent (3 mL respectively) was added and kept at 70°C (± 2°C) for 30 minutes (± 1 min).

Subsequently, the reaction vessels were cooled to room temperature (20-25°C) over 2 min (Table 3).

Table 3. Reduction parameters

Sample	Sodium citrate pH=6 [mL]	Sodium hydroxide pH=6 [mL]	Sodium dithionite 200 mg/ml [mL]	Sodium hydroxide 10% [mL]
1 A	15	-	3	0.2
1 A'	15	-	3	0.2
2 A	20	-	3	0.2
3 A	15	-	4	0.5

Separation and concentration of aromatic amines

In the reaction vessel (Figure 2) we added a 10% volume of sodium hydroxide (0.2 and 0.5 mL), and after vigorous stirring, the solution was transferred to a column of diatomaceous earths (Figure 3) - Sigma Aldrich and maintained to be absorbed by the column for 15 minutes.

Meanwhile, 10 mL of t -butyl-methyl ether was added to the reaction vessel, and after vigorous stirring, it was poured into the diatomaceous column (repeated procedure), followed by 60

mL of t-butyl-methyl ether they poured directly into the column.

The extract was collected in a 50 mL round bottom flask and the solvent was evaporated to a minimum volume of 1 mL in a rotary evaporator; this volume of extract from each sample was then taken up with 1 mL of acetonitrile and analyzed by liquid and gas chromatography method.

Figure 2. Dye reduction to amine

Figure 3. Purification of the amine extract

Results of HPLC-MWD and GC-MS analyzes on textile-dyed samples

Sample <u>1A</u>

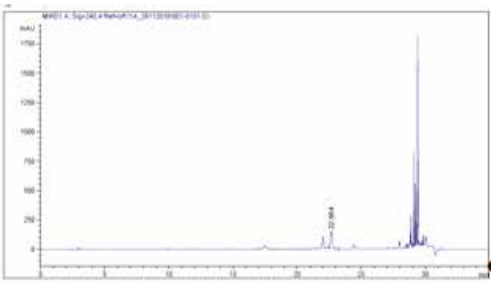


Figure 4. Chromatogram of sample 1A
HPLC MWD detection at 240 nm

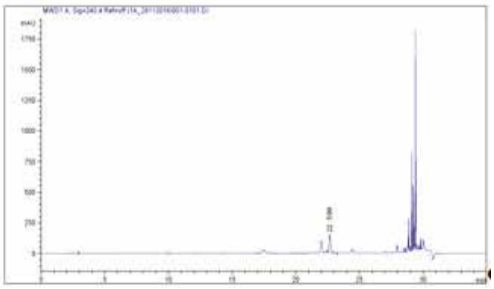


Figure 5. Chromatogram of sample 1A'
HPLC MWD detection at 240 nm

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ug/ml]	Grp	Name
22.664	VB	1522.86292	3.35605e-2	51.10911		amina 4
Totals :				51.10911		

RetTime [min]	Type	Area [mAU*s]	Amt/Area	Amount [ug/ml]	Grp	Name
29.196	BV	52.36035	0.09748e-2	4.23987		amina 22
Totals :				4.23987		

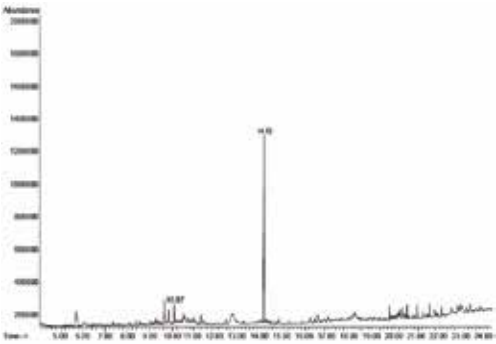


Figure 6. GC-MS Chromatogram of sample 1A

Table 4. Concentration of amines resulting from dye reduction for sample 1A

Component	Name	CAS #	Conc. [ppm]
1.	Amine 4: 2-naphthylamine	91-59-8	53.0021
2.	Amine 22: 4-aminobenzene	60-09-3	4.2561

Table 5. Concentration of amines resulting from dye reduction for sample 1A'

Component	Name	CAS #	Conc. [ppm]
1.	Amine 4: 2-naphthylamine	91-59-8	51.4628
2.	Amine 22: 4-aminobenzene	60-09-3	3.9592

Table 6. Concentration of amines resulting from dye reduction for sample 2A

Component	Name	CAS #	Conc. [ppm]
1.	Amine 4: 2-naphthylamine	91-59-8	1.0938
2.	Amine 22: 4-aminobenzene	60-09-3	4.9751

Table 7. Concentration of amines resulting from dye reduction for sample 3A

Component	Name	CAS #	Conc. [ppm]
1.	Amine 4: 2-naphthylamine	91-59-8	47.3265
2.	Amine 22: 4-aminobenzene	60-09-3	3.3105

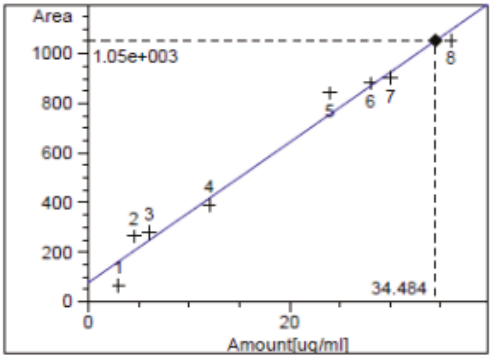


Figure 7. Calibration curve for amine 4

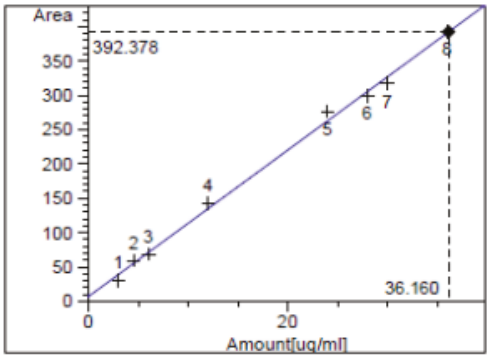


Figure 8. Calibration curve for amine 22

CONCLUSIONS

As a result of analyzes performed by both HPLC and GC, for samples 1A and 1A' respectively, the simultaneous detection of the amines 4 and 22 is observed by the two methods.

The specific structure of the dye has determined, by its splitting the appearance of the two amines.

By changing the volume of xylene (50 mL vs. 25 mL) and the volume of citrate (20 mL versus 15 mL), the decreased sensitivity of the method for determining aromatic amines is noticeable, meaning that amine 4 can no longer be detected.

Modification of extraction parameters (use of 25 mL of methylene chloride versus 25 mL xylene) and reduction parameters (use of sodium dithionite: 4 mL vs. 3 mL and 10% sodium hydroxide: 0.5 mL versus 0, 2 mL) there was also a decrease in the sensitivity of the method proved by lower amounts of amines compared to the standardized method.

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MBBRs FUNCTIONALIZATION WITH *CERIOPORUS SQUAMOSUS*

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Abstract

Most widely applied technologies wastewater treatment biological technologies are based on the selection of microbial communities dominated by bacteria (activated sludge).Wastewater treatment through Moving Bed Biofilm Bioreactors (MBBRs) has been widely used during the last years. The wastewater treatment with moving bio media consists in adding biofilm carriers (small cylindrical/ round/ plate shaped polyethylene/polypropylene/ polyurethane foam carrier elements) in aerated or anaerobic basins to support biofilm growth. The paper explored the functionalization of MBBRs (polyethylene support) structures in a Biotec FE 007 fermentor, with Cerioporus squamosus strain (a basidiomycete bracket fungus). Scanning Electron Microscopy and optical microscopy analysis were carried out pre and post microbial functionalization on the MBBRs in order to assess the colonization of the MBBRs structures and internalization of microbial biomass. The functionalized MBBRs will be further used in experiments of removal of recalcitrant compounds from cellulosic wastewaters.

Key words*: MBBRs, wastewater, Basidiomycota, fungi.*

INTRODUCTION

Worldwide there are several wastewater treatment processes available. Most widely applied technologies are based on the selection of microbial communities dominated by bacteria (activated sludge). Even though bacteria are effective (Calderón et al., 2012) in the removal of most of the organic compounds from municipal wastewaters, industrial wastewaters contain a significant concentration of several compounds that are not biodegraded by bacteria.

These compounds need to be removed by further treatments grafted on the main pipe of the primary treatment, usually consisting in chemical-physical technologies, demanding for reagents and energy and generating sludge.

Biofilm reactor configurations applied in wastewater treatment include trickling filters, high rate plastic media filters, rotating biological contactors, fluidized bed biofilm reactors, airlift reactors, granular filters, and membrane immobilized cell reactors. A general division between fixed and moving bed processes based on the state of the support material is usually done. Fixed bed systems include all systems where the biofilm is formed on static media such as rocks, plastic profiles, sponges, granular carriers or membranes.

The wastewater treatment with moving bio-media consists in adding biofilm carriers (small cylindrical/round/plate shaped polyethylene/ polypropylene/polyurethane foam carrier elements) in aerated or anaerobic basins to support biofilm growth.

A rotating biological contactor is a biological treatment process used in the treatment of wastewater following primary treatment.

It consists of a series of closely spaced, parallel discs mounted on a rotating shaft which is supported just above the surface of the wastewater.

Microorganisms grow on the surface of the discs where biological degradation of the wastewater pollutants takes place. The rotating packs of disks are contained in a tank or trough and rotate at between 2 and 5 revolutions per minute. The shaft is aligned with the flow of wastewater so that the discs rotate at right angles to the flow with several packs usually combined to make up a treatment train (Lazarova and Manem, 2000).

Moving bed systems comprise all biofilm processes with continuously moving media, maintained by high air or water velocity or mechanical stirring. Biofilm carrier material (media or bio media) is selected based on size, porosity, density and resistance to erosion. By using a material with a large specific surface area (m^2/m^3) high biological activity can be maintained using a relatively small reactor volume. Small parts made of special materials with close-to-water-density, are immersed in bioreactors. The biofilm carriers are kept in suspension and even mixed with the help of air bubbles generated by the aeration system (aerobic bioreactors) or with the help of a mixer (anoxic bioreactors). This type of support is most effective because it is not clogged. Worldwide there are several models of biofilm carriers.

The MBBRs process is based on the aerobic/anoxic biofilm principle and utilizes the advantages of activated sludge and other biofilm systems without being restrained by their disadvantages. The biofilm carriers provide a large protected surface area for the biofilm and optimal conditions for the bacteria culture to grow and thrive. The biofilm that is created around each carrier element protects the bacterial cultures from operating excursions to yield a very robust system for those industrial facilities loaded with process fluctuations.

In recent years, fungi have been largely investigated in wastewater treatment and their potential in the removal of recalcitrant compounds was demonstrated. Thanks to their extracellular enzymes, such as laccases (Spina et al., 2015), peroxidases (Chen et al., 2015) and tannases (Salgado et al., 2016), active on a broad range of substrates, fungi are able to degrade several recalcitrant compounds (pharmaceuticals, endocrine-disrupting compounds, PCBs, herbicides, dyes, tannins etc.). Moreover, the fungal initial oxidative attack increases the biodegradability of the recalcitrant compounds, improving the effectiveness of bacteria in activated sludge.

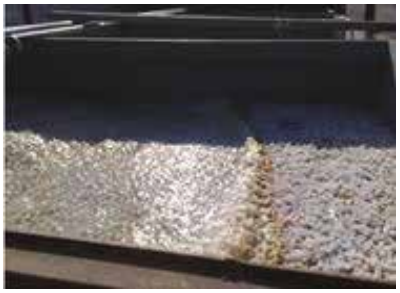
MATERIALS AND METHODS

MBBRs

DFR Systems has obtained results in using MBBRs technology and holds a patent for a model of biofilm carrier (Patent no. RO 123174/28.01.2011), (Figure 1).

a) vectorized MBBRs

b) carrier with biofilm



c) MBBRs in treatment tank

Figure 1. Biofilm carrier

In MBBRs systems the biofilm grows protected within small plastic carriers, which are carefully designed with high internal surface area.

These biofilm carriers are suspended and mixed throughout the water phase. The biological wastewater treatment process consists of adding biofilm carriers in aerated or anoxic basins to support biofilm growth. When the microorganisms in the attached biological film die, the film breaks up and peels off from the solid support being carried away by the liquid

current. The destroyed cellular material is removed as sludge.

Fungal strain

Cerioporus squamosus is a basidiomycete bracket fungus (also known as dryad's saddle or pheasant's back mushroom) (Spahr, 2009), and has special importance in natural ecosystems, being able to degrade a wide range of cellulosic substrates. The strain develops Dimitic hyphae, which are composed of skeletal hyphae (axial or inflated) (Zmitrovich, 2016).

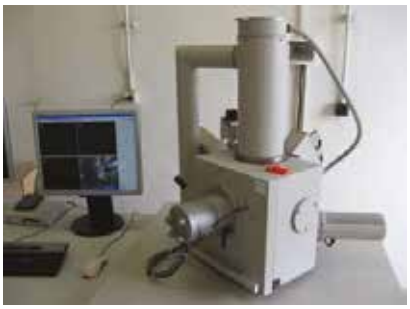
Fresh culture strain was started in Potato-Dextrose Nutrient Broth (Scharlau), for 4 days at 28^{o}C, at fermenter level (Biotec FE 007), in a final volume of 500 mL, environmental volume for 72 hours at 28°C under aerobic conditions (continuous oxygenation) and agitation set to 250 rpm (Figure. 2).

Figure 2. *Cerioporus squamosus* growing at fermenter level

After strain growing, for 4 days at 28^{o}C, MBBRs pieces (previously sterilized at 121^{o}C for 15') were put in the fermenter, and the process was further continued for 7 days at 28^{o}C.

SEM analysis

Microscopic analysis and morphological characterization was performed by scanning electron microscopy (SEM) using a Quanta 200, Fei (Netherlands) electron microscope (Figure 3). SEM analysis was also conducted on *Cerioporus squamosus strain* grown on Sabouraud-Agar plates, incubated at 28^{o}C for 14 days, for hyphae development, and compared to liquid media growth, which was used for MBBRs functionalization.



Scanning Electron Microscope

SEM specimen chamber

Figure 3. Scanning Electron Microscope, Quanta 200, FEI

Morphological analyses were performed on the GSED detector, ESEM mode, spot beam size of 4.0, 10kV filament voltage, with image acquisition at 27.2 seconds.

Optical microscopy analysis was carried out on an Olympus SZX7 stereomicroscope, with 7:1 zoom ratio, built-in electrostatic discharge protection, and advanced Galilean optical system for highly resolved images. Analyses were carried out at a magnification level of 0.8X, on both treated and untreated MBBRs.

RESULTS AND DISCUSSIONS

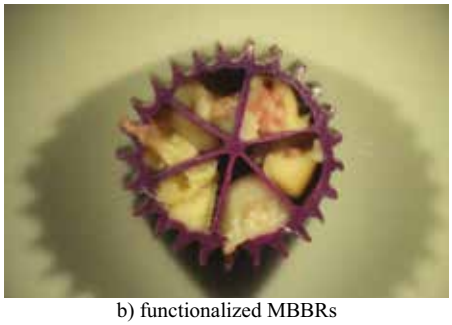
Indigenous Ascomycota are the dominant fungal phylum in polluted environments, where they are able to transform or remove also significantly stable and toxic recalcitrant (Marco-Urrea et al., 2015). Polluted wastewaters represent a source of Ascomycota,

putative degraders for which studies are surprisingly scarce.

In this context, many unstudied fungal species need to be explored, to understand their specific interactions in engineered ecosystems, because they appear to play a primary role in actual polluted scenarios. Some Ascomycota undoubtedly possess great potential for bioremediation purposes (Mariner et al., 2008), and the key seems to be the intracellular enzymatic machinery coded in their genome, rather than the extracellular battery of oxidative enzymes already described for White Rot Fungi.

Optical microscopy analyses revealed *Cerioporus squamosus* biomass deposition inside the MBBR structure (b) when compared to untreated MBBRs (a) (Figure 4).

a) control MBBRs



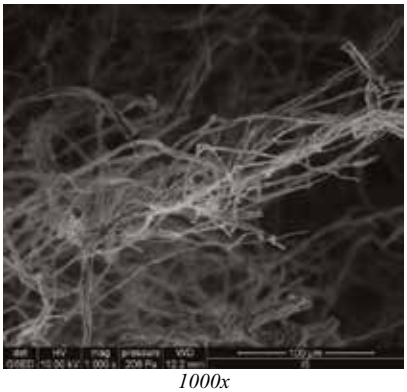
b) functionalized MBBRs

Figure 4. Internalization of biomass inside the MBBRs

Analysis highlighted attachment of microbial biomass inside the MBBRs, but not on the external spaces of the polymeric structures. It can be highlighted that a longer process (more than 7 days) could translate into a higher quantity of biomass that will be internalized between the MBBRs empty spaces (inside the structure).

Another aspect that was noted is that the biomass was not firmly attached by the polymer surface, and could be easily washed.

SEM analysis on *Cerioporus squamosus* standalone strain, grown on Sabouraud-Agar Petri plates, carried out at pressure levels between 200Pa and 208Pa highlighted a fibrillated, branched structure with a high degree of coverage on the carbon band and hyphae size ranging from 1.60 μm to 2.72 μm, for 4000x magnification analysis. The strain has a multi branches hyphae organization, these having dimensional width variations, and pyramidal structure in section (Figure 5).



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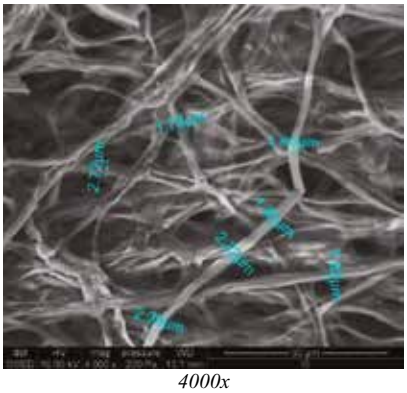
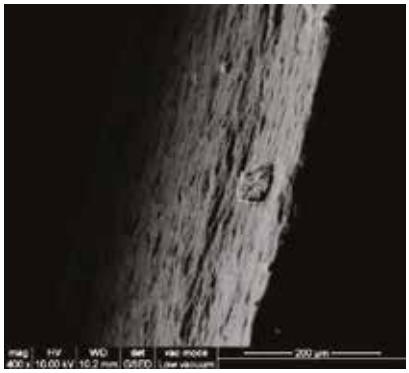


4000x

Figure 5. SEM analysis of morphological characters for *Cerioporus squamosum* strain

Scanning Electron Microscope analysis was carried out on the control MBBRs, but due to high magnification levels allowed by the equipment, combined with the dimensions of the MBBRs, only details of the polymeric walls could be assessed (Figure 6).



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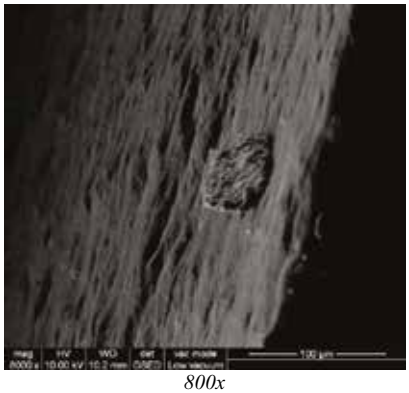

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Figure 6. SEM analysis of control MBBRs

SEM analysis allowed highlighting of a rough surface, at microscopically level, of the MBBRs, which can lead to a greater degree of mechanical attachment of microbial biomass, when compared, for example, with a smooth surface structure.

The internal structure of the MBBRs allows for high quantities of microbial biomass fixation, having a total internal contact area of 837.12 mm^2 (Figure 7).

Furthermore, SEM analysis was conducted in order to assess the morphological characterization of *Cerioporus squamosus* MBBR internalized biomass (Figure 8), grown in submersed environment (fermenter level).

The strain biomass grown in submerged conditions, under aeration presented the same morphology as that grown on solid media plates, highlighting high biomass yield even in only seven days of growth.

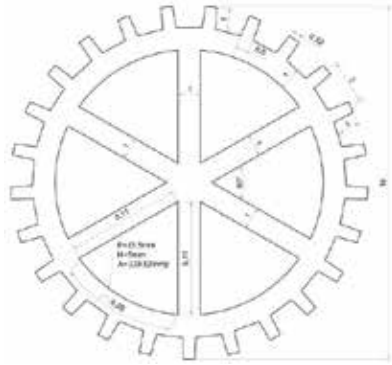
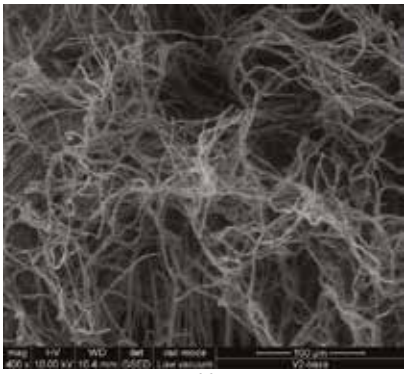


Figure 7. Artificial mobile support (scale 10:1)



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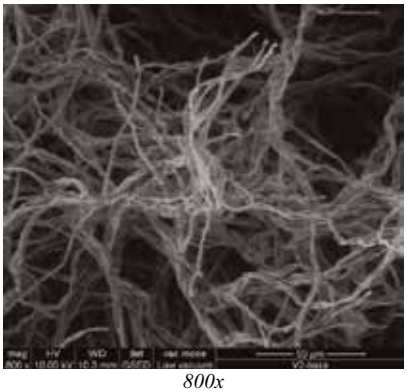

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Figure 8. SEM analysis of morphological characters for *Cerioporus squamosum* strain

CONCLUSIONS

Despite the massive work already done by the scientific community, biotechnologies based on fungi are not mature for full scale application in wastewater treatment.

The present research work successfully explored the functionalization of moving bed biofilm reactor structures with *Cerioporus squamosus* fungal strain, in a fermenter control conditions, and allowed microscopically characterization of the internalized biomass. Future research work will be centred on development of new composite materials with cellulose (cellulose functionalized MBBRs) which will allow the fixation and growth of certain cellulolytic microbial species, and further used in treatment of wastewaters originated from paper-mill and cellulose industry.

The successful implementation of biological processes based on fungi, and their integration with activated sludge, will deeply innovate the state-of-the-art towards more sustainable standards from both an economic and environmental point of view.

The EU industry will benefit from the application of new biological treatment technologies, thanks to more efficient and cost-effective solutions to mitigate their energetic impact and improving effluents quality. Moreover, the proposed technologies must be directly related to greenhouse gas emissions reduction.

The application of biological processes for various compounds removal from sources of wastewater is addressed to save energy since contrarily to other alternative technologies; it does require a lower consumption of energy and chemicals.

This is particularly important in a scenario where climate change has to be considered. Finally, the potential reduction of pollution both at global (reduced GHG emissions) and at local level (improved effluent quality) will improve the quality of the environment with further social and economic benefits.

ACKNOWLEDGEMENTS

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THE EFFECT OF THE TIME OF CONTACT ON THE MICROBIOLOGICAL TREATMENT OF LEACHATE

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Abstract

The study aimed to establish the optimum conditions for biological treatment of the leachate from the Glina household waste disposal site. The variation in nitrate, nitrite, phosphate, ammonium and suspended matter content in relation to contact time between microorganisms and leachate was analyzed to highlight the activity of microorganisms at different contact times. Experimental results have shown that the highest efficiency in the removal of nitrates and nitrites corresponds to the contact range of 16-24 hours, while the degradation efficiency is very low for contact time below 8 hours. The higher content of leachate suspensions was recorded over 5 days of contact, after which a continuous decrease was achieved by the end of the experiment. Positive inflection on biological purification by lowering the content of ammoniacal nitrogen, phosphorus, oxygen content and biochemical oxygen content between 16 and 32% after 20 hours of contact time

Key words*: leachate landfill, biological epuration, temperature, COD, BOD.*

INTRODUCTION

Controlled storage in ecological landfill is the main method of processing waste in many countries in the world due to technical and economic advantages this method presents in comparison to other processing methods.

Leachate results from landfills, which if not treated properly and disposed of safely, can migrate into soil and groundwater basements with serious effects on eco-systems, as leachate contains many pollutants resulting from waste (Kamarud, 2013).

The presence of pollutants in high concentrations has become one of the major problems of landfill operators in particular in compliance with strict regulations regarding the safe disposal of leachate. Biological treatment is applied when the organic substances present in the leachate are degradable and are not accompanied by toxic substances. Bacteria use enzymes to get food in the form of hydrocarbons by breaking down substances in the leachate. levigat (Arpita, 2017).

In the microbiological treatment of leachate, biodegradation is performed by microorganisms that can degrade organic compounds and carbon dioxide under aerobic sludge and biogas (a mixture containing mainly CO_2 and CH_4) under anaerobic conditions (Ghasimi et al., 2010).

Under anaerobic conditions, Kamaruddin (2015) demonstrated that organisms played a significant role in the effective removal of leachate pollutants, their activity being strongly influenced by the pH of the leachate. By lowering the pH of the leachate sample, the percentage of COD removed increased from 39.7% to 43.7%.

Under these conditions, all organic compounds were completely oxidized to carbon dioxide. Increasing the pH in the range of 8 to 9 would lead to a slight (second) increase, from 49 to 51%. In this case, although anaerobic organisms are not an oxidizing agent, microorganisms in the leachate solution are responsible for the degradation of organic content (Kamaruddin, 2015).

Research by Mehmood MK et al. showed that anaerobic organisms would effectively activate neutral pH leachate; a similar finding being observed for the removal of NH3-N. Under acidic conditions, NH_3-N removal was observed below 29%, while a slight increase was recorded when the pH increased from 7.8 to 9.2 (Mehmood, 2009).

Among the factors influencing the biological process, the following were analyzed in the present study: the contact time or the crossing time of the aeration lagoon, the pH.

MATERIALS AND METHODS

In experimental determinations samples of leachate were used coming from the electrical discharge leachate from Cell 2 waste landfill Glina, namely the settling tank located around the lagoon aeration, to highlight the effect of the lagoon on organic compounds from leachate.

Samples were collected in the period December 2015 - November 2016 at the beginning of each month. Measurements were carried out according to specific standards of each component (Table 1).

Tabel 1 Analysis method

Nr. crt	Quality indicator	U/M	Determination method	Method principle
1.	pH		Electrometric method	The method is based on measuring the potential difference of an electrochemical cell in which one half is the measurement electrode and the reference electrode is the other half. Measuring electrode potential is a function of hydrogen ion activity measurement solution.
2.	Materials in suspension	mg/l	Filtration and drying	The separation of suspended particles by filtration and drying in a vacuum oven at 105^0C and then weighing.
3.	Nitrate NO_3^-	mg/l	Sulfosalicylic acid spectrometric method	It is based on determining the intensity of yellow coloration complex, sodium nitrosalicilate formed between salicylic acid and nitrate. Absorption maximum at λ = 415 nm is. In the sulfuric acid interacts with nitrate ions of sodium salicylate, 3-nitrosalicylic forming acids and 5-nitrosalicylic whose salts have a yellow coloration. Nitrate ions can be determined within the range 0.1-20 mg / l, without dilution or concentration of the sample analyzed.
4.	Nitrogen NO_2^-	mg/l	Molecular absorption spectrometric method	The measurements are usually compared to a reference sample, by comparison, contained in a cell of the same size as that in which the sample to be analyzed. The reference sample typically contains solvent and sample constituents, except a species whose absorbance measurements. With such a reference solution in the cell, the intensity of the incident radiation intensity of the radiation transmitted is less than that lost by diffusion, reflection, and absorption due to any other components.
5.	Ammonia NH_4^+	mg/l	Manual spectrometric method	The principle of the method consists in the reaction of ammonium ions, in a basic medium, with tetraiodomercuratul potassium (K2 [HgI4]) which form a complex (iodide oximercuramoniu) of yellow-brown color.
6.	Phosphorus total	mg/l	Ammonium molybdate spectrophotometric method	Phosphate anion was reacted with ammonium molybdate in acidic medium and the formed ammonium phosphomolybdate, ammonium phosphomolybdate result form under the action of reducing a blue complex known as molybdenum blue complex The color intensity is proportional to the phosphate concentration.
7.	CBO_5	mgO_2/l	Dillution and seeding method with input aliltiouree	Oxygen consumed is determined for 5 days by microorganisms in the water by the difference between the amount of oxygen found in the sample of water immediately and 5 days after harvest
8.	CCOCr	mgO_2/l	The method with potassium dichromate	COD value is determined directly from the wavelength of a control sample prepared and treated as the test sample but containing only distilled water and oxidant mixture in the same proportions in a laboratory spectrophotometer.

RESULTS AND DISCUSSIONS

A municipal waste repository is not homogeneous, since there is waste which is water absorbent such as cardboard or paper, and at the other extreme waste such as plastic, glass or construction waste. Qualitative analysis conducted by researchers (Ghose Pooja and Gupta Asmita, 2015) have revealed the presence of numerous xenobiotics very different groups: halogenated aliphatic, aromatic compounds, polycyclic aromatic hydrocarbons, esters, and other compounds.

Location deposits in areas characterized by predominantly rainy weather generates a quantity and quality leachate higher if the

coverage is not adequate. Climatic conditions lead to significant seasonal variations of microbial activity and consequently the effects of biological purge harder to appreciate (Pooja Ghos, Gupta Asmita, 2017).

Contact time

The contact time or the time of crossing of the technological objective in which the biological process takes place is one of the essential factors which determines the efficiency of the biological treatment. To carry out the process of decomposition, the concentration of the bacteria, the time to decomposition can vary.

The mechanism involved suggests that anaerobic metabolism involved a mixed culture of many species of microorganisms, some of which can convert NH_4^{++} to NO_3, thus lowering the potential for N-fraction (Javaid, 2010).

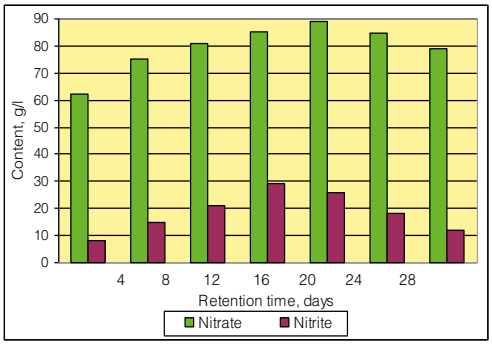

Figure 1. Content variation in nitrate and nitrite with contact time

Experimental determinations carried out on leachate samples in 2016 revealed an increase in concentrations over the first 20 days of nitrate treatment from 61.8 g/l to 89.1 g/l, and in the first 16 days of nitrate the increase was from 8.5 g/l to 28.9 g/l and 20.4 g/l respectively (Figure 1).

Increased contact time allowed leachate anaerobic microorganisms to adapt to the conditions of the aeration lagoon, harness the existing microorganisms in the lagoon sludge and enhance their biodegradation activity.

As the contact time was prolonged, a decrease in nitrogen content was observed.

In experiments we noticed that longer contact time between anaerobic organisms and the leachate sample will reduce the ability of microorganisms to react effectively with leachate pollutants because the oxygen content in the leachate pools is much lower.

The biological treatment process results in organic matter degradation, to various stages of technology and equipment and biomass growth (estimated at 40-60%) in the form of insoluble, sedimentable cell material, as well as in some metabolic products, more easily removed.

Concerning the concentrations in ammonium and phosphates, in figure 2 a constant increase of the concentration with the increase of the contact time can be seen, which shows that the nitrification processes - long-term denitrification are present.

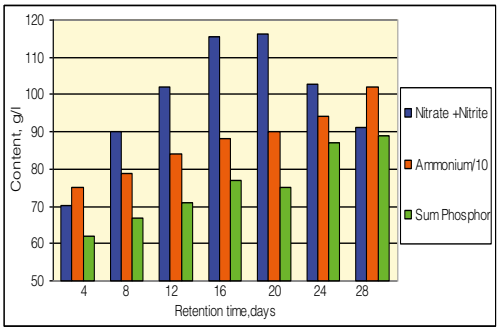

Figure 2. Change in total nitrate, ammonium and phosphate content with contact time

Higher ammonium concentration is generated by the biodegradation of the protein portion; also some nitrogen compounds were transferred as NH_3 after bioreaction.

These results suggest that bacteria produce enzymes whose optimal activity takes place at different research (Gabarro et al., 2012).

The presence of these compounds in a high proportion indicates a decrease in the biodegradation rate expressed by the reduction in oxygen consumption, thus decreasing the values of the biochemical oxygen content (BOD) and the chemical oxygen content (COD), the decrease also explained by the depletion of the dissolved oxygen content.

The refore, a slow biodegradation rate determined the increase in BOD and COD content over time to day 16, as shown in figure 3.

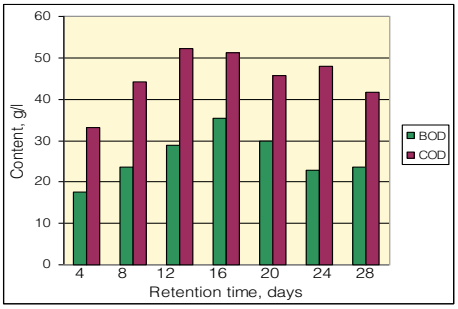

Figure 3. Variation of BOD, COD with contact time

In the period of time when the temperature is lower and consequently the activity of the microorganisms has a reduced intensity, the contact time required to achieve the leaching level required is higher.

Differences in pollutant reduction in leachate can also be attributed to bacteria of different species and variation in bacterial biomass concentration, as well as variation in the composition of the waste.

The continuous reduction of suspended matter, as can be seen from figure 4, can be explained not only by biodegradation processes but also by sedimentation in the aeration lagoon.

As previously shown, the biodegradable activity of the leachate microorganisms is strongly influenced by the pH of the leachate.

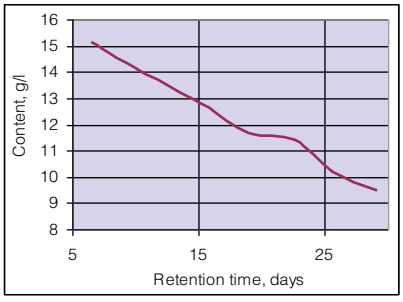

Figure 4. Variation of suspended material with contact time

The average pH of leachate samples for mature deposits is 7.52. According to Umar et al. (2010), the pH of a young leachate is less than 6.5, while for old waste landfills, leachate has a pH greater than 7.5. The low pH of the initial phase is caused by the high concentration of volatile fatty acids (VFAs). Similarly, stabilized leaching shows a fairly constant pH value with small variations ranging from 7.5 to 7.9. (Umar et al., 2010) From the research conducted in our country by Bold O.V. and collaborators, 2012, it was found that the pH of the leachate at the exit from the deposit is basically basic, with values greater than 9.2 (variations between 9.2 and 10.8). Also according to Rashid (2017), most microorganisms exhibit optimal growth at pH values between 6 and 8, and most microorganisms could not tolerate a pH above or below 4.

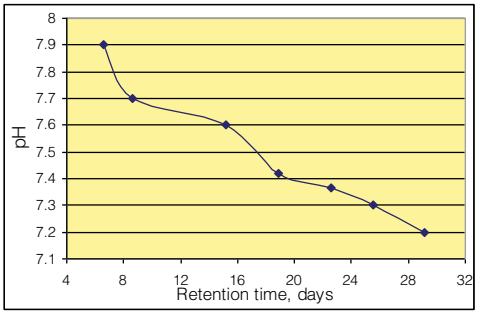

Figure 5. pH variation with contact time

The determinations made in this experiment showed a rather small variation of pH over the determination period (Figure 5), with pH values ranging from 7.2 to 7.9. However, a continuous and relatively uniform pH decrease with increasing contact time is observed.

It is observed in figure 6 that by increasing the pH of the leachate sample from 7.2 to 7.4, the BOD content increased from 23 g/l to 32 g/l and the COD content increased from 42 g/l to 53 g/l.

In these conditions, almost all organic compounds were completely degraded, a phenomenon due to leachate microorganisms.

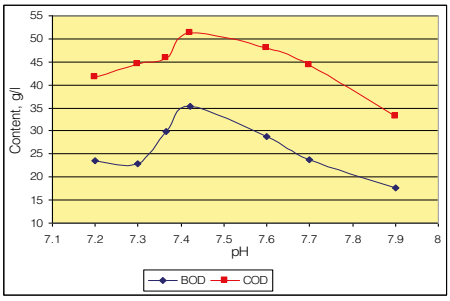

Figure 6. Variation of BOD and COD with leachate pH (2016)

Increasing the pH of the leachate samples over 7.4 has led to a decrease in chemical and biochemical oxygen consumption, which implies a decrease in bacterial activity and a slowing down of the biodegradation process

Over time, the concentrations of the compounds in the leachate decrease, the content being formed by water, dissolved gases and biomass. Quantitative levigate increases in the first 4 years, decreases until the 8th year and finally reaches a value representing about 1‰ of the maximum amount.

It is relevant to the efficiency of purification, first of all, the knowledge of the microorganisms present in the leachate, their activity and evolution and the interaction with other organisms present in the leachate (Fernandes, 2013).

The composition of waste by the high degree of diversification generates similarly a high degree of diversification of the composition of the leachate; thus waste with a high content of biodegradable materials influences its quality.

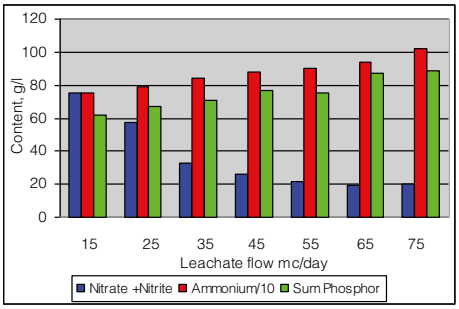

Figure 7. Variation in nitrate, ammonium and phosphate content with leachate rate

Due to the variation in the leachate flow rate and the very high concentrations of pollutants present in the leachate, there is a progressive decrease in the reaction rate until it is canceled; this phenomenon is called **substrate inhibition or product inhibition**. Figures 7 and 8, drawn from experimental determinations, evidence the dependence of various pollutants on leachate flow.

In this case, there are several processes which show the fixation of several substrate molecules, which produces the attenuation of the nitrification-denitrification reactions and thus the decrease of the chemical and biochemical oxygen content from 53.2g/l to 37.6g/l (COD) and 33.4 g/l to 17.2 g/l (BOD), respectively.

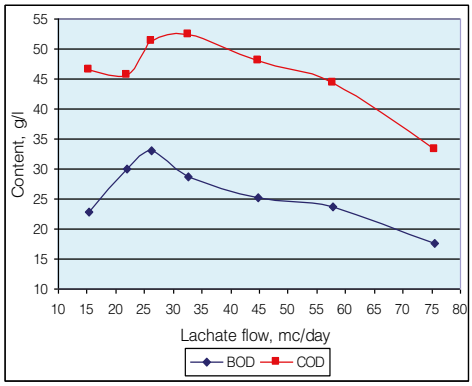

Figure 8. Variation of BOD, COD with leachate rate

The presence of certain substances in waste or leachate can negatively influence the activity of microorganisms that cause the degradation of organic pollutants. Germicides are substances that destroy bacteria by contact, and bacteriostatic agents are chemical compounds that inhibit the reproduction of cells.

Their presence in the aqueous environment can even lead to the extinction of the metabolic process.

Also, antimetabolites are chemicals that destroy or alter metabolic or growth factors - essential factors for the normal life of bacterial cells.

CONCLUSIONS

Microbiological treatment of leachate is an effective method because of technical and economic advantages, consisting of leachate treatment efficiency with high concentrations of organic matter with high nitrogen content and a high ratio COD/BOD.

Experimental determinations have shown an increase in the concentration in the first 16-20 days of treatment with nitrates and nitrites and, therefore, a slow rate of biodegradation of BOD and COD in time, up until the 16th day.

Increasing contact time allowed anaerobic microorganisms in samples of leachate to adjust to the conditions in the lagoon aeration to mix with existing microorganisms in the sludge in the lagoon and to intensify the work of biodegradation. As the contact time was

extended, there was a decrease in the nitrogen content components.

Increasing evidence of leachate pH above 7.4 resulted in the decrease of the chemical and biochemical oxygen demand which implies a decrease in bacterial activity and a slowdown between 7.2 and 7.8 revealed a pH value equal to 7.4 which is the maximum microbiological effectiveness of treatment.

The presence of certain substances in waste or leachate can affect in a negative way the activity of microorganisms that produce germicides degradation of organic pollutants. Germicides are substances that kill bacteria by contact and bacteriostatic agents are chemical compounds that prevent cell reproduction. Their presence in the aqueous environment may even lead to extinction of the metabolic process.

Also anti-metabolites are chemicals that destroy or alter metabolic agents or growth - factors essential for normal life of bacterial cells.

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SUSTAINABLE STRATEGIES ON IRRIGATION MANAGEMENT FOR IRRIGATED MAIN FIELD CROPS (WINTER WHEAT, COTTON, CORN) IN GAP REGION OF TURKEY

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Abstract

To get an appropriate yield and production for winter wheat, it must be irrigated. Cotton and corn must be almost irrigated in the regions grown. Amount of irrigation water of 4000-4500 m^3 ha^{-1} need for optimum wheat production. More than 50% of the country's cotton production is in Southeastern Anatolia Region of Turkey and cotton need amount of irrigation water approximately 10000 m^3 ha^{-1} for an appropriate production using surface irrigation methods. However, the amount of irrigation water of 5 000-6 000 m^3 ha^{-1} is enough if modern irrigation technologies such as drip irrigation are used. Similarly, amount of irrigation water more than 10000 m^3 ha^{-1} has been used for corn production under the surface irrigation conditions and it is possible to save nearly 40-50% of water using drip irrigation method in the same region. One of the most important ways of ensuring sustainability of irrigated agriculture is to use micro irrigation, and it may help in saving significant amount of water and increase the quality and quantity of produce. Thus, it is possible to achieve both higher water productivity and higher yield by means of drip irrigation.

Key words*: cotton, corn, irrigation, sustainability, winter wheat.*

INTRODUCTION

Water scarcity is becoming a significant problem to the sustainability of irrigated agriculture. This issue is of primary interest especially in arid, semi-arid and developing countries where increasing population and standards of living, economic and social development. Thus, the use of water requires careful and continuous assessment of models and strategies and sustainability for water resources.

There are gloabally competitons among sectors used water, agricultural, domestic and industrial use.

This situation has raised the interest of consumers and governments to adopt water conservation practices and to limit environmental charges. We have to consider and/or focus on increasing the efficiency of water use in the the agricultural systems since agricultural sector is the major consumer of water resources because it uses more than 70% of global water resources. Thus, we have to find or/and use ways of efficiently use of water for irrigated agriculture. Efficient irrigation management also contributes to the reduction of environmental impact and sustainable use of resources. On the other hand, excessive irrigation results in low water use efficiency, leaching, and runoff of water, fertilizers, and other agrochemicals, contributing to make the agriculture an important source of non-point source pollution. However, irrigation management involves some technical, socio-economic and environmental issues. Management decisions directly affect the whole chain of water delivery and its application to the fields. Hence, irrigation practices affect quantatities and qualitatives of crops in agricultural production.

The sustainability of irrigation involves many variants and constraints like availability of water as a resource, ecological balance, socio-cultural impacts, and climate change effects.

Considering irrigated agriculture consuming water much more compared to other sectors, we can improve irrigation efficiency by some adopting practices such as deficit irrigation, appropriate irrigation scheduling, installing more efficient irrigation systems and conservation tillage.

Irrigation is vital important input to grow some main crops and increase yield and crop production in Southeastern Anatolia Region of Turkey since it has climate characteristics. Thus, irrigation might increase the yield from 100% up to 500% depending on soil and

climatic conditions, agricultural practices and technologies and farmer conditions.
Total cultivated agricultural area in Turkey is 23.7 million ha. The ratio of the main field crops used in Turkey are 32% wheat (7.7 million ha), 2.9% corn (0.68 million ha) and 1.7% cotton (0.416 million ha).
Water is the main limiting factor affecting agricultural production in arid and semiarid regions in the nearly whole areas of Turkey. The winter wheat are grown the all regions of Turkey. However, to get an appropriate yield and production, it should be irrigated. Cotton and corn must be almost irrigated in the regions grown.
In this article, it is discussed and given sustainable strategies on irrigation management for irrigated main field crops (winter wheat, cotton, corn) in Southeastern Anatolia Region of Turkey

WINTER WHEAT

Wheat is the most important world crop grown on more of the world's area than any other crop in terms of feeding of human. Turkey is in arid and semi-arid region, wheat production depends strongly on annual rainfall and irrigation. The effects of rainfall amount and distribution, temperature, nitrogen and irrigation according to growing stages of wheat on yield were not independent from each other.
Yields and quality are changing by regions and by fields due to irrigation and precipitation differences. If well-distributed rains in the spring resulted in high yields beyond farmers' expectations, favorable weather conditions had contributed to wheat yields (Karabina, 2017).
Insufficient rainfall especially in the late spring period limits wheat production in the Mediterranean countries. Western Turkey will have constraints in wheat production in future due to water deficits in spring and summer due to the expected climatic changes (Erekul et al., 2012).
Rosenzweig (1991) stated that higher temperature was the major cause of yield reductions because shorter crop life cycles occurred with corresponding decreases in grain filling.
The principle climatic factors affecting crop production are precipitation, temperature length of growing season light and wind.
On the other hand, increasing temperature due to climatic change would speed development rate and reduce the phenological period. Significant reduction in grain yield as a result of the drought after flowering stage was found (Gevrek and Atasoy, 2012). The negative effect of early drought (before milk stage) on grain yield was more significant than that of late drought (after milk stage) (Ozturtk, 1999).
In the study area, Southeastern Anatolia Region of Turkey, seasonal water consumption of winter wheat is about 750 mm and amount of irrigation water requirement is about 450 mm. The critical stages of wheat for irrigation are sowing, booting, heading and milk formation. In general, rainfall is appropriate during sowing and booting stages except occurring extreme drought conditions. The two stages, heading and milk formation depending on climatic conditions are significantly important water demand thus; these two stages must be irrigated but irrigated primarily.
As the economic maximum fertilizer nitrogen, the rates of 70 kg N/ha under non-irrigation conditions and 150-170 kg N/ha under irrigated (one at the beginning of heading and one at the beginning of milk stages) conditions can be recommended. However, in case of drought occurrence, the rate of 120- 130 kg N/ha may be used under irrigated conditions. Drought or limitation of the rainfall limits use of nitrogen and its positive effects on grain yield (Cetin, 1993a; Cetin and Ogretir, 2000).

COTTON

Cotton is an important cultivation to the general economy because it provides fiber for textiles. Southeastern Anatolia Region is one of the most important cotton-producing areas in Turkey, accounting for more than 50% the country's cotton production. Cotton is, thus, one of the main crops grown in irrigated fields in this area. Cotton crop can grow method irrigation in this region since climatic conditions, dry and arid conditions.
Most of the cotton fields in the area are irrigated by surface irrigation. However, the use of drip irrigation and fertirrigation for cotton has increased enormously as a result of government subsidies. Drip irrigation and fertirrigation techniques are more and complex

compared with conventional applications such as surface irrigation and fertilizing. (Cetin et al., 2015).

Three stages of cotton crop, vegetative stage (sowing-flowering) (I), flowering-ball formation (II), ball formation-opening of balls (about 10-15%) are significantly important in terms of irrigation and water consumptive use. If deficit irrigation is considered, it should not be applied at the stages of II and III. However, it should apply at the only stage of sowing-flowering if it is needed (Kara and Gunduz, 1998).

Comparing to different irrigation methods on cotton yield, drip irrigation produced 21% more seed-cotton than the furrow method. Hence, drip irrigation resulted in not only higher cotton yield but also considerable water savings. At the same time, the highest IWUE was recorded in drip-irrigated plots. Thus, use of drip irrigation increased not only yield but also saving water (30-40%) compared to conventional irrigation (surface-furrow irrigation) (Çetin, 1993b).

Sprinkler irrigation increase the shedding reaction of cotton compared to furrow and drip irrigation, thus, if cotton irrigated by sprinkler during the noon time, the yield can lower since increasing shedding. Three main reason for higher shedding ratio with the sprinkler method may be attributed to moisture stress in the soil profile under the extreme climatic such as very low relative humidity (33%) with high temperature up to 46.8^{o}C (Cetin and Bilgel, 2002).

On the other hand, nitrogen fertirrigation by drip irrigation should apply with one-fifth of the total amount of N during sowing through the soil and equal applications of the remaining N every two irrigations (10 days). For this, one-fifth of the total N should be applied to the soil at sowing, and the remaining N should be applied in equal doses (an average of 7 fertigations) every two irrigations (10 days) by fertirrigation.

CORN

The areas grown and cultivated corn in Turkey is 68% of grains and 32% silage (Özden, 2017). The production and cultivated areas of corn have increased depending on increasing irrigation lands.

Corn as a second crop in the Southeastern Region of Turkey are more suitable and appropriate because of climatic conditions and long growing season. However, corn growth needs more amount of irrigation water compared to the other regions of Turkey. Because of high temperature (up to 46.8^{o}C) and very low relative humidity (~15%) cause much more water consumption. For this, corn needs about 1000 mm (or 10000 m^{3}/ha) of irrigation water if the surface irrigation (furrow method) is used.

Corn is grown under irrigated conditions and, therefore, requires higher amounts of irrigation water compared to the other field crops (Musick et al., 1990; Cetin, 1996).

Highest average corn grain yield (11920 kg/ha) was obtained from the full irrigation treatment with six-day irrigation interval.

Irrigation intervals did not affect corn yields; however, deficit irrigation affected crop yields by reducing seed mass and the seed number.

Deficit irrigation generally reduced corn yields. Irrigating at less than 100% of pan evaporation may not produce enough leaching for a salt balance in the root zone since the average annual rainfall in the project area is only 38 mm. Thus, deficit irrigation of corn with a trickle system is not recommended for the region. The trickle system permitted precise control of irrigation applications. With proper management, trickle irrigation can avoid some application losses, which are inevitable with sprinkler and surface methods.

Water savings in the vicinity of 50% could be possible with trickle systems under proper management (Yazar et al., 2002).

The trickle irrigation systems can be used successfully for irrigation of corn under the climatic conditions of the GAP area in Turkey. However, a final decision on using trickle systems for irrigating corn in this region should be made after a thorough economic analysis Each 6 day interval and water irrigation need about 581 mm and yield 11.9 t/ha (Yazar et al., 2002).

The optimum level of irrigation was 100% Class A pan evaporation for optimum dry matter of silage corn.

When calculating the amount of irrigation water for the drip-irrigated silage corn production, an optimum wetted area must be

considered. In this study, an appropriate value was 0.65. Thus, the requirement of irrigation water was 447 mm in average value. Similarly, the optimum nitrogen frequency was application of one-fifth of the total amount of N fertilizer at the sowing date, with the remaining N applied at each irrigation cycle for 5 days based on 240 kg ha^{-1} N. (Yolcu and Cetin, 2015).

CONCLUSIONS

Considering sustainability of irrigation and optimum use of water resources, drip irrigation is more adapted to climate change. It certainly does reduce evaporative losses, and reduces fertilizer use when liquid fertilizer is added to the mix and delivered precisely to the root of the plant (fertirrigation). Thus, the use of micro irrigation system will save significant amount of water compared to traditional method of irrigation such as level borders and furrows. Large-scale adoption of drip irrigation for cotton and corn can, thus, serve as successful examples for efficient use of water.

Micro-irrigation has been particularly successful for not only horticultural, ornamental and landscape applications but also field crops. Thus, it could be applied to a wide range of climatic conditions from humid to arid and semi-arid regions and all topographic conditions. Its advantages with respect to water and energy savings, increased yields, improved fertilizer application, reduced the rate of salinization, eliminated wood and diseases, and reduced labor, are well recognized.

On the other hand, having the highest water use efficiency does not mean that net returns will be highest. As more water is applied per land area, crop yields generally increase, but each increase in yield is less than for the previous unit of water applied.

Converting to drip can be expensive because it requires water in pressurized pipes (rather than open, gravity-fed canals) or requires a large storage pond on each farm and energy. However, Ministry of Food, Agriculture and Livestock in Turkey is subsidized as 50% of total investment of drip irrigation for farmers

As a result, it is possible to save nearly 40-50% of water using drip irrigation method in the region. One of the most important ways of ensuring sustainability of irrigated agriculture is to use micro irrigation, and it may help in saving significant amount of water and increase the quality and quantity of produce. Thus, it is possible to achieve both higher water productivity and higher yield by means of drip irrigation.

Considering sustainability of irrigation, physical productivity (water use efficiency) and economical productivity (net return per unit area and per unit volumetric water) of irrigation water should be evaluated and taken into account together with them.

The farmers should be, thus, used yield-response curve pertaining each soil and climatic conditions to get an economical yield for any crop.

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SOCIO-ECONOMIC IMPACT ASSESSMENT IN RURAL DEVELOPMENT– CASE STUDY CAMELINA PRODUCTION IN ROMANIA

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Abstract

This paper aims to present a solution for the fragmented agricultural land in the rural area of Romania, involving farmers and local authorities from different villages. The need to set up local associations for everybody's benefit is further explored, based on the outcome of the EC Project ITAKA, of which Romanian organisations were partners. A framework is proposed, SEIA (Socio-Economic Impact Assessment), to investigate the social aspects and economic impacts associated with Camelina feedstock production. The selected feedstock is linked to the aviation biofuel production, thus a strong argument for economic diversity and prosperity. An understanding of local culture was essential when recording community perception relating to Camelina investment and production in a particular area from Cluj County. The SEIA used in Romania was structured primarily around development and economic factors: land ownership and use, levels of agricultural mechanisation, the size of the available workforce, existing infrastructure and level of taxes raised. Social aspects linked to quality of life, incorporated into the 'people development' category, included increased employment and lower social costs, better education and health, a cleaner environment. A different feedstock of economic interest may be considered, but the main objective is to find proper solutions for a fertile, but uncultivated land in Romania's rural area.

Key words*: socio-economic impact, rural development, Camelina feedstock, community.*

INTRODUCTION

Over the past 50 years, the amount of land given over to farming has declined due to the introduction into Europe of cheap food products (Millstone E., 1999).
Considerable areas of land have also been lost to food production due to contamination caused by industrial processes (Schierhorn et al., 2013).
These changes have been driven by and taken place, a long side growing patterns of migration into urban areas (Pasakarnis G. and Maliene V., 2010), which have led to increasing levels of poverty and social deprivation in many rural communities.
The production of biofuels, which are seen as a way of addressing the challenge of energy security through the growing and processing of crops (such as Camelina), has the potential to revitalised rural communities, creating employment, supporting social and economic growth and developing new skills.
The sustainability of biofuels from agricultural sources is however, a critical issue that needs to be assessed before large scale production can be considered, and given that this industry could compete with food production through land use and water supplies and, therefore threaten food security.
The aim of this paper is to challenge some of the outputs of the SEIA (Socio-Economic Impact Assessment) framework presented in the ITAKA (Initiative Towards sustAinable Kerosene for Aviation) project (www.itaka-project.eu).
The area considered is the Sanmartin Commune from Cluj County, an area comprising 8 villages.
The main objectives are to identify the relevant social and economic aspects, to assess the potential development impacts associated to Camelina production and propose a SEA framework which can be later adapted to other Romanian regions, such as Targu-Mures and Satu-Mare.

MATERIALS AND METHODS

As a methodological tool, SEIA is designed to assist communities in making decisions that promote long-term sustainability, including economic prosperity and social development, which leads to an increased quality of life. There are no methods that are universally applicable, and these must be developed on the local level (Eijck et al., 2013). A reliable sustainability assessment methodology requires location-specific and operational data. Existing SEIA Guidelines (MacDonald, 2006) need to be followed (or proper guidelines developed) prior to start the SEIA process. The approach used in this paper was to explore the socio-economic impact of Camelina production via a case study scenario that was representative of small rural villages, based on experience with Camelina cultivation in 2014 & 2015, as part of ITAKA project, involving a *baseline survey*, which was conducted to gather the necessary data, using a *mix methodology* (quantitative and qualitative) for identifying and quantifying the SEIA pillars.

The SEIA Framework was designed based on selected socio-economic values and available data for the selected case-study. Subsequent phases required the application of this Framework to Sanmartin area, to identify existing challenges related to Camelina production in terms of opportunities, benefits and risks that could be later mitigated. Experience on rural challenges from Targu-Mures and Satu-Mare gave a better perspective to this particular context.

RESULTS AND DISCUSSIONS

Scenario development

The selected case study was Sanmartin Commune from Cluj County: altitude 320 m, population 1384 (2012 census). Out of 8 villages, which are Sanmartin, Diviciorii Mici, Diviciorii Mari, Mahal, Targusor, Samboieni, Cutca and Ceaba, only 3 were involved in this study: Sanmartin, Cutca and Targusor. (https://www.google.com/maps/@47.0322852,24.086648,1830m/data=!3m1!1e3)

It is worth to mention, the census of 2002 recorded a population of 1744 inhabitants in the Sanmartin commune. The difference illustrates an evidence of population leaving rural area due to poor economic conditions. Adding this aspect to the ageing population in the villages, it makes the socio-economic aspects of the selected area, a real challenge.

Figure 1. Targusor/Sanmartin: images of fragmented land - via satellite (30 March, 2018)

The trial of Camelina cultivation took place during the autumn of 2014 and summer of 2015. The land involved was only existing agricultural land, using Camelina as a rotation crop. Land-use change was not an issue. The aspect of productivity was not important in this exercise, only the perception of the importance of cultivating a crop with potential for large, economic contracts was considered, based on the potential of Camelina value chain in aviation biofuels production.

Figure 2. Camelina - in Pirloage, Targusor (12 March, 2015)

The stakeholders involved were: land owners (8), farmers (12), work force (9), and local authorities (6). The fragmented land constituted an issue from the beginning, the involvement of cultivated land varying from 0.5 ha to max 7 ha. The study started with a roundtable discussion held at Sanmartin village Hall, to explain the aims and objectives of this study and challenge the knowledge of sustainability, while mentioning *fuel versus food approach*. The initial objectives were shaped based on the interest of the stakeholders involved: better quality of life based on an economic perspective due to the cultivation of a new crop in the region.

The selected SEIA method used in the ITAKA project needed to be adjusted and partly modified to local situation, in order to engage with the main stakeholders. The background information from literature was poor for Sanmartin area, so a semi-structured interview proved the best option to capture the perception of respondent(s) regarding possible interests, advantages or risks associated to Camelina production. The data gathered on existing infrastructure was split into two categories, given the fact that respondents had knowledge of existing infrastructure needs (hard infrastructure), level of education and health services (soft infrastructure).

Thus, the hard infrastructure involved questions related to the existing state of the roads, water supply, sewage system, gas and electricity supply.

The soft infrastructure represented the access to health and education, logistics and communication aspects (telephone, mobile), access to information (library, computers), hospitality in the area etc.

Measuring the perception of social well-being showed the aspects of roads and water supply being a priority in developing the local infrastructure, but lack of proper health facility was also mentioned.

The questions were formulated around the following pillars:

- Existing local regulations and stakeholders involved: what legislation needs to be known and who are the stakeholders involved in SEIA process: landowners, farmers, workforce, NGO, local authority etc.
- Local ownership and involvement: who is the land owner: private, association, state; how large is the community; population size: how large is the selected trial.
- Taxation policy at local, regional, national and EU level: tax on land at different level; any kind of subsidies
- Selected villages and consideration (infrastructure, income, work-force, employability, education, health).
- Assessing and Quantifying Socio-Economic Impact at local level; represent benefits, *profits* due to Camelina production versus *risk*s vulnerability.

The information gathered needs to be refined from time to time and the link between pillars may change, according to the assessment outcome.

This type of social change is more problematic to quantify than changes in the economic environment, because the assessment relies on the perceptions of residents about the proposed development. This part of survey was better covered through interview, when participants were asked to make explicit their perceptions and attitudes about the anticipated changes in the social environment when Camelina production will be a reality, not a project.

Data collection

Data acquisition had two approaches: published statistical data and newly collected field data, gathered via a questionnaire and consultation with land owners, farmers, workforce and local authorities, via several interviews.

The SEIA developed for use in Sanmartin area was structured mainly around development and economic factors: land ownership and use, mechanisation, local workforce, development of hard and soft infrastructure, taxes on land and profit due to investments. Social aspects and quality of life are incorporated in 'people development' box, which implies increased employment/lower social costs, better education and health, cleaner environment. 'Rural social cohesion' box, which shows aspects of depopulation and induced growth, illustrate also social aspects related to SEIA.

Following collection of primary and secondary data, a statistical analysis was carried out to

provide an understanding of, and mapping of the positive social and economic impacts and benefits of Camelina cultivation, as well as to identify associated risks that could be later mitigated.

The analysis revealed different impacts depending on type of stakeholders' involved in Camelina feedstock production:

1. impacts upon landowners and farmers;
2. impacts upon workforce;
3. impacts upon local authorities/local communities/NGOs.

Impacts (social, economic and combined) were in some cases perceived and in others, deduced from data analysis.

The positive impacts

The social dimension

The results of the ITAKA study demonstrate that the social benefits of biofuel (i.e. Camelina feedstock) production can be broken down into those relating to an increased employment and standard of living for the local workforce and those that contribute to increased social cohesion and stability for rural communities. The former being of greater significance in Romania and the latter aspect being more important in Spain, where the local workforce comprised a number of different nationalities and some were seasonal workers. The application of these results in Sanmartin case-study proved *the economic aspects being more important than the social ones*.

Macroeconomic effects

The use of indigenous resources implies that much of the expenditure on energy provision is retained locally and is re-circulated within the local/regional economy giving rise to the development of secondary industries and associated services. The increased use of biofuels, which exhibits both a broad geographical distribution, and diversity of feedstock, could secure long-run access to energy supplies at relatively constant costs for the foreseeable future. Camelina can be used for transport sector in general, for cosmetics (oil) and as animal feed (Camelina cake). If Camelina is grown on contaminated land, a special assessment needs to be conducted.

In this particular case-study, the use of Camelina oil for cosmetics and farmaceutical industry proved a better, sustainable solution, due to predicted small quantities, based on a fragmented land which requires a farmers' association to be set up in the region.

Supply side effects

Supply side effects are likely to differ in kind and will depend upon the development (i.e. especially in Romania), but generally such 'economies of speculation' relate to changes and improvements in local/regional productivity, enhanced competitiveness, as well as any investment in resources to accommodate any inward migration that may result from the development. The insufficient data gathered during this survey did not help a clear conclusion on this aspect.

The negative impacts

According to the results of the ITAKA project applied to this study, and mainly from the perceptions assessed via interviews, the negative impacts of Camelina feedstock production are anticipated to include: an adverse impact upon existing farming activities, biodiversity losses and congestion on local roads and in communities due to increased traffic. However, these views were countered by experts who saw improvements in agricultural output, particularly in Romania. In addition, given that proposals for development of a Camelina value chain need to comply with sustainability criteria detailed in the RSB Principles, these negative aspects are likely to be avoided, diminished or mitigated. Sustainable rural development has a basic rule, which says that an advantageous economic development needs to be based on sustainable principles regarding all natural components: air, water, soil, biodiversity, forests and underground resources. These issues play an important role in community life and are representatives for rural communities, expressing strong conservation values and beliefs. In the Sanmartin case-study, these values were firstly explained, and then debated. The approach to 'conservation villages' and natural resources' was brought to discussion mainly by farmers, incorporating 'clean air & water' as a component of environment.

The Camelina cultivation impacts seem to be felt mostly in the economic areas, related to job creation and employment opportunities, as well as opportunities for local economy

diversification. Furthermore, at each community level, the positive impacts and benefits, on one hand, and the uncertainties on the other, could now be put together (due to SEIA process), for a better understanding of risk mitigation areas.

The expected impact on main population groupings involved:

- **The impact on workforce:** for rural areas, Camelina production has the potential to provide significant (direct and indirect) employment opportunities for local people, both those looking for work and those looking for employment improvement
- **The impact on farmers/landowners** Camelina crop is an attractive feedstock as it does not require significant or costly agricultural input (e.g. fertilizers) and requires low specialisation agricultural machinery. Given the low agricultural mechanization level in Romania, this crop will be attractive not only for big farmers but also for small local agricultural companies and small family-owned businesses.
- **The impact on Local community/Local authorities:** By promoting and helping expand Camelina crop production, the local economy will benefit in terms of new jobs, an increase in local tax collected, economic diversification (as farmers source materials and services locally) and the development of better services, as people have more to spend locally. Local authorities see additional benefits in promoting rural development and reducing urban migration.

An important secondary benefit generated by this feedstock is related to its use on abandoned and contaminated soil. Camelina cultivation may also improve soil quality and productivity as factor of soil remediation, this constituting the second benefit.

Discussion

One important requirement when assessing socio-economic benefits is to find the appropriate balance between the needs and aspirations of different stakeholders (local authorities, farmers and landowners, the local workforce and NGOs), taking account of their capabilities and incentives, the potential benefits that accrue to each, and the potential risks of investing in Camelina feedstock production.

It is important to reiterate that the SEIA conducted in Romania and Spain as part of the ITAKA project was an initial exercise, the aim being to design a framework and explain how it works. This framework now needs to be refined with additional data and recorded perceptions and comments received from stakeholders involved. The framework proposed for Sanmartin case-study (Fig 3) is a concrete illustration of the ITAKA outcome. The interest and engagement of the selected participants is a confirmation of a proper selection of SEIA pillars. Defining quality of life differs from the illustrated case-studies in ITAKA project, as in the Sanmartin case-study, the hard infrastructure being basic and poor (no water supply or sewage infrastructure in the houses), was evidence based of the need for improved economic conditions before talking about social cohesion.

Engagement of the local workforce is seen to be key to sustaining rural communities, both in terms of their willingness to develop the necessary skills to support Camelina feedstock production, and in terms of their interest in remaining to live and work in these local communities. In this regard, local authorities, farmers and land owners need to work together to support local workforce development programmes.

The relevance of the findings

The findings of the Baseline Survey show a clear interest in promoting Camelina production amongst three groups of stakeholders, local authorities, farmers and landowners, as well as the local workforce.

Stakeholders

- Are primarily concerned about economic security, so job creation is seen as essential and risks associated to Camelina production are almost ignored. This is also reflected in the ITAKA SEIA report which demonstrates that Romanian respondents identified mitigation options for all identified risks.

- Social aspects are perceived mainly through employment opportunities with job creation being suggested as a direct link to improved quality of life.
- Agricultural land utilisation was of concern, including uncultivated land, however there is recognition of the benefits and opportunities of growing Camelina on larger areas, generated by setting up of local associations.
- The ageing population, which will translate in lack of local workforce, was seen as a challenge but the opportunities of creating local employment and therefore reducing rural to urban migration of young people was seen as an opportunity.
- Local authorities welcome Camelina feedstock production, seeing direct benefits in terms of opportunities for improved local infrastructure: roads, water and sewage.

The potential workforce needed to support Camelina production is generally local and their current income is mainly from agricultural activities.

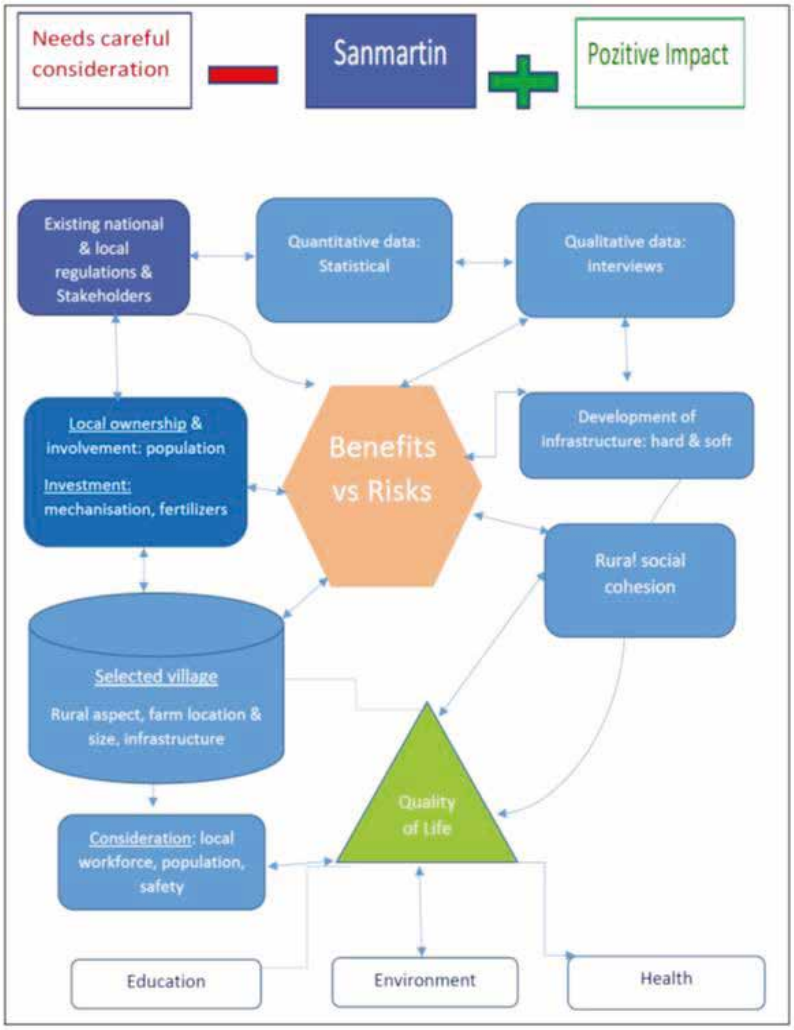

Figure 3. Proposed SEIA Framework based on the survey results (addapted from Dimitriu, 2016)

Drivers in expanding Camelina production

One important subject that would influence attitudes is an understanding of the benefits and risks of expanding Camelina feedstock production. According to ITAKA project, in both Romania and Spain, *farmers seem to be the main drivers,* as they have the necessary knowledge of the issues and connections to mitigate any production-related risks at local level. In Romania, farmers were interested in working with Local Authorities to nurture and develop local skills, and this proved true in the Sanmartin case study as well. Another reason for engagement by farmers and a willingness to commit the investment is that many are looking to diversify away from their current crops and Camelina is a very promising option. It is noteworthy that Romanian farmers expressed an interest in developing long term contracts, linked to markets for oil, seeds and Camelina cake. Considering the existence of several cattle herds in Sanmartin region, Camelina cake was welcome by the local farmers.

Difficulties and lesson learned

The most challenging part of this study was the collection of socio-economic data, as part of initial survey. Sanmartin stakeholders engaged positively with the study, providing their unpaid time, both out of curiosity and in the hope of securing investment in Camelina feedstock production at a later stage, following completion of the ITAKA project. Although initially there was some reluctance to engage in the project, the example given by those involved in Camelina cultivation, made other farmers and land owners curious about this new feedstock in the area and asked permission to have access to the study, to provide their thoughts and discuss the results. Thus, although the involvement in the survey was small as number (34 participants), it remains representative to the population of Sanmartin commune and it can be stated that the stakeholders engagement was above the expectations.

To some extent, data may be considered skewed towards those with a vested interest (farmers/landowners) and therefore prepared to give up their valuable time. This is explained quite simply by their desire to seek out opportunities for local economic diversification.

Data collection presented some obstacles, as even where data were available, they were often incomplete, or included information (from different sources – e.g. census and national statistics) that were contradictory or confusing. Due to existing different data sources to gather primary data, additional information from Local authorities, was of a great help.

Lesson learned

This study has revealed the following lessons for application in future research (similar with the ITAKA project ones):

- All appropriate survey methods need to be initially considered, with the specific methodology chosen for final use selected after consultation with key stakeholders.
- The availability of economic, agricultural, labour force and other structural and census data needs to be confirmed prior to the finalisation of the survey methodology.
- An understanding of local conditions and local culture is critical not just to ensure engagement from stakeholders, but also to design an appropriate SEIA framework and maximise opportunities for securing the appropriate data to provide meaningful outputs.
- The benefits of spending more time with community leaders to take on board their views regarding issues of local significance such as priorities, existing projects, the role of, and need for economic diversification or social cohesion.
- The need to redesign the SEIA framework to take on board lessons learnt during initial questionnaire and survey work.
- There is a need to *proactively engage* with key stakeholder groups, provide the appropriate information and develop an awareness campaign well in advance of the study, to maximise levels of engagement and participation.

The broad SEIA Framework adopted for this task proved to be an effective way of assessing

the potential social and economic impacts of Camelina feedstock production in both countries, but the precise methodology adopted had to be adapted to the particular conditions, culture and data availability at each study location.

CONCLUSIONS

The Sanmartin case-study was an application of the ITAKA project outcome, aiming at motivating farmers to set up associations in order to increase the productivity of a very fertile- but uncultivated and under-cultivated land.

The results indicate existing perceptions of a net positive socio-economic impact, brought by Camelina as a new feedstock.

However, further investigation would be required to fully confirm this, given that this approach to SEIA is in its infancy and, also, considering the scarcity of data collected from this selected case-study.

There is considerable potential to undertake a more comprehensive assessment of the potential economic benefits of extensive Camelia cultivation across Romania, using data on local and national taxation, local economic development, local employment and job creation potential.

The tool developed in this research could be further refines to facilitate an economic study. Additional trials are foreseen for Targu-Mures and Satu Mare regions.

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STUDY ON IMPLEMENTED AND FUTURE PROJECTS FOR SUSTAINABLE DEVELOPMENT IN AGHIRESU AREA, CLUJ COUNTY

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Abstract

The study aimed the development of the rural environment in Aghiresu area, for a sustainable and inclusive economy, necessary for the ambitious targets of the member states of the European Union. The National Rural Development Program is considering projects to support agricultural practices that protect the environment. Through sustainable agriculture, the natural space is preserved, the landscape is protected, and biodiversity is defended. Identifying future projects, favorable to the Aghiresu area, Cluj County is an important factor for sustainable rural development and environmental protection. Through the active involvement of local authorities and financial support from the European Union, projects that are important for the local community and also for neighboring areas have been developed. Through inadequate farming practices the soil degradation has been increased. Measures for soil protection and restoration by reducing the amount of fertilizers and pesticides have been shown to have beneficial effects on the quality of agri-food products, animal welfare and human health. Agri-environment schemes have been beneficial for the protection of soil resources. Soil improvement and waste treatment measures lead to a healthy environment.

Keywords*: soil erosion, slope stability, waste treatment, environment.*

INTRODUCTION

The rural environment is a space with great importance for Romania, considering the significant area, namely 90% of the entire country. The share of rural residents is among the largest in Europe, over 46% of the total population. Starting from this data, it can be noticed that the development of the rural environment through sustainable development projects represents a main starting point for sustaining and future of the agricultural sector and agricultural activities. For the rural and urban population, the need for food can be mostly satisfied through farming on fertile land from rural areas, where much time has to be spent for work in nature, and considerable amounts of money must be invested for the superior quality of the soil (Dirja and Salagean, 2015; Omar et al., 2013). The projects that have improved living conditions in rural areas can be found in good quality infrastructure, land improvement activities, and rural tourism development (Grigore et al., 2009; Eswaran et al., 2001). In this context, this paper presents an analysis of the projects developed in the Aghiresu area, in order to highlight the significant investments made in road infrastructure as well as several land improvement activities for the development of agricultural activities, based on data from the period 1990-2017.

MATERIALS AND METHODS

The study was made in the North-West part of Romania, Aghiresu area, Cluj County. In order to characterize the rural environment, the data used refers to types of projects developed, the areas where they were implemented, the value of the investments, and the number of inhabitants who benefited from the projects. The data were collected from the Aghiresu Local Council, Cluj County, as well as from the website of the National Institute of Statistics - INSSE, and have been statistically processed and interpreted.

RESULTS AND DISCUSSIONS

Located in Transylvania, in the „Dealurile Cluj" area, Aghiresu is one of the 75 existing communes in Cluj County, and is one of the most important areas. Surface where the study was applied has 105.8 km² and it is situated at an altitude of 447 m. The economy of the area is based on surface mining, agricultural production, animal husbandry, trade activities,

handicraft, and tailoring. To promote the area and bring the necessary services closer to citizens, the economic investors were supported by local authorities, so that in Aghiresu-Fabrici was built a fuel station and a bank unit, and at the same time was arranged a minimarket, these being just some of the local investments after 2000. Unfortunately, the lack of necessary funds for the development of the area after 1989 has determined this area to develop very little in the period 1990-2000, when only maintenance works was done. No significant projects have been made for the sustainable development of the area, even more, the number of employees in the enterprise has been reduced and many locals had to start commuting by train in Cluj-Napoca or in Huedin, where they have found a job. In the studied area there is a population of 6755 people (2017). The research also highlighted the fact that the poverty rate was high for this period, benefiting even from humanitarian aid from some developed European Union countries. After the integration of Romania into the European Union in 2007 and until now, it has been noticed that in the Aghiresu area, a large number of people have gone looking for a better paid job in other developed countries.

Of these investments, it should be noted those made through the European SAPARD program, through which it was introduced the sewerage system in Aghiresu-Fabrici, the most populated village of the commune, a project worth 829,971.63 Euro and which was accomplished with many difficulties between October 2002 and May 2007 (Figure 1).

Figure 1. Sewage treatment plant from Aghiresu-Fabrici

In 2009, through the provisions of O.G. No.7/2006 on the establishment of the Rural Infrastructure Development Program, the sports centre in Aghiresu-Fabrici was modernized; the football field was also rehabilitated, by a project that worth 53,576 Euro, an investment with a special importance considering the possibility, afterwards, to organize sports competitions and increase the health of young people in the area (Figure 2).

Figure 2. The sport base and football field from Aghiresu

In 2011, a project for the extension of the water supply and waste water sewerage network in Aghiresu-Fabrici was implemented.

Through the project of the National Agency for Land Reclamation (ANIF) Cluj, in 2014 was made the reception for the work „Regularization of leakage on the slopes and prevention of landslides in Somesul Mic hydrographic basin, Valea Inucului sub-basin, Cluj County", through which an area of 450 hectares was rehabilitated by an investment of 238,961.201Euro (Figure 3).

Figure 3. Land reclamation works in Inucu area

In 2015 have had begun works in order to achieve construction-installation works on the completion of the investment objective: „School sports hall with level of local competitive sports practice, handball field and 150 seats for spectators, Aghiresu-Fabrici village, no. 367, Cluj County", the estimated price of the works was 811,802.446 Euro.

In 2016, with the non-reimbursable financial support of AFIR (Agency for Rural Investment Financing) the project for the modernization of communal roads, in Aghiresu-Fabrici village and endowment of the house of culture, in the commune of Aghiresu, the second place after the number of inhabitants, a project with a total eligible value of 113,074 Euro. In September 2016, Cluj County Council started a comprehensive program of maintenance and repair works aimed at a section with a total length of 22.4 km of the county road DJ 108C Gârbău - Aghiresu, which is a very important investment for improvement of the quality of life (Figure 4).

Sustainable rural development in the studied area had as a priority the creation of better living conditions for the inhabitants, attracting investors and combating the phenomenon of migration of rural youth to urban areas.

Figure 4. Modernization of communal roads

In the study, it has been noticed that significant amounts have been allocated to infrastructure, which has improved the quality of life in the Aghiresu area. In the chart below (Figure 5) it is represented the value of significant investments in Aghiresu area, during a period of ten years, presented above in the paper.

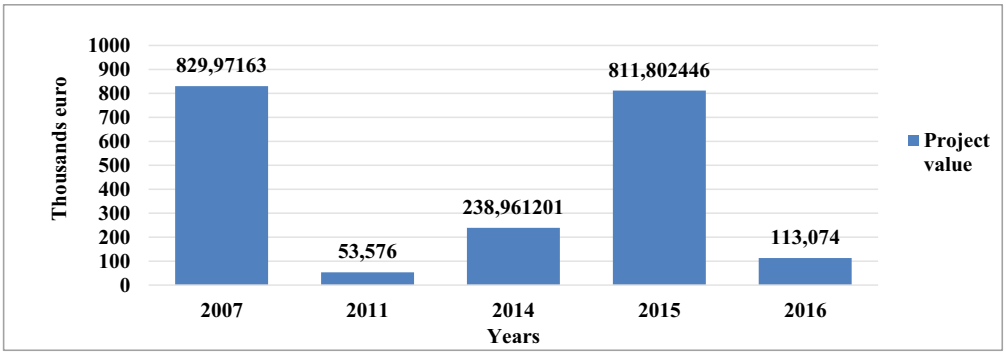

Figure 5. The value of significant investments in Aghiresu area, during a period of ten years

Through specially designed programs, in order to support the preparations for the accession of the countries of Central and Eastern Europe, starting with 2002, the Special Accession Program for Agriculture and Rural Development (SAPARD) was implemented and then, after its reorganization by the Romanian Government, continued in our country with the name APDRP - AFIR.

The Local Action Group NAPOCA Porolissum contribute to the socio-economic development in the area and comprises 13 communes, namely Aghiresu, Capusu Mare, Gilau, Maguri-Racatau, Izvoru Crisului, Manastireni, Risca, Marisel, Belis, Margau, Calatele, Sacuieu, Sancraiu and the Huedin town. The research has shown that road infrastructure is of good quality and has connections with national roads and highway sections, which greatly contributes to raising the quality of life, and is an essential factor for freight traffic and road transport. The Aghiresu area is significant by their numerous subsoil riches, such as quartz sands, kaolin and dacite tuft. In the studied area there is also the natural reserve „Gipsurile de la Leghia", a natural monument, a protected area of national interest that corresponds to IUCN, IV category. Through the serious involvement of local authorities in Aghiresu, for the problems that the community is still confronted with, solutions have been identified and projects have been implemented and, according to the data obtained, it results that other projects will be carried out, which will support the economic development of the area and the fight against the poverty.

The variety of gypsum in the area, called alabaster, has been exploited for decades to make decorative and handicraft articles. Setting up the local action group and implicitly the development of the area through the projects that will be presented below, have led to the improvement of the quality of life of the inhabitants and to the reduction of poverty; for the entire G.A.L. the weighted average for poverty, indicates 33.31% and for the Aghiresu area 28.9%, according to data corresponding to 2016 (INSSE-2018). The new rural strategy for Romania, by implementing the sustainable rural development tools, should result in the Romanian rural structures getting compatible with the EU rural structures in a short period of time. At the same time, the Romanian rural area also needs a modern infrastructure, correlated with the present needs of life in the countryside and with the complex rural economic activity (Otiman, 2008).

Considering the way of evaluating and re-evaluating the administrative-territorial units in terms of the tourism potential of the territory, which was carried out on two levels, the evaluation of the concentration of the natural and anthropic tourism resources and the diagnosis of the technical and tourist infrastructure dysfunctions, the studied area obtained assessment note 4, which is a good score compared to the other communes in the neighbourhood (http://www.mdrap.ro).

Statistically, many young families in the commune have gone to work in other EU countries, which have led to a decline in the number of people employed in agriculture even though there are real opportunities in the area for the development of organic businesses, agricultural land being of good quality.

Future projects for the studied area, regarding sustainability are building a synthetic football field at Aghiresu-Fabrici school, and the rehabilitation of eight smaller houses of culture in villages belonging to Aghiresu.

During the year 2018, the priority for local authorities is to start finding financial founds for the sewerage works in Aghiresu village, the second place as the number of inhabitants in the area. Although the population in the area it is heterogeneous, most of the inhabitants practice the commuting, considering the possibility of finding better paid jobs in the city of Cluj-Napoca. A more and more obvious lack of the studied area was found to be the absence of the authentic countryside.

CONCLUSIONS

The investments made in the past 10 years in Aghiresu commune have been created an important change related to improving the quality of life. Sustainable development of the area through the projects presented in the research has shown that younger generations will have good development conditions in rural areas and will not have to migrate to urban areas.

Through future development projects in studied area, will be offered attractive conditions for economic investors and so will be created new jobs, well paid, in the rural area.

Support for investment in infrastructure and rural economy will lead to poverty reduction, thus contributing to inclusive growth, these measures being provided for in the Rural Development Strategy of Romania 2014-2020.

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METHODS OF SAFETY ASSESSMENT THROUGH ANALYTICAL AND EXPERIMENTAL APPROACHES

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Abstract

The paper is intended to present some aspects regarding the safety evaluation methods by determining those defining characteristics of a structural system (behaviour in time through dynamic characteristics evolution). This assessment should first be initiated in the case of buildings with essential functions and which could pose a major threat to public safety in case of collapse or serious damage. Determining, using intelligent wireless sensor networks, used within of a real-time data transmissions system, of some accelerograph data obtained from earthquakes with significant magnitude, will lead to an image of the spatial distribution of peak ground acceleration (PGA). Obtaining additional data over time will highlight some conclusions about acceleration values and directivity of seismic waves in the territory. On the other hand, the determination of the dynamic characteristics of structural systems by non-invasive and non-destructive instrumental measurements, under normal micro-seismic agitation, offers the possibility of obtaining important data in the structural safety assessment process after a major earthquake. Correlation of structural dynamic information, determined in situ and by analytical approaches, is a necessary step in the continuous process of risk exposure in an area with disaster potential. Data about a few study cases are presented.

Key words*: experimental investigation, PGA distribution, structural frequencies.*

INTRODUCTION

The paper is intended to present some aspects regarding the safety evaluation methods by determining those defining characteristics of a structural system (behaviour in time through dynamic characteristics evolution).
Instrumental post-earthquake and eventual post-consolidation data are not sufficient unless there are pre-earthquake data. In this sense, it is possible to have pre-earthquake control data by determining the natural periods of the structure, in the current state and after an earthquake (moderate or severe). Thus, there will be a dynamic database with predetermined pre and postseismic values.
This assessment should first be initiated in the case of buildings with essential functions and which could pose a major threat to public safety in case of their collapse or serious damage.
Immediately after a strong future earthquake, a public institution will be interested in determining as soon as possible the „health" of its headquarters and other buildings, especially those that are needed to carry out its tasks of emergency situations or orders to customers: the headquarters of the county emergency inspectorates; buildings belonging to universities/high schools/schools; hotels; high buildings falling within the requirement for seismic instrumentation according to Annex A4 of the seismic design Code P100-1/2013.

MATERIALS AND METHODS

A real-time data transmissions system. The seismic stations of this system are placed in some ground floor-buildings type, assimilated with the free-field, or in buildings with 1-3 levels. First application of the system is related to the accelerographic data, obtained from earthquakes with significant magnitude, or from ambient vibrations, which will lead to an image of the spatial distribution of peak ground acceleration (PGA).
Obtaining additional data over time will highlight some conclusions about acceleration

values and directivity of seismic waves in the territory. From data obtained within the URBAN-INCERC network (through the real-time data transmission system), during M>5 Vrancea seismic events, that occurred in 2016 and 2017, the spatial distribution of the peak ground accelerations confirms certain typical patterns, as the NE-SW general directivity and the PGA amplification at large distances from the epicentre area, observed also in previous larger-magnitude events.

Basic signal processing within the system. The procedure used to reduce leakage of a measured signal, when the measuring time is not a integer multiple of the signal period, this meaning those non-zero values at frequencies other than that of interest, is the signal transformation by the introduction of a window function, depending on the analysed signal type. Also, some filters are applied, as low-pass, high-pass etc.

Signal analysis. The signal analysis and determination of the dynamic characteristics of structural systems for damage detection use only the output signals. Depending of the type of input (ambient excitation or severe earthquake), generally difficult to be measured, with the global [M], [C] and [K] matrices obtained from the geometry and material properties for the dynamic system, the output is measured and some frequency/time domain approaches are applied in order to obtain the modal parameters which are needed to the damage estimation (damage is frequently associated with inter-story drift and behaviour of structural and non-structural components). It is assumed that mass does not change; there is a change in stiffness (also in damping). In the case of the ambient excitation, the response is considered in the linear range, in large frequency band-width and with low amplitude, and the damping takes very low values.

On the other hand, the dynamic characteristics of structural systems determined by non-invasive and non-destructive instrumental measurements, under normal micro-seismic agitation, offers the possibility of obtaining important data about the behaviour of the building in the structural safety assessment process after a major earthquake (Dobre and Dragomir, 2017).

Stiffness loss. In one dynamic degree of freedom (or all, but matriceal), the damage (stiffness loss) is calculated with a simplified formula:

$$\Delta K = \frac{K_{init} - K_{current}}{K_{init}}, \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where:

K_{init}= the stiffness before a major event,

$K_{current}$= the stiffness after a major event.

After simple processing,

$$\Delta K = 1 - \left(\frac{\omega_{current}}{\omega_{init}}\right)^2 \quad (2)$$

The method of getting the dynamic characteristics of structural systems and the damage/stiffness loss is presented in Figure 1.

Study cases. Data about a few study cases are presented:

- Recorded data in 2017 at the Building A of the Parhon Institute, Bucharest (built in 1928) (Figure 2).

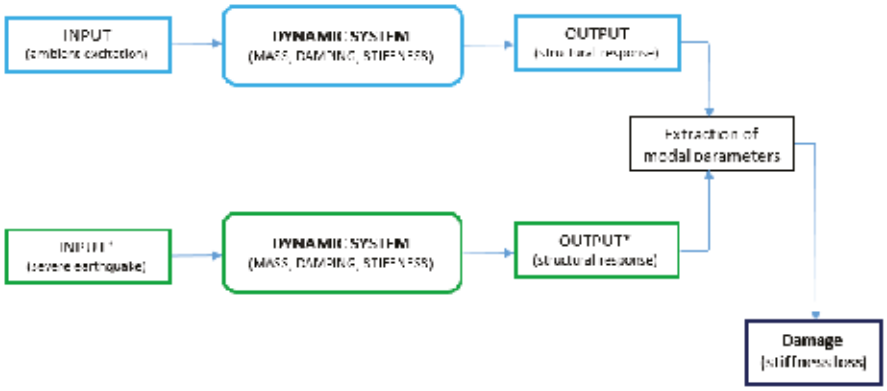

Figure 1. Method of damage detection using ambient vibration signals

- Recorded data in 2016 at the Building of the Hospital N. Oblu, Iasi (built in 1972), (Figure 3).
- Recorded data in 2016 at the Building of the General Inspectorate for Emergency Situations (IGSU), Bucharest (built in 1968) (Figure 4).

Figure 2. Vertical layout of sensors (ground floor, level 2, terrace), H=12.39 m

Figure 3.Vertical layout of sensors (basement 2, ground floor, level 3, level 6), H=28.9 m

Figure 4.Vertical layout of sensors GMS Plus (Building A - ground floor, level 3, level 5, terrace, and Building B - ground floor, level 3, level 5 and level 6), H=28 m/30.1 m

RESULTS AND DISCUSSIONS

Correlation of structural dynamic information, determined in situ and by analytical approaches, is a necessary step in the continuous process of risk exposure in an area with disaster potential, (Tables 1, 2 and 3 and Figures 5, 6, 7 and 8).

The dynamic characteristics of building vibration can be obtained also from a simplified formula, according to the Code P100-2013: $T_1=C_tH^{3/4}$, where C_t=0.075 for spatial frames from reinforced concrete or steel/ C_t=0.05 for other structural systems; H = the height of building.

Table 1. Vibration frequencies, Parhon Institute

from seismic/microseismic/ambiental records	f_x= 3.5...5.6 Hz f_y= 2.0...3.8 Hz

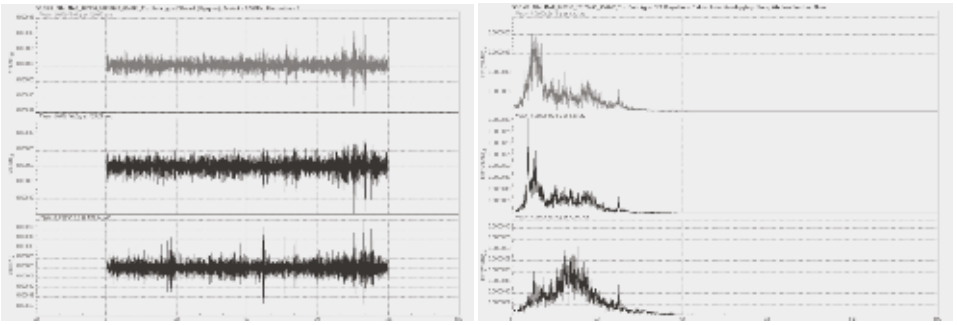

Figure 5. Accelerogram processing and Fourier spectra, level 2, T_1=0.3s.
According to the Code P100-2013: T_1=0.3s (C_t=0.05)

Table 2. Vibration frequencies, Hospital N. Oblu

from seismic/microseismic/ambiental records	f_x= 1.88/1.93 Hz f_y= 2.00/1.98 Hz

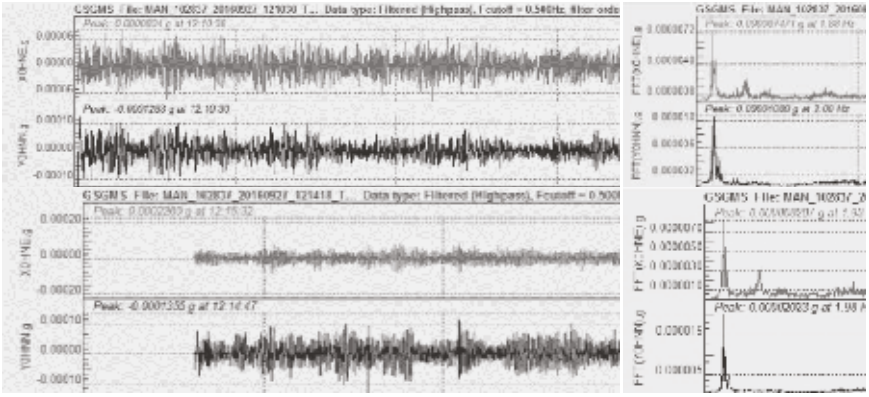

Figure 6. Accelerogram processing and Fourier spectra, level 6, T_1=0.53s;
according to the Code P100-2013, T_1=0.62s, (C_t=0.05)

Table 3. Vibration frequencies, IGSU Bucharest

from seismic/microseismic/ambiental records	Building A	Building B
	f_x = 1.56…1.64Hz f_y = 1.49…1.56Hz	f_x = 1.56…1.71Hz fy = 1.50…1.54Hz

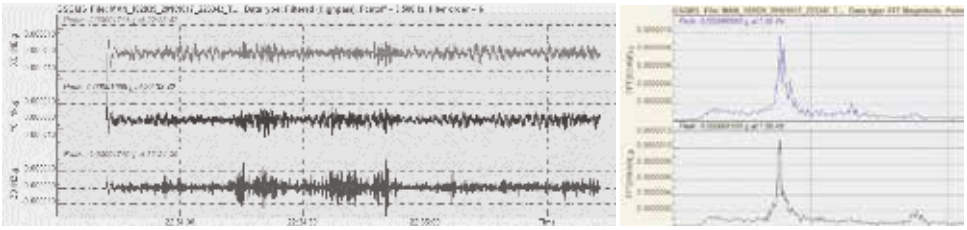

Figure 7. Accelerogram processing and Fourier spectra, Building A, T_1=0.60s; according to the Code P100-2013, T_1=0.60 s (C_t=0.05)

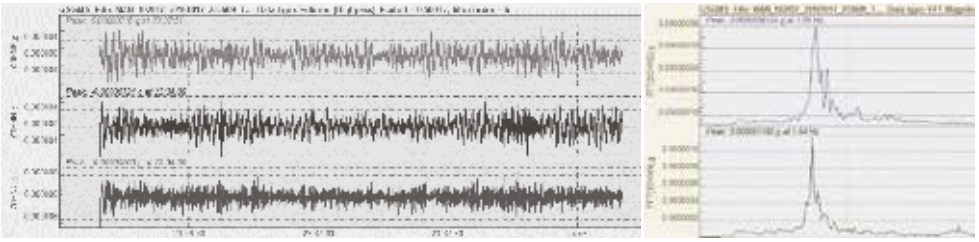

Figure 8. Accelerogram processing and Fourier spectra, Building B, T_1=0.64s; according to the Code P100-2013, T_1=0.60 s (C_t=0.05)

CONCLUSIONS

Vibration-based structural health monitoring is an approached widely used due to its 'output only' nature. The core of this method is to detect the changes of the dynamic features extracted from the structural response - the variations of natural frequencies.

Immediately after a strong future earthquake, a public institution as a hospital will be interested in determining as soon as possible the structural health of its buildings and in this respect a „zero reading" of the dynamic structural features is important (Dragomir et al., 2017).

Determining the level of vibrations in a structural system is used also for choosing the procedure or the mechanism of mitigates this type of response (the comparison among passive, active and semi-active control systems) (Pastia et al., 2016).

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WATER LOSS MANAGEMENT IN ORDER TO PROTECT AVAILABLE WATER RESOURCES

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Abstract

Water losses are water supply systems performance indicators whose values have been rising in recent years. The paper presents an analysis of the „water loss" phenomenon in Iasi County and City, highlighting the exaggerated values in some territorial areas. The case study has made a correlation between the amount of water lost and the groundwater available in the county. The research conducted has highlighted the drastic decrease of available water volumes, simultaneously with an increase in water consumption. The available water resources in Iasi County are around 106.00 million m^3 and the water demand is about 31% higher. The paper shows that water losses in transport and distribution networks must be drastically reduced to about 15-25%. At the same time, it is necessary to re-evaluate the water demand and to preserve the existing water sources at optimal quality parameters.

Key words*: efficiency, physical water loss, water sources contamination, water stress.*

INTRODUCTION

National lost water volumes amount to an average of 48.3% (Racoviteanu et al., 2015). Globally, developed countries reach a level of water loss of up to 11% (Australia), while in developing countries, the losses rise up to 65% (Albania) (Danilenko et al., 2014)
Global warming, intensely felt in recent years, is largely reflected in the available drinking water resources. In this context, water resources management and control bodies, such as AWWA (American Water Works Association), IWA (International Water Association) or ARA (Romanian Water Association) draw attention to the importance of reducing water losses and describe methodologies and work procedures to protect water sources (Lambert and Hirner, 2000).
Protection of water sources is regulated internationally by each country in relation to the magnitude of the phenomena „waste water" and „water stress" recorded there.
USA legislation distinguishes itself in this area by introducing water companies' obligation to perform network audits and to regularly report performance indicators (Sturm et al., 2015). By contrast, in Romania, the water loss issue is at a primary stage, but the recorded values are steadily increasing. In this situation it is necessary to formulate legislative directions regulating the water loss aspect for each water-sewage company.
Recent events in major cities around the world attest the importance of conserving and using water resources efficiently. The lack of adequate water loss management along with the global warming phenomenon, manifested by prolonged droughts, has led to historical water crises.

MATERIALS AND METHODS

In 2008, Barcelona was on the verge of shutting off potable water distribution due to the small water volumes available in storage reservoirs. Moreover, the poor infrastructure in São Paulo fails to capitalize on Brazil's rich water resources, resulting in a water supply system dealing with frequent water shortage.
The world's first big city without water, Cape Town, faces an unprecedented situation. Despite the measures taken in recent years, „day zero", in which the supply of drinking water to consumers will be stopped, was set for June 4th 2018.
Researchers and engineers' warnings that South Africa's water reserves and Cape Town's in particular, will not be able to meet the water demand of a growing population, in the context

of climate change in recent decades, have led the authorities to formulate a plan to efficiently use the available water sources. Strategies to reduce water losses and consumption as that implemented in 2007 by the municipality of Cape Town that reduced water demand by 20% to 640 million m^3/year, have proved to be insufficient in terms of scale and duration of application (Department of Water Affairs, 2013).

The „water loss" phenomenon is recorded in all components of water supply systems. The value and intensity of the phenomenon, however, varies depending on the factors that generate it. Thus, the characteristic parameters of a water loss produced by mechanical factors will be different from those due to biochemical factors (Luca and Chirica, 2017).

The water balance established through the IWA methodology groups water losses in the category of apparent and physical losses. While apparent losses quantify fraudulent consumption and measurement errors, physical losses are recorded on the ground and hold the largest share (Lambert and Hirner, 2000).

Water losses are manifested within all water supply systems components. Thus, physical water losses can be grouped according to their location in (GIZ, 2011):

- losses on water distribution and convey pipelines, displayed on pipes, joints and valves, with medium to large flows and medium and small water emission times;
- connections losses, characterized by very low flows and very high water emission times;
- losses from storage tanks, displayed through seepage and through overflow equipment discharge.

Worldwide, drinking water supplies are limited. In this context, water supply systems are put under pressure. Satisfying water demand for consumers is conditioned by issues such as population growth, urbanisation, economic context, global warming, water contamination and the age of existing networks. The UNESCO report shows that most countries in Africa, Central America and northern Asia are currently facing water shortage and others will be affected by this phenomenon within a short time period (UNESCO, 2009).

The material used in the research consists of the geographical area of the Moldavian Plain and Plateau, which covers Botosani, Iasi and Vaslui counties. This geographic area is characterised by a low number of viable, groundwater and surface water sources. Moldova, Siret and Prut rivers and their tributaries are the main water sources in this area (Figure 1).

In terms of quantity, the rivers cover the consumers' water requirement. However, from a qualitative point of view, water treatment processes are required in order to meet the requirements imposed by existing regulations.

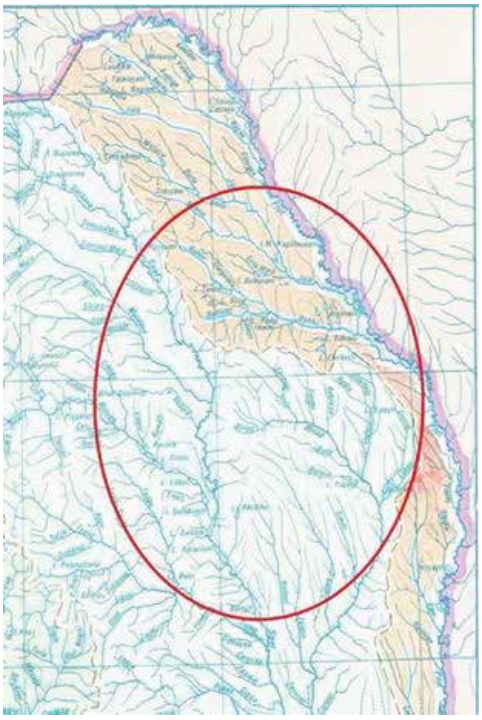

Figure 1. Study area hydrography

The research methodology consisted in documenting and collecting data on the quality of underground and surface water resources available in the study area and the influence of the contamination phenomenon.

The data processing was achieved through comparative analysis, specific statistical computation programs and the use of pipe networks water loss interpretation models.

RESULTS AND DISCUSSIONS

Watersheds are often defined by high levels of chemical content. The degradation of water quality parameters highlights the need to protect available water volumes and make water supply systems more efficient by reducing water losses.

Data from Table 1 shows that out of the total volume of surface water sources, only 26.22% can be used to ensure water demand for consumers. Compared to the available volume of surface water, groundwater resources are up to 75% lower. Given that groundwater quality is superior to that of surface water, requiring minimal treatment processes, measures must be taken to ensure minimal water losses on the lay-out between the catchment and consumption points.

Table 1. Existing and available water volumes in Prut – Barlad catchment area

Water source type	Total volume (mil. m^3/an)	Available volume (mil. m^3/an)	Available volume (%)
Surface	3661	960	26.22
Groundwater	251.4	35.7 phreatic	100
		216.7 depth sources	

The available water resources in Iasi County are around 105.000 million m^3. Figure 2 shows the variation of the water resource in dry and rainy years. The values registered in 2012 are below the annual average, and those in 2013 exceed it by about 12%. The share of surface water sources accounts for 65% - 75% of the total available resources, while groundwater accounts for 25% to 30% of the total water supply.

The variation in water volumes extracted from 2011 to 2014 shows that the demand for water is steadily increasing. Figure 3 shows that the volumes extracted do not cover the water requirement of all consumers. The study data highlights the distinct evolution of consumption categories. While agricultural water consumption increased by about 45% in 2013, maintaining itself at about 57- 58 million m^3, water volumes for the population decreased in the same year by about 8% and continued to decline in 2014 by 25%. The same downward trend is also observed in the extractions for industrial consumption.

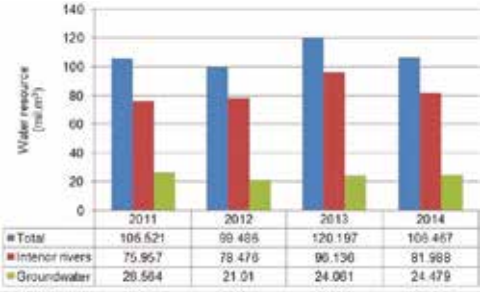

Figure 2. Iasi County available water resources during 2011 - 2014 (ABA Prut-Barlad, 2016)

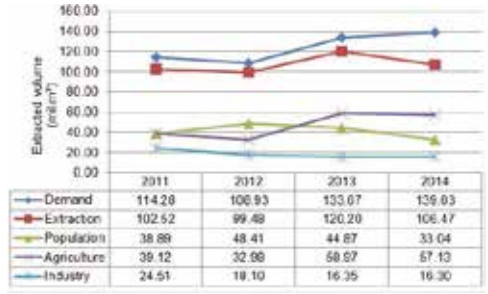

Figure 3. Volumes extracted by activity type (ABA Prut-Barlad, 2016)

The evolution of recorded values is justified for each consumption category. Thus, agricultural extractions have increased due to the development and implementation of irrigation systems, industrial water consumption has declined as a result of the collapse of industry in recent years, and water volumes for the population consumption continue to decline as a result of massive investments in water infrastructure, rehabilitation and replacement works, and intensive water reduction measures.

In Iasi County, at the end of 2016, the regional operator S.C. APAVITAL S.A. managed water supply networks with a length of 3,164 km, out of which 2,293 km of distribution networks and 871 km of main supply pipes (Figure 4).

Iasi County regional water supply system draws raw water from Timisesti and Prut sources. The Timisesti groundwater source is located in Neamt County, about 100 km from Iasi, in the Siret catchment area. The water collected through drains and catchment areas reaches Iasi storage tanks from Timisesti by

gravity. Prut surface source is located 15 km from Iasi City. The water conveyed from this point reaches Chirita treatment plant by pumping. Comparing the two water sources, Timisesti source is superior to Prut source. The groundwater quality does not require complex treatment processes, and the flow by gravity reduces energy consumption to minimum values. Considering these aspects, the protection of the Timisesti source and its optimal exploitation is a priority for the water - sewer operator.

The technical expertise works conducted on the Timisesti - Iasi main supply pipes located in the Moldova River undercrossing in Soci area revealed important aspects regarding the structural and hydraulic integrity of the pipes.

The research revealed the physical degradation of the building materials, following the great operational period (over 100 years).

The hydrodynamic phenomena in the riverbed have manifested themselves by uncovering the protective layers covering the pipes and exposing them to environmental factors.

The morphological transformations recorded in the river bed of Moldova River have caused the advanced degradation of the hydro-technical constructions from the site (Luca et al., 2015; Luca et al., 2017).

The results obtained from the main supply pipes' technical expertise showed the magnitude of the water losses recorded from them. Awareness of the real values of physical water losses on this component has led to measures to ensure the limitation of lost water volumes.

The main directions of action consisted of (S.C. APAVITAL S.A., 2017):

- rehabilitation works of the Timisesti - Iasi main supply pipes with a length of 2,690 m, in the Moldova River undercrossing and Siret River overpassing;
- rehabilitation works on 6,351 m of main supply pipes;
- extension works on 5,409 m of main supply pipes.

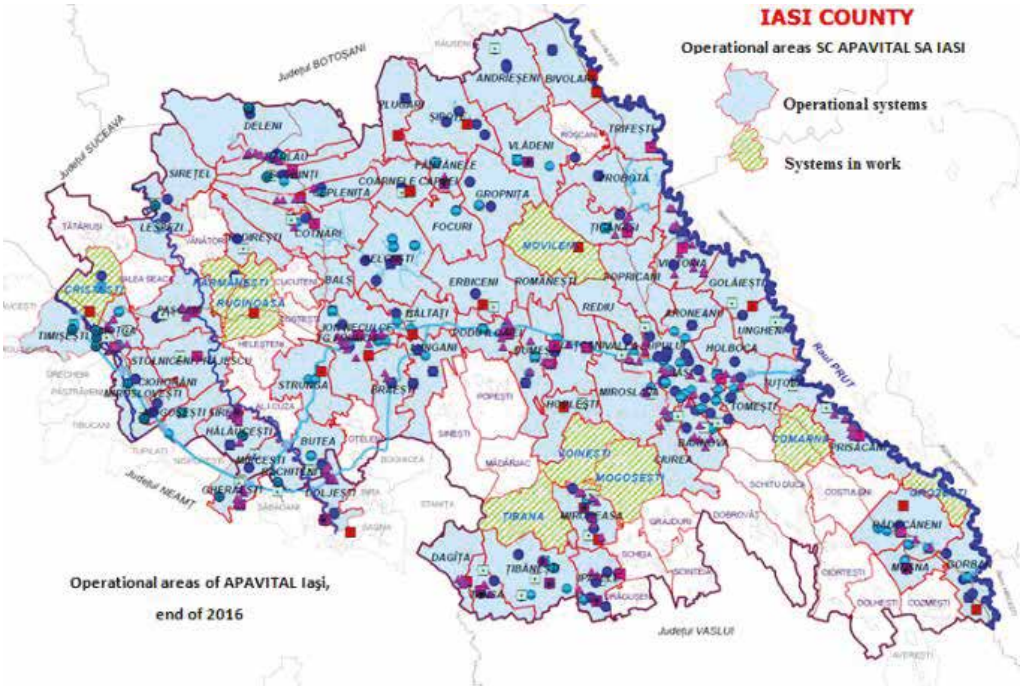

Figure 4. Iasi County S.C. APAVITAL S.A. operational area; colour code: blue - systems operated; green - systems in work; white - systems not operated (S.C. APAVITAL S.A., 2017)

Water loss management at S.C. APAVITAL S.A. consists of a series of measures and working procedures. These are (Doruş et al., 2015):

- GIS and SCADA software developing and hydraulic network modelling implementation;
- constant updating of the system's technological lay-out;
- facilitating real-time data transmission by field personnel (interventions, observations, findings etc.);
- the possibility to access SCADA and GIS databases remotely;
- the delimitation of distribution areas through valves in order to create district metered areas (DMA), enabling consumption monitoring;
- drawing up the water balance and assessing the water volumes conveyed into the system;
- periodic inspection and calibration of field equipment;
- the establishment of working procedures to ensure the monitoring of pumping stations, storage tanks, treatment plants etc., in order to detect water losses from early stages;
- regular networks inspection with water loss detection equipment;
- analysing the field data gathered with the specialised equipment and establishing the areas to be excavated in order to carry out remediation works for the damages detected.

In terms of water losses identified and repaired, 2016 is characterized by a number of 7,451 interventions. Of these, more than 35% were found in the metropolitan area, respectively 2,660 damages and 4,791 interventions, representing 65%, in the rest of the county (S.C. APAVITAL S.A., 2017).

In table 2 it can be seen that the recorded water losses on the entire operating area were 30.41%, below 48.30% - the national average. The values obtained in Iasi City and metropolitan area is close to the average value recorded over the entire surface of the operational area. Values 50% lower than the county average were recorded in Podu Iloaiei and Targu Frumos towns. The phenomenon is explained through the massive investments made in the water supply systems of the two cities, where the storage tanks and the drinking water treatment plants were rehabilitated and the distribution networks with overdue life usage were replaced. Overall, the SOP Environment financing has allowed the extension of 27,335 m of distribution networks and the rehabilitation of 53,326 m in Iasi City and county towns, together with the rehabilitation of 10 storage tanks.

Table 2. Performance indicators achieved during 2016

Operational area	CDWQ (%)	ML (%)	WL (%)
Iasi Metropolitan Area	97.5%	99.88%	29.80%
Iasi City	99.6%	99.73%	30.93%
Podu Iloaiei City	99.1%	99.78%	14.50%
Targu Frumos City	99.0%	99.97%	13.10%
Operational area overall	99.36%	99.74%	30.41%
CDWQ -compliance with drinking water quality; ML – metering level; WL- water loss			

In terms of quality parameters of water provided to consumers, the compliance rate amounts to 99.36% in the operational area. Values above 99% are also recorded on the surface of Iasi municipality and Podu Iloaiei and Targu Frumos towns. The degree of compliance with drinking water quality in the metropolitan area of 97.5% suggests the presence of disturbing factors in the distribution system. Given that the area is in an intensive real estate development process, excavations for placing public utilities on the same route as water pipes can accidentally affect the structural integrity of the latter. Damages produced in this way facilitate the entering of substances that change water quality parameters into pipes.

The high metering rate achieved ensures an optimal degree of monitoring of the water supply systems operated.

Measuring the conveyed water volumes enables the detection of early network anomalies, allows control of the extracted water quantities, limits the amount of water losses and ensures the efficient use of drawn water volumes.

The effectiveness of water loss reduction measures results from the percentages obtained

from the implementation of rehabilitation and replacement programs for degraded and aged pipes.

The projects initiated through SOP Environment led to the reduction of lost water volumes by over 11%, from 59% to 47.87%. The complementary SOP Environment investment programs, through which storage tanks and main supply pipes have been rehabilitated, have lowered the percentage of water losses to 30% (Dorus et al., 2015). Thus, in about 7 years, the lost water volumes were halved, increasing the efficiency of the regional water supply system.

CONCLUSIONS

1. The water loss complex phenomenon is addressed worldwide in relation with the characteristics of each water supply system.
2. Economically developed countries are implementing ample water loss management models based on rigorous legislation in this area, thus ensuring optimal results.
3. Policies regarding the efficient usage of available water resources should not be confined solely to the current situation, but must rely on complex scenarios related to future situations.
4. The global warming phenomenon, emphasized in recent years, highlights the need to adopt measures and strategies that lead to the efficient use of available water sources through balanced consumption and the lowest possible value for water losses.
5. The quality of drinking water supplied to consumers is affected by the infiltration of outside contaminants through degraded pipe walls.
6. Water loss management at national level reveals the lack of rigorous water loss law regulation to control the activities of water - sewer agencies in this aspect.

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RESPONSE OF ON-LINE EMITTER TO DIFFERENT WATER TEMPERATURES AND PRESSURES

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Abstract

This research was conducted in hydraulic laboratory of Irrigation Department, Suleyman Demirel University, Isparta, Turkey. Different water temperatures (20, 30, 40 and 50°C) and operating pressure (80-200 kPa) were applied to determine emitter discharge equations ($q= kH^x$), standard temperature discharge index (TDI, standard temperature is 20^oC), coefficient of manufacturing variation (CV) and uniformity parameters such as Christiansen uniformity (Cu) and emission uniformity (CUE). On-line pressure compensating emitter with 2 Lh^{-1} discharges at system pressure of 100 kPa according to the manufacturer recommended, was used. Emitters were placed at 20 cm interval on the laterals with 16 mm diameter. Discharge equations related to temperatures were obtained as $q=2.01H^{0.00}$, $q=1.96H^{0.00}$, $q=1.61H^{0.04}$ and $q=1.54H^{0.05}$ respectively. Increased water temperature decreased the emitter discharge. The rate of emitter discharge decreased average 2.5% by increasing of water temperature from 20 to 50°C. TDI values decreased with increasing of water temperature ($p<0.001$). CV, Cu and CUE values of the emitters under different water temperatures ranged between 0.027-0.033, 97.3-98.5% and 89.2-96.7%, respectively.

Key words: *discharge, on-line emitter, pressure, water temperature.*

INTRODUCTION

The amount of water resources used in agriculture is rapidly decreasing in last decades. Therefore, more efficient irrigation methods are required. Drip irrigation systems provides the highest efficiency compared to other irrigation methods and high efficiency in these systems depend on uniformity of emitter discharge. The implementation of a drip irrigation system with successful water distribution uniformity depends on the physical and hydraulic properties of the lateral. Factors affecting uniformity in drip irrigation are: a) manufacturing variability; b) head loses formed along the pipeline; c) pressure variations due to the change in height; d) sensitivity of the emitter to the irrigation water temperature and the pressure; e) emitter clogging (Mizyed and Kruse, 1989; Rodriguez-Sinobas et al., 1999; Clark et al., 2005; Dutta, 2008). Manufacturing variability and temperature are uncontrollable and variable parameters affecting the discharge and uniformity of emitters in drip irrigation systems. Drip irrigation laterals and emitters used in the field may have full or partial exposure to the sun in summer period. Therefore, viscosity, density and emitter flow passage can be affected by temperature changes (Peng et al., 1986; Rodriguez-Sinobas et al., 1999).

The aim of the study was to evaluate the effects of different water temperatures and pressures on discharge, standard temperature discharge index, coefficient of manufacturing variation and uniformity parameters such as Christiansen uniformity and emission uniformity of the on-line pressure compensating emitter.

MATERIALS AND METHODS

The research was conducted in hydraulic laboratory of Irrigation Department, Suleyman Demirel University, Isparta, Turkey. Laterals were placed in the emitter testing bench without inclination. Sensitive graduated cylinder and manometers were used to determine discharge of the emitters and to measure pressure. Water was supplied from a 216 L capacity reservoir with the aid of a small pump having 3.4 m^3h^{-1} discharges at 4.2 bars. The water was heated by two 1500 watts resistance and water temperature was monitored both by temperature control panel and by a digital thermometer measured from emitter output accurate to $\pm 1^oC$. In the research, pressure compensating on-line

emitter with 2 Lh^{-1} discharges at system pressure of 100 kPa, according to the manufacturer recommended, was used. Emitters were placed on the laterals with 16 mm diameter at intervals of 20 cm. Water temperatures from 20 to 50°C and pressure values from 80 to 200 kPa were used to determine the effects of different water temperature and pressures on emitter discharge equations, standard temperature discharge index (TDI), coefficient of manufacturing variation (CV), Christiansen uniformity (Cu) and emission uniformity (CUE).

Each test was conducted by measuring the discharge of 24 emitters placed on laterals in testing bench under a constant temperature and different pressures. Before each test, the system was operated for 5 minutes to reach constant pressure then discharge was measured volumetrically and these values were converted to Lh^{-1}. For the water temperature test, temperature was changed from sensor screen and waited about 30 minutes to reach the desired temperature (Rodriguez-Sinobas et al., 1999; Clark et al., 2005).

Regression test procedures were used to determine coefficients (k) and exponents (x) of discharge equations ($q = kH^x$) and correlation coefficients for each temperature. In addition, standard temperature discharge index (TDI), standard variation (S), coefficient of manufacturing variation (CV), Christiansen uniformity (Cu) and emission uniformity (CUE) were calculated using Equation 1-5 (Bralts and Edwards, 1986; Christiansen, 1942; ASABE, 2003).

$$TDI = \frac{qt^0}{qt^0_{20}} \quad (1)$$

$$S = \left[\frac{\sum_{i=1}^{n}(q_i - q_{mean})^2}{n-1}\right]^{1/2} \quad (2)$$

$$CV = \frac{S}{q_{ort}} \quad (3)$$

$$Cu = 100\left(1 - \frac{\Delta q_0}{q_{mean}}\right) \quad (4)$$

$$CUE = 100\left[1 - \frac{1.27CV}{\sqrt{n}}\right]\frac{q_{min}}{q_{mean}} \quad (5)$$

where:

- qt^0 is the emitter discharge (Lh^{-1}) at the test water temperature;
- qt^0_{20} is the emitter discharge (Lh^{-1}) at the 20°C;
- S is the standard variation;
- q_i is the emitter discharge (Lh^{-1});
- q_{mean} is the average emitter discharge (Lh^{-1});
- n is the total number of emitters;
- Δq_o is the absolute deviation of the average (Lh^{-1});
- q_{min} is the minimum discharge obtained from minimum pressure (Lh^{-1}).

RESULTS AND DISCUSSIONS

The x values for different water temperature were determined close to 0 as expected, which is consistent with flow regime of the pressure compensating property belong to the manufacturer's data.

According to emitter discharge and pressure relationships, while regression analyses were found to be significant at 40 and 50°C ($p<0.001$), they were not significant at 20 and 30°C (Figure 1). It was observed that the discharges of the pressure compensating on-line emitter increased by increasing pressure at 40 and 50°C ($r = 0.79, 0.85$). Although discharge was stable under low water temperature, there was a slight increasing trend in emitter discharge with pressure under high temperature.

These results are similar to the previous studies in that discharge in pressure compensating on-line emitter varied not clear (Rodriguez-Sinobas et al., 1999; Nasrolahi et al., 2011).

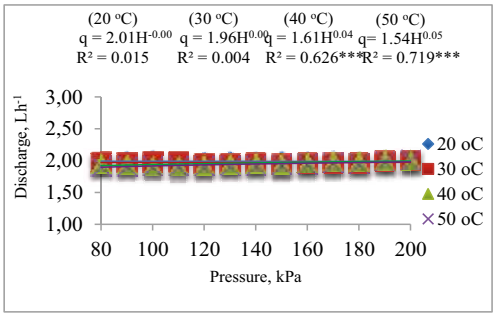

Figure 1. Emitter discharge - pressure relationships at different water temperatures

The average discharge variations in temperature changes from 20 to 50°C were illustrated in figure 2. Linear regression was obtained between emitter discharge and water

temperature in pressure compensating on-line emitters (r≈0.99). As the temperature increased, the discharge of the emitter decreased.

The rate of emitter discharge decreased average 2.5% due to increased water temperature from 20 to 50°C. Some other researchers explained that the relationship between water temperature and discharge with linear regression similar to our study and water temperature tend to decrease discharge of some pressure compensating emitters (Zur and Tal, 1981; Dogan and Kirnak, 2010; Nasrolahi et al., 2011).

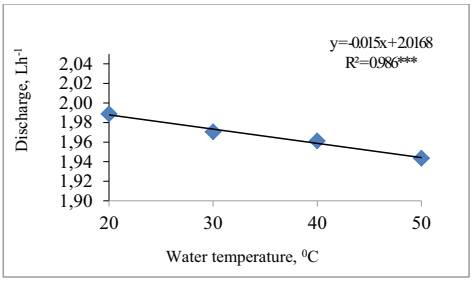

Figure 2. Water temperature - emitter discharge relationship

Standard temperature discharge index (TDI) values were calculated from discharges from standard water temperature (20°C) and different water temperature (30, 40 and 50°C). Then, regression analyses were done (Figure 3). Strong linear relationship between TDI and water temperature was found (r≈0.99).

This data is consistent with some previous researches (Zur and Tal, 1981; Von Bernunth and Solomon, 1986).

TDI values for the pressure compensating on-line emitter were significantly decreased with an increase in water temperature ($p<0.001$).

The result is similar to the studies by Parchomchuk (1976) and Dogan and Kirnak (2010).

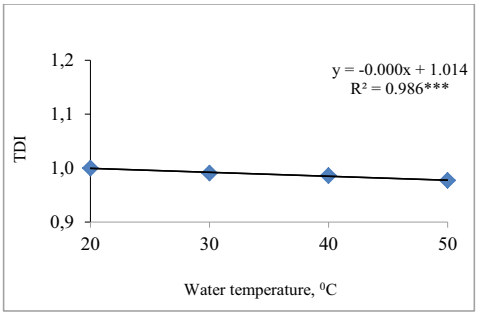

Figure 3. Water temperature- standard temperature discharge index (TDI) relationship

CV values ranged from 0.027 to 0.033 and were lower than 0.05. They were ranked in „excellent" class under pressure changes for different water temperatures (ASABE, 2003). CV values of the emitter were not affected from changes in water temperature. Our results are similar with Clark et al (2005) and Dogan and Kirnak (2010) indicated that there was no relationship between CV and water temperature.

Cu values of the emitter tested changed between 97.3 and 98.5% under different pressure and water temperatures. Cu≥95% condition recommended by Wu and Gitlin (1979) was provided in all temperatures and pressures and Cu values also provided almost the condition as Cu≥98% suggested by Perold (1977) in generally.

CUE values varied from 89.2 to 96.7%. In all water temperature and pressure, CUE values classified as „good - excellent" class according to ASABE (2003) stayed between 87 and 94 %. However, CUE values exceeded 94 % and took place in the „excellent" class at recommended for operating pressure of 100 kPa. CUE values of pressure compensating on-line emitter had a downward tendency with increased water temperature ($p<0.05$), while there were no relationship between CV and Cu values and water temperature (Figure 4).

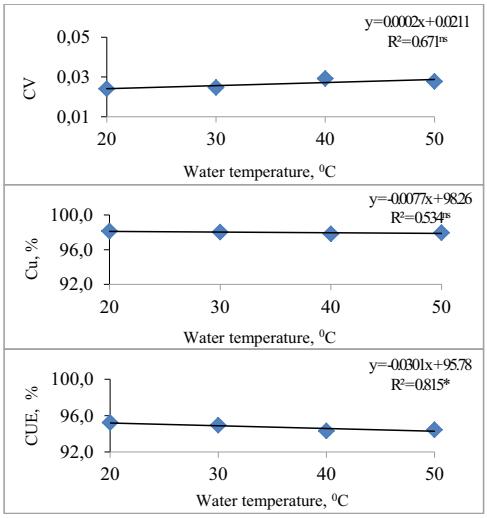

Figure 4. Effect of water temperature on uniformity parameters

CONCLUSIONS

In the study, according to regression analyses between emitter discharge and pressure, although discharge was stable under low water temperature (20 and 30°C), there was a slight increasing trend in emitter discharge with pressure under high temperature (40 and 50°C). The x values of the emitter discharge equation for different water temperature were obtained as 0 in accordance with the flow regime of the pressure compensating property. Linear relationships were observed between both emitter discharge and TDI and water temperature. Both emitter discharges and TDI values were decreased with the increase of water temperature.

The data indicated that while the water temperature had no significant effect on CV and Cu, CUE values had a downward tendency with increased water temperature.

In conclusion, temperature may have a significant effect on the emitter discharge under the sunlight conditions during the summer period. Therefore, manufacturer should provide the information to drip irrigation system designers and users about responses of water temperatures and pressures to emitter discharges.

In addition, users should measure water temperature and pressure and make associated correction when the irrigation system is operated in the field for high efficiency.

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RESEARCH ON CADMIUM SOIL POLLUTION IN THE FORMER ALMASU MARE MINING AREA

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Abstract

The gold mining activity performed in the past in Romania has led to the pollution of the environment, the degradation of large areas of land and currently represents a significant risk to human health. As a result of the gold mining activities performed in Almasu Mare area, there were large sterile dumps and gold mine galleries that continue to give their mark on the quality of the environment and human health through the amount of heavy metals in the soil and the sterile material improperly deposited, the water that comes out of the underground to the contaminated surface and which flows into the rivers in an uncontrolled way. This paper brings details of cadmium soil pollution in the studied area. The results obtained in the analysis of cadmium concentrations through the AAS spectrometry show that the analysed soil exceeds the admissible limits provided by the legislation in force, and the sterile material collected from the sterile dumps reflects values of the Cd concentration in the interval 10.7 – 22.6 mg/kg. Due to the high concentrations present in the soil and sterile material analysed, soil remediation interventions are required in the area.

Key words*: mining activities, sterile dump, gold mine galleries, soil pollution, cadmium concentrations.*

INTRODUCTION

Pollution has become an issue that currently concerns the entire world, its effects can lead to ecological imbalances, poisoning, etc. In the last decades, the assessment, environmental pollution and the threat they pose to the whole ecosystem have been vital challenges in the environmental engineering sciences (Pindaru, 2013; Sur and Micle, 2012).

One of the most serious soil pollution is the one caused by the presence of heavy metals, which have a particularly serious effect on the physiology of the terrestrial ecosystem vegetation as well as on humans and animals which comes in direct or indirect contact with the polluted sites.

For many regions around the world, heavy metal pollution from mining activities is considered to be a serious environmental problem. First, the fertile soil layer is lost, and then it can no longer be used agriculturally (Plugaru et al., 2017).

Pollution from the extractive industry also raises major problems along with pollution from tailing ponds and sterile dumps.

Their unsuitable management in the past has resulted in the accumulation of heavy metals in the environment, contributing to the contamination of soil substrates, the destruction of its texture, ecological landscapes, groundwater pollution and the decline in biological diversity (Liu et al., 2008).

The mining is an activity that has been taking place in Romania for more than 2000 years. The mining waste disposal has been done in many cases without preventive measures due to the lack of the legislative framework, the effect being on the quality of the environmental factors.

Consequently, many mining sites have a negative impact on human health and the environment. Many metals are essential components of the soil at low concentrations, but they exert toxic effects at high concentrations, such as those found in polluted environments (Romero et al., 1999).

Cadmium is one of the most dangerous heavy metals and is very toxic to humans and animals. It naturally occurs in soil at a concentration below 1 ppm (Karaca et al., 2010).

The aim of this paper is to determining the cadmium concentration from soil and sterile material samples collected from Almasu Mare mining area in order to apply the most suitable technology of remediation.

MATERIALS AND METHODS

The study area is located in the commune of Almasu Mare, which is situated on the southern periphery of the Apuseni Mountains, in the subunit of the Metaliferi Mountains, bordering the town of Zlatna from the county of Alba. The total area of Almasu Mare is 9330 ha. The mining activities performed in the past in Almasu Mare area have generated considerable amounts of mining waste (sterile dumps and acidic waters) in the environment that have put their mark on the quality of environmental factors (water, air and soil). Until the present no effective greening measures have been taken in the study area, which is still under the „Mining Strategy for 2008-2020" aiming at restoring the environment affected by mining operations (Keri et al., 2010; Hulpoi, 2008; Stancu, 2013).

In order to analyze the current situation of soil quality in terms of concentrations of cadmium, from the Almasu Mare area samples of soil and sterile material were collected from four different points and from three distinct depths (0-10 cm, 10-30 cm and 30-100 cm).

The first sampling point, shown in figure 1, belongs to the sterile dump „Hanes".

Figure 1. The sampling of sterile material on the „Hanes" dump

It is located approximately 150 m from the "Hanes" mine. On the surface of this heap, the vegetation is totally missing, and the acidic waters coming out of the Hanes mine pass over this wasteland and then reach the Ardeu brook and further on the Ampoi River and the Mures River.

The second sampling point is located near the „Hanes" mine, about 100 m away from it and 50 m from the sterile dump (between „Hanes" mine and the „Hanes" dump). At this point the vegetation is present very little, as can be seen in figure 2, and the soil is slightly wet, reddish-rusty due to the mine spills that have crossed this area of land.

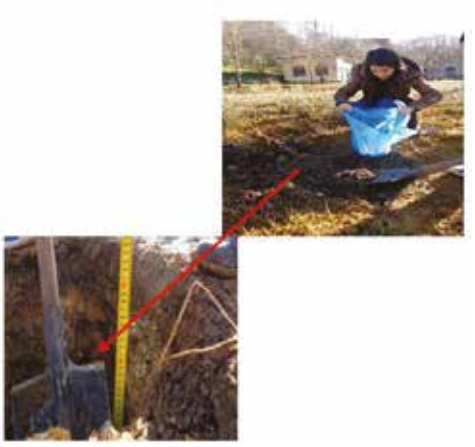

Figure 2. The soil sampling near the „Hanes" mine

The sampling point 3 is located on the „Rades" dump (Figure 3), and the sampling point 4 along the „Rades" gallery.

Figure 3. The sampling of waste material on the „Rades" dump

The sampling point 4 is located in front of the Rades heap, the sampling point 5 is upstream of the dumps and mine galleries, and point 6 downstream of them.

Soil sampling was performed in accordance with STAS 7184/1-75 „Soils - sampling for soil and agrochemical studies" and was processed in accordance with SR ISO 10381-6: 1997 and SR ISO 11464: 1998, in November, 2016.
Soil samples and sterile material from Almasu Mare area were analyzed through Atomic Absorption Spectrometry (AAS) using a SHIMADZU AA-6800 spectrometer. Prior to the AAS analysis, the moist soil and sterile material was crumbled, dried at 40°C, sieved and milled. Then 3 g of prepared samples were placed in a 100 ml beaker with 21 ml of concentrated HCl and 7 ml of concentrated HNO_3. The glasses were covered with a glass plate and left for mineralisation. After these, samples were filtered. Since for calibration of cadmium by atomic absorption spectrometry it is necessary to draw a calibration line, calibration solutions were prepared (Figure 4).

Figure 4. The samples preparation for determination of cadmium concentrations

After preparation each calibration solution was introduced into the flame and the absorption signal was measured at the analytical wavelengths of the metals to be determined. Finally, the samples were analyzed in flame in order to measure the cadmium absorption signals followed at the same wavelengths as those used for calibration.

RESULTS AND DISCUSSIONS

In order to assess the degree of soil pollution in the studied area, the values of cadmium concentrations in the soil samples were compared with the reference values: the alert threshold and the intervention threshold for less sensitive soils set by Order No. 756/1997 of the Ministry of Waters, Forests and Environmental Protection.
Based on the values obtained, the following graphs were drawn: graphs 1, 2 and 3 showing the cadmium concentrations present at the six sampling points.
Figure 5 shows the Cd concentrations present in the samples of sterile material collected from the sampling point 1 („Hanes" dump) and sampling point 3 („Rades" dump).

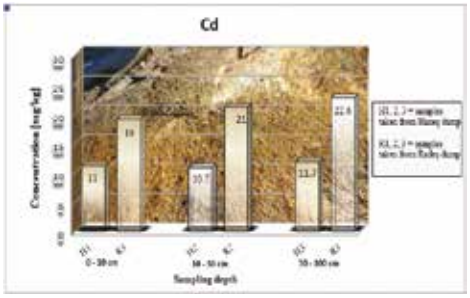

Figure 5. Cadmium concentrations present in sterile material collected from the „Hanes" and „Rades" dumps

The results obtained by analyzing the Cd concentrations in the samples collected from the sampling point 1 („Hanes" dump) showed that Cd concentration values were in the range of 10.7 – 11.7 mg/kg. The Cd concentrations determined from the samples collected from the „Rades" dump showed higher values than those in the „Hanes" dump, these being in the interval 19 - 22.6 mg/kg, a concentration increase with the depth being observed.
Figure 6 shows the Cd concentrations present in the soil samples collected from the sampling point 2 („Hanes" mine) and the sampling point 4 („Rades" mine).

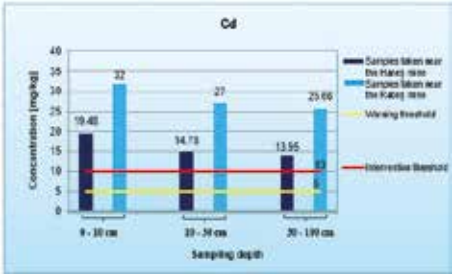

Figure 6. Cd concentrations present in the soil samples collected from near the „Hanes" and „Rades" mines

The cadmium concentrations determined from the samples taken near the „Hanes" and „Rades" mining galleries exceed the admissible values, both the alert threshold and the intervention threshold. Soil samples taken from the Hanes mine reflect a decrease in Cd concentration with depth, with values ranging from 19.48 to 13.95 mg/kg. In the case samples taken near the „Rades" mine, Cd concentrations are higher, but they also decrease with depth, ranging from 32 to 25.66 mg/kg.
In figure 7, Cd is highlighted in soil samples collected upstream and downstream of pollution sources.

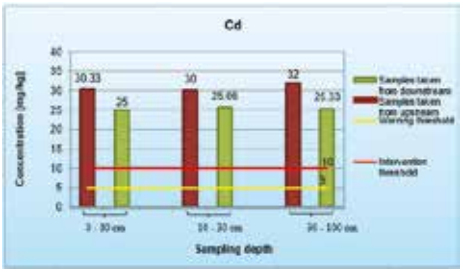

Figure 7. Cadmium concentrations in upstream and downstream of pollution sources

Upstream from the sources of pollution, the Cd concentrations are slightly higher than the downstream. Upstream were registered, values in the range 30 – 32 mg/kg, downstream concentrations were around 25 mg/kg.
All recorded values exceed both the alert threshold and the intervention threshold provided by the legislation in force.

CONCLUSIONS

The sterile dumps and mine galleries are considered to be widespread contamination of the environment. Cadmium concentration from the sterile material collected from the „Hanes" and „Rades" dumps is in the range 10.7 – 22.6 mg/kg. All of the soil samples collected from near the mine galleries exceeds the alert threshold and the intervention threshold. The samples collected near the „Rades" mine are higher than those near the „Hanes" mine.
Upstream and downstream of pollution sources, Cd concentrations are higher than downstream of these. Both sampling points exceeded the intervention thresholds at all sampling depths. In this area it is necessary to apply remediation methods.

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USE OF GREEN ALGAE TO REDUCE HEAVY METALS FROM INDUSTRIALLY POLLUTED WATERS

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Abstract

A number of different physicochemical and biological processes are commonly used to remove heavy metals from industrial wastewater before being discharged into the environment. Conventional physicochemical methods, such as electrochemical treatment, ion exchange, precipitation, osmosis, evaporation, are not cost-effective and some of them are not environmentally friendly. On the other hand, bioremediation processes show promising results for metal removal, even when they are present in very low concentrations if the physicochemical elimination methods fail to function. Moreover, this is a cross-compatible and economically feasible option. The bioremediation strategy is based on the high metal binding capacity of biological agents, which can remove heavy metals from contaminated sites with high efficiency. In this sense, micro-organisms can be considered as a biological tool for metal removal as they can be used to concentrate, remove and recover heavy metals from contaminated aquatic environments.

Key words*: heavy metals, water, pollution, bioremediation, green algae.*

INTRODUCTION

Today, heavy metal pollution is one of the major problems in the environment (Jerold et al., 2016). Heavy metal pollution is a serious environmental problem and poses a threat to human beings and the ecosystem.

Unlike organic contaminants, heavy metals such as chromium, cadmium, copper and lead are the main pollutants of water because of their carcinogenic and persistent nature (Wael et al., 2016).

Removing heavy metals is considered an important environmental issue and economic considerations (Azza et al., 2013). Romania has a long tradition in mining, especially in the Apuseni Mountains. Unfortunately, there are various negative consequences in this area that arise as a direct and indirect result of mining processes, such as mining water drainage, heavy metals pollution and environmental and life degradation (Babau et al., 2017). Heavy metal pollution has a cumulative and residual character, which means that pollutants accumulate slowly (Sur et al., 2016). The city of Baia Mare has been identified as one of the most polluted areas in Romania and even in Europe. This area presents the historical pollution due to the long period in which the mining industry was the main branch of the industry (Sur et al., 2017). Negative effects have influenced both the environment and people's health (Sur et al., 2012). Green algae play an important role in mitigating contaminating effects on other trophic levels through sorption or biodegradation.

Algae bioassays are now an indispensable part of water monitoring processes because first of all, algae are the main food chain producers and secondly they are more susceptible to contaminants than some species of fish or invertebrates (Wong, 1995). Unicellular planktonic algae, which are the main organics and oxygen producers in aquatic environments, occupy vital space not by increasing body volumes but by generating new individuals, so determining the rate of multiplication by successive cell divisions is the main means of assessing the dynamics changing the population density in order to bioindicate the direct effects of aquatic habitats pollution and to evaluate the treatment processes of heavy metals (Fodorpataki et al., 2010).

The relevance of the biological response of the bioindicator is directly proportional to the systemic level at which the pollutant acts, whether cellular, or organ, body or even population. Bioindication can be considered

an induced anthropogenic molecular and biochemical response, manifested by changes in physiological parameters, the effects being perceived at one or more levels of the biological system (Fodorpataki et al., 2015). The present study focused on demonstrating the ability of some microorganisms, green algae, to accumulate a very toxic heavy metal for the environment, Cr^{6+} and the use of these microorganisms in bioremediation processes. Concentrations of metals absorbed by algae are influenced by many environmental factors (Shanab et al., 2012).

Biosorption is an innovative technology that uses living or dead biomass to remove toxic metals from water (Ghoneim et al., 2014).

Removing metals from wastewater through traditional treatments is expensive. Because of this, the research aims at developing more cost-effective alternatives and methods. And in this respect, I refer to the bioremediation processes that represent the method of elimination of environmental pollutants by microorganisms by transforming them from toxic compounds into non-toxic compounds, without affecting the environment. The viability of the process has been demonstrated in laboratory conditions by analysing various experimental parameters such as exposure time, initial metal concentration and pH that can significantly influence bioremediation.

MATERIALS AND METHODS

The test organism used is *Scenedesmus opoliensis*, green algae with unique propagation by spores, which excludes the hereditary variability of individuals, ensuring uniformity of responses to pollutants. In the experiments were used monoalgal axenic cultures of *Scenedesmus opoliensis*, strain AICB 141, a native cell line from Stiucilor Lake, Sacalaia, Cluj County.

The following steps have been taken:

1) Preparation of BBM culture medium (Bold's Basal Medium) with different concentrations of Cr^{6+};
2) Sterilization of the culture medium;
3) *In vitro* inoculation of algae;
4) Growth of static culture in growing room under fluorescent light emitting white light. Algal cultures were periodically monitored at 3, 6, and 14 days by making observations using a microscope and a cytometer. The growing medium used for algae incubation is a standard nutrient medium containing a wide range of inorganic nutrients to ensure the natural growth conditions of the body. We prepared the stock solution required for the growing environment as recommended by the European standard ISO 8692 on water quality.

After preparing the growth medium, the choice of Cr6+ concentrations to which algae were exposed was made. We used 3 different concentrations of Cr^{6+}: a concentration of 5 μM, 50 μM and 500 μM, respectively chromium-free control samples.

The test was carried out over several weeks in which three Cr^{6+} departed concentrations were tested at a basic pH of 9 and an acidic pH of 5. Finally the demineralisation of the remaining chromium in the aqueous medium was carried out by filtration of algal cultures; the aqueous substance was subjected to spectrometric analysis in an atomic absorption spectrometer: SHIMADZU AA-6800.

RESULTS AND DISCUSSIONS

The pH of the aqueous media was adjusted to baseline of 9, baseline, with 30% KOH solution and 5% acid, respectively, with H_2SO_4. The total volume of the test samples was kept identical in all vessels. pH determination was performed according to methodological rules.

The table 1 shows the pH changes in the aqueous medium.

The effects of Cr^{6+} on algal cultures were more or less pronounced, depending on the type of concentration, the exposure time and the pH of the medium.

Experimental data show that this alga has a promising potential to extract heavy metals, including chrome from various polluted environments.

Table1. Changes in pH from the aqueous medium during the development of algal populations (expressed as difference in pH units versus control

Variants	Basic pH 3 days	Basic pH 6 days	Basic pH 14 days	Acidic pH 3 days	Acidic pH 6 days	Acidic pH 14 days
control	increase with 0.230±0.08	increase with 0.240±0.08	increase with 0.200±0.08	increase with 0.250±0.08	increase with 0.230±0.08	increase with 0.190±0.08
5 µM Cr^{6+}	decrease with 0.155±0.015	decrease with 0.130±0.045	decrease with 0.130±0.045	decrease with 0.160±0.007	decrease with 0.090±0.004	decrease with 0.015±0.005
50 µM Cr^{6+}	decrease with 0.330±0.021	decrease with 0.090±0.008	decrease with 0.090±0.008	decrease with 0.020±0.005	decrease with 0.210±0.010	decrease with 0.024±0.010
500 µM Cr^{6+}	decrease with 0.440±0.015	decrease with 1.460±0.004	decrease with 1.460±0.004	decrease with 0.140±0.005	decrease with 0.360±0.007	decrease with 0.024±0.005

The presence of chromium in the aquatic environment is a major concern for the industry.

At present, chemical precipitation methods are used to remove chrome from wastewater but lead to the formation of solid chromium waste. By the ability of these microorganisms to accumulate different amounts of chromium, bioremediation using algae can be accomplished successfully.

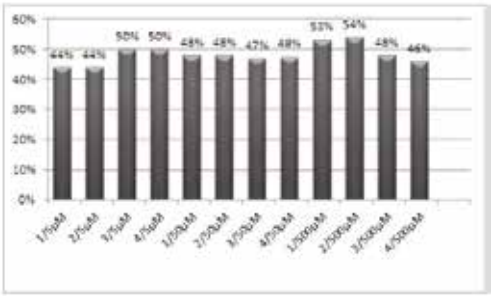

Figure 1.The quantity of Cr^{6+} extracted from algal cultures from aqueous solutions after the first week of exposure, basic pH (n = 4)

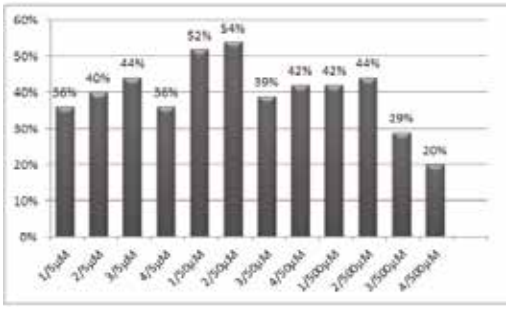

Figure 2. The quantity of Cr^{6+} extracted from the algal cultures from the aqueous solutions after the second week exposure, basic pH (n = 4)

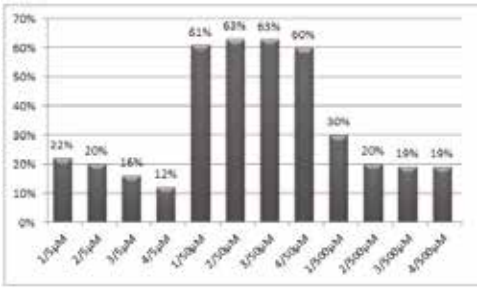

Figure 3. The quantity of Cr^{6+} extracted from the algal cultures from the aqueous solutions after the first week of exposure, acidic pH (n = 4)

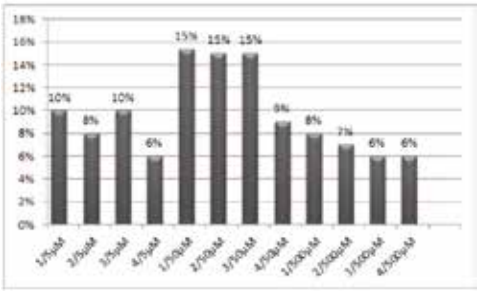

Figure 4. The quantity of Cr^{6+} extracted from the algal cultures from the aqueous solutions after the second week of exposure, acidic pH (n = 4)

Research suggests that *Scenedesmus opoliensis* has proven to be a good bioacumulator of metals, and can serve as a model for treating chrome-contaminated waters.

Scenedesmus opoliensis is one of the most abundant algae used in the treatment of heavy metals polluted waters and with a high potential for removing chrome. It is also true that the absorption/removal of metals is influenced by several factors, in a complex manner, to be evaluated for any program that targets large-scale applications to remove chrome from water.

It can be seen that the bioremediation process decreases with increasing chromium concentration, exposure time and pH environment (Figure 1).
Experiments show that when the pH is basic (Figure 2), the activity of the algae increases and in reverse, in the acidic environment, (Figure 3 and Figure 4), their activity decreases.
The optimal bioremediation period can be achieved over a short period of time in an acidic and long-term environment in the basic environment.

CONCLUSIONS

Natural and anthropic activities generate large amounts of wastewater containing toxic metals, which can generate various ecological problems.
The obtained results show the differences in growth between the control samples and the sample test.
A strong increase in algal density in the control samples and an inhibition of growth in the test samples were observed in both growth media.
This type of algae well tolerates concentrations of 5 μM, 50 μM and in some cases even those of 500 μM at a basic pH, and its use in bioremediation processes can be achieved over a longer period of time.
If polluted water has an acidic pH, bioremediation can be more effective over a shorter period.

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SOIL CONTAMINATION WITH PETROLEUM COMPOUNDS AND HEAVY METALS - CASE STUDY

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Abstract

Crude oil, petroleum fuel and oil products represent most environmental contaminant of soil and the common sources of these products are motor fuel station underground storage tanks, home and commercial heating oil storage tanks, fuel distribution centers, refineries, crude oil production sites, and accidental spills. The main target of this paper is the study of the critical soil pollutants in a Romanian refinery area where soil pollution with petroleum products is one of the main sources of soil contamination. The methodology of study is measuring and monitoring of the pollutants and codify soil pollution profile. The chemical analysis of the crude oil-contaminated site included different groups of contaminants: PAHs, BTEX compounds, and heavy metals determined in the soil samples from the investigated area. The analytical procedure to measure petroleum contaminants and the heavy metal concentrations was performed according to standard methods in force: SR ISO 13877:1999, ISO 22155:2011 SR ISO 11047:1999 and ISO 20280:2007, and with the appropriate equipment. The results are shown that there is a plenty of pollutants in the critical situation and higher than standard.

Key words*: soil contaminated, oil industry, total hydrocarbons, heavy metals, analytical methods.*

INTRODUCTION

Today is widely recognized that the contaminated lands represent a potential threat to human health, and it has led to international efforts to remedy many of these sites, either as a response to the risk of adverse health or environmental effects caused by contamination or to enable the site to be redeveloped for use (Marinescu et al., 2010; Onutu et al., 2010; Diphare, 2014).

In refinery, and vicinity of a refinery, the major sources of petroleum contamination are constituted of crude oil and petroleum products spills on soil, leakages from pipelines, underground and surface fuel storage tanks, indiscriminate spills and careless disposal and mismanagement of waste and other petroleum by-products (Onutu, 2010; Onutu et al., 2015; Popa et al., 2016).

Petroleum refining processes led to the generation of large quantities of oil sludge consisting of hydrophobic substances and substances resistant to biodegradation. Soil oil contamination is a result of fuel storage tank leakages, crude oil spill sand refinery waste disposal. Such sites often contain organic contaminants including benzene, toluene, ethylbenzene, and petroleum hydrocarbons (Pinedo et al., 2013). The solubility of mentioned compounds, in pure water is low, and they are strongly adsorbed in soils, especially onto terrestrial colloids (Wang et al., 2012; Mulligan et al., 2001).

Petroleum fuels and oils are complex mixtures of hydrocarbons and the compositions of these products are made up of several hundred hydrocarbon compounds that could determine the health risk. This is the reason that petroleum fuel or oil contaminated sites have been characterized by two measures; specific indicator compounds called the chemicals of concern (COCs) and by the total of all the petroleum hydrocarbons, called total petroleum hydrocarbons (TPH). The indicator COCs had human health risk derived closure levels, but TPH did not have closure levels based upon human health effects (RISC Technical Guide, 2006).

Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) (Wuana et al., 2011).

Pollutants specific, to a former ramp and depot for loading and unloading petroleum products in a Romanian refinery, are total petroleum

hydrocarbon (TPH) benzene and mono and di-alkylated benzene compounds: toluene, ethylbenzenes and (ortho, para and meta) xylenes, lead compounds (Adeniyi et al., 2002). In this context, the paper presents the assessment of soils exposed to oil products expressed by total petroleum hydrocarbons (TPH) measure.

However, the TPH assessment does not indicate the individual substances that may produce contamination. This study, focused on 36 samples collected from a certain site, evaluates TPH and BTEX concentrations in soils. Several indices of pollution are defined for the assessment of individual variables (TPH, B, T, E, and X) and lead content. This preliminary study provides useful information about the soil processes and current trends in quality assessment methodology (Hernandez et al., 2013).

MATERIALS AND METHODS

In order to obtain accurate measurements of specific pollutants a proper sample collection and preservation were applied.

TPH samples, especially unknown petroleum products and gasoline range organics samples were collected and preserved in a manner that minimizes the volatilization and biodegradation of the hydrocarbons. Soil samples were collected according to the methodology in place so that the sampling program provided (Onutu et al., 2012).

The values determined for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) and Lead in soil samples were compared with the values established by *Ministry of Waters*, *Forests and Environmental Protection* (MWFEP) - Order no. 756/1997 (Table 3).

In this experimental study, soil samples taken from the investigated area, has conducted a series of analyzes for determining the following:

- Total Petroleum Hydrocarbons (TPH) content;
- Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) concentrations;
- Lead content.

Sampling 36 samples of soil were taken, over the length of the drilled range, in the absence of precipitation (Table 1).

Table 1. Coding of boreholes and recollected samples

Drilling Cod	Sampling point coding	Sample names
F1	F1/0.5 cm	soil from the depth of 0.50 cm
	F1/1 m	soil from the depth of 1 m
	F1/3 m	soil from the depth of 3 m
	F1/8 m	soil from the depth of 8 m
F2	F2/0.5 cm	soil from the depth of 0.50 cm
	F2/1 m	soil from the depth of 1 m
	F2/3 m	soil from the depth of 3 m
	F2/8 m	soil from the depth of 8 m
F3	F3/0.5 cm	soil from the depth of 0.50cm
	F3/1 m	soil from the depth of 1 m
	F3/3 m	soil from the depth of 3 m
	F3 /8 m	soil from the depth of 8 m
F4	F4/0.5 cm	soil from the depth of 0.50m
	F4/1 m	soil from the depth of 1 m
	F4/3 m	soil from the depth of 3 m
	F4/8 m	soil from the depth of 8 m
F5	F5/0.5 cm	soil from the depth of 0.50 cm
	F5/1 m	soil from the depth of 1 m
	F5/3 m	soil from the depth of 3 m
	F5/8 m	soil from the depth of 8 m
F6	F6/0.5 cm	soil from the depth of 0.50 cm
	F6/1 m	soil from the depth of 1 m
	F6/3 m	soil from the depth of 3 m
	F6/8 m	soil from the depth of 8 m
F7	F7/0.5 cm	soil from the depth of 0.50 cm
	F7/1 m	soil from the depth of 1 m
	F7/3 m	soil from the depth of 3 m
	F7/8 m	soil from the depth of 8 m
F8	F8/0.5 cm	soil from the depth of 0.50 cm
	F8/1 m	soil from the depth of 1 m
	F8/3 m	soil from the depth of 3 m
	F8/8 m	soil from the depth of 8 m
F9	F9/0.5 cm	soil from the depth of 0.50cm
	F9/1 m	soil from the depth of 1 m
	F9/3 m	soil from the depth of 3 m
	F9/8 m	soil from the depth of 8 m

Sampling and transport of soil samples:

- collecting samples in glass containers with a lid;
- storage of samples under refrigeration conditions before and during transport to the laboratory in accordance with the storage procedures.

Analytical methods of analysis.

The analyses were carried out in the laboratories of the Faculty of Oil and Petrochemical Technology and EUROTOTAL Company. Because gas chromatography (GC) still remains the most important single technique for oil spill identification due to its equipment, relatively cheap and readily available, and easy to operate the determination of hydrocarbons in the soil was performed on the samples, using standard SR EN ISO 16 703 and GC-FID apparatus (Dumitran et al., 2009; 2010).

Apparatus and methods of analysis used to determine soil pollutants (TPH, PAH, B, T, E, X and lead content) for case study are presented in Table 2.

Table 2. Apparatus and methods of analysis used to determine soil pollutants

Current number	Polluant	Matrix	Standard Method	Used Equipment	Accredited/non-accredited method
1	Total Petroleum Hydrocarbons content C10-C40	Soil	SR EN ISO 16703:2011	GC –FID Dani Instrument Master Fast GC-AS	Accredited method
2	Determination of aromatic hydrocarbons: benzene, toluene, o, m, p-xilenes and ethylbenzene by gas chromatography	Soil	SR EN ISO 22155:2013	GC ECD Dani Instruments Master Fast GC-HS	Accredited method
3.	Determination of polycyclic aromatic hydrocarbons (HAPs) (naphthalene, phenanthrene, fluoranthene, pyrene, benzo (b) fluoranthene, benzo (k) fluoranthene, benz (a) pyrene, dibenzo (a,h) anthracene1, 2, 3 - cd) of pyrene	Soil	SR ISO 13877:1999	U HPLC Thermo Scientific Dionex Ultimate 3000	Non-Accredited method
4	Determination of lead content	soil	SR ISO 11047/1999	Atomic flame absorption spectrophotometer PG Instruments AA500	Accredited method

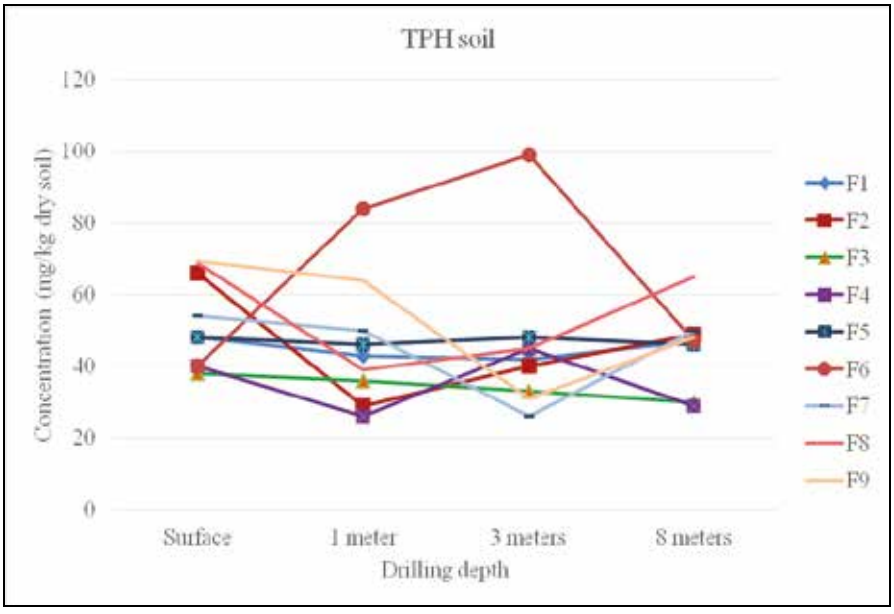

Figure 1. Total Hydrocarbons from Petrol (THP) in contaminated soil for the 36 samples and the 9 coded drillings

Figure 2. View of a broken crude oil pipeline

RESULTS AND DISCUSSIONS

Taking into account the results of the determinations carried out on the soil samples compared to the threshold values established by Ministerial Order 756/1997, the following aspects were highlighted: The measured values for Total Petroleum Hydrocarbons on soil samples are under and some around the normal values below the alert threshold, for less sensitive soil (industrial use) in each sampling bore at all soil sampling depths. The determined values are around the normal values as outlined in Figure 1. In addition to TPH, measurements of the individual benzene, toluene, ethylbenzene, and xylene (BTEX) compounds are routinely made for purposes of defining the nature and extent of fuel spills.

Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds are always present in gasoline and should be tested for at all gasoline contaminated sites. For an improved assessment of the soil quality were included aromatic volatile hydrocarbons like benzene, toluene, ethylbenzene and xylenes (BTEX). (Table 4).

The measured values of the BTEX content for all analyzed samples are above the normal values, set by the legislation in force, but below the alert threshold (Table 4).

For several years (1973–1996) leaded gasoline was used as octanic additive. After 1996, lead compounds EDB (ethylene dibromide) and EDC (ethylene dichloride) are unlikely to be present at environmentally significant levels in most gasoline releases. However, leaded gasoline is still allowed for off-road uses such as aviation, farm equipment, marine engines and racing fuels.

In addition to the inorganic compounds of lead, there are a number of organo lead compounds such as tetraethyl lead.

The toxicities and environmental effects of organo lead compounds are particularly noteworthy because of the former widespread use and distribution of tetraethyl lead as a gasoline additive (Stoian et al.,2017).

For these reasons, the lead, EDB and EDC has to be tested to establish whether these contaminants are present at the site. If they are found, additional testing should be conducted to establish the extent of soil and groundwater contamination (Onutu et al., 2015).

Table 3. Threshould values according to Ministerial Order (M.O.) 756/1997.

Contaminant	Normal values, mg/kg d.s.	Alert thresholds, mg/kg d.s	Intervention thresholds, mg/kg d.s
TPHs	100	1000	2000
B	<0.01	0.5	2.0
EB	<0.05	10.0	50.0
T	<0.05	30.0	100.0
X	<0.05	15.0	25.0
Lead	<20	250	1000

Table 4. BTEX values according to Ministerial Order (M.O.) 756/1997

Contaminant	Normal values, mg/kg d.s.	Determined values, mg/kg d.s.	Alert thresholds, mg/kg d.s
B	<0.01	<0.22	0.5
EB	<0.05	<0.23	10.0
T	<0.05	<0.24	30.0
X (M+P)	<0.05	<0.47	15
X (O	0.05	<0.24	15
Lead	<20	48	250

Note. The the values obtained experimentally and presented in the table represent average values of the contaminants studied. These values were exceeded only in isolated cases.

Thus, the lead content measured on soil samples record values below the Alert Threshold (250 mg/kg d.s.) from the surface to the depth of about 3 m, except values from the depth (8 m) for drilling F1, F4, F8, F9 exceeding the alert threshold value (250 mg/kg dry soil) and the depth values (8 m) at drills F2, F3, F5, F6, F7 exceed the intervention threshold/kg su (Table 5).

The determined values are around normal values up to a depth of about 3 m in each soil sampling drill, and at 8 m depths exceeds the

alert value (250 mg/kg su) or the intervention value (1000 mg/kg su).
Interestingly, a higher lead content is found on soil that has less TPH content, which is explained by the fact that the site was contaminated with tetraethyl lead.

Table 5. Lead content values according to Ministerial Order (M.O.) 756/1997

Crt. no.	Sampling point coding	Determined values, mg/kg d.s.	Crt. no.	Sampling point coding	Determined values, mg/kg d.s.
1	F1/0.5cm	**47**	19	F5/3m	**197.5**
2	F1/1m	**47**	20	F5/8m	**1141**
3	F1/3m	**70**	21	F6/0.5 cm	**65**
4	F1/8m	**625**	22	F6/1m	**42**
5	F2/0.5cm	**57**	23	F6/3m	**59**
6	F2/1m	**58**	24	F6/8m	**1580**
7	F2/3m	**149**	25	F7/0.5 cm	**45**
8	F2/8m	**1255**	26	F7/1m	**41**
9	F3/0.5cm	**66**	27	F7/3m	**132**
10	F3/1m	**72**	28	F7/8m	**1705**
11	F3/3m	**91**	29	F8/0.5 cm	**25**
12	F3/8m	**1640**	30	F8/1m	**46**
13	F4/0.5cm	**37**	31	F8/3m	**120**
14	F4/1m	**37**	32	F8/8m	**644**
15	F4/3m	**48**	33	F9/0.5 cm	**40**
16	F4/8m	**554**	34	F9/1m	**37**
17	F5/0.5cm	**20**	35	F9/3m	**110**
18	F5/1m	**45.5**	36	F9/8m	

CONCLUSIONS

Historically, there are numerous sites at which petroleum spills or leaks have occurred. Crude oil and fuel storage tanks pump houses, and fuel lines can be typical sources of unexpected releases of fuels to the environment.
Among the phases that make up the Contaminated Site Management procedure, as stated in the National Strategy, namely: (1) inventory, (2) historical/preliminary investigation, (3) detailed investigation, (4) actions for correction, (5) evaluation of the contaminated sites management process, the finalization of the corrective actions, in this paper was described the stage 3 - the detailed investigation.
The experimental results on soil pollution related to a former petroleum storage facility (leaded tetraethyl lead, petroleum, diesel oil) showed that such activity does not affect soil for 20-30 years if the equipment used is properly maintained and its operation takes place according to technological requirements.
The assessment of soils exposed to crude oil or petroleum products can be conducted through the comparison between a measured concentration and an intervention value (IV). Several national policies include the IV based on the so called total petroleum hydrocarbons (TPH) measure. However, the TPH assessment does not indicate the individual substances that may produce contamination.
The soil quality assessment can be improved by including common hazardous compounds as polycyclic aromatic hydrocarbons (PAHs) and aromatic volatile hydrocarbons like benzene, toluene, ethylbenzene and xylenes (BTEX).
This study, based on 36 samples collected from investigated site, allows to that TPH and PAH concentrations above the IV are mainly found in medium and heavy oil products such as diesel and heavy oil. On the other hand, unacceptable BTEX concentrations are reached in soils contaminated with gasoline and kerosene. The TPH assessment suggests the need for further action to include lighter products. This work provides useful information about the soil quality assessment methodology of oil products in soils, focussing the analysis into the substances that mainly cause the risk.
Critical values for contaminant are retained as soil remediation standard. The methodology for site specific risk assessment is based on the approach followed to derive soil remediation standards. Finally, the ecological restoration and reconstruction of the soils affected by the pollution involves an assembly of technical works and works of agropedoameliorative character.
The agropedoameliorative work to be carried out is based on a pedological study, in one cycle or in a series of cycles, for each polluted area, depending on the type of soil, the degree of pollution (pollution intensity) and the type of pollutant or sewage).

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APPLICATIONS OF GIS MODEL FOR WATER SUPPLY SYSTEMS

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Abstract

GIS models present a wide-ranging application of water supply and sewerage monitoring. In the last period, on national and international plans the administrations have expanded their applications. Thus, in Romania, most water-sewer company are using GIS applications in different programs to analyse water supply systems. This paper presents a GIS model in Iasi County that presents the advantage of a complex detail of the water supply system components. The model also allows data to be obtained for redesigning complex pipelines and installations or for re-engineering some rehabilitation works. GIS models can provide themed maps, work reports, and mathematical models for design and exposition in a relatively short time.

Key words*: real estate cadastre, hydrant, distribution network, database.*

INTRODUCTION

Applications of GIS models for monitoring water supply networks are used by water-sewer companies as well as by researchers to carry out case studies. GIS models along with water network sizing programs can help design and verify the operation of drinking water distribution networks. Thus, Montasir M. et al. (2013) used the EPANET program to assess existing capacities and limitations of the water supply system. A hydraulic simulation of the network parameters was also carried out by Ramesh H. et al. (2012), where census data were used for the study area, the model of the water supply network integrated in EPANET and data on the estimation of water consumption etc. Through the two programs a hydraulic simulation was carried out at different nodes in the network for flows and pressures in order to analyse the performance and behaviour of the pipeline network in various situations.

Using similar data, Brinda D. et al. (2015) conducted a study that determined the population's water consumption forecast and the future development of the water supply scheme. Also, using ArcMap, Marian R.A. et al. (2012) has developed scenarios where two hours damage affects households, crops and road routes etc.

The use of GIS models presents both advantages and disadvantages. Thus, the GIS models have the following advantages: facilitating the data interrogation process, shortening working time, reducing maintenance costs, upgrading and rehabilitating by combining textual and graphic data, simulating the various mathematical models needed to perform verification calculations, facilitating communication with authorities and customers.

Given today's technology developments, GIS models don't pose major drawbacks, but for implementing such a model it is necessary to purchase programs that may sometimes be costly. Also, these models must be developed and monitored by industry specialists, who must pursue the continuous improvement of the GIS model and endowment with advanced storage software.

THE CURRENT STATE OF GIS MODEL APPLICATION

The application of GIS models in monitoring water supply systems is carried out in a differentiated way, internationally and nationally. Thus, in countries such as Turkey,

the Netherlands, France and USA, applications are good developed (Lates I., 2016). Although they have well-developed systems, they are still looking for ways to improve and develop them. In a number of countries around the globe, the application of GIS models has been achieved in only a few cities. Such a situation is mentioned in Kosovo, where the system is still at the project stage (Lates I., 2016).

Internationally, GIS models of water supply systems have evolved over Romania, although some countries have implemented advanced GIS models and they are in a continuous process of editing and improvement (Lates I., 2016).

At a national level, a number of localities use GIS models in water supply and sewerage companies. Water communities use different programs, platforms and applications: GIS NetSet, AutoCAD Civil 3D, Audesk, ArcGIS (Lates I., 2016). Not all Romanian water sewer company benefit from advanced GIS systems and some of the cities are still in the state of analogue maps and old databases that no longer meet modern technical requirements.

In the literature there are presented impact analyses on negative influences on water in the pipeline network, where GIS models were used (Lates I., 2016).

Also, case studies are carried out by corroborating the calculation programs specific to the GIS pipelines and the specific conditions of the pipeline location (geotechnical, hydrogeological, seismic etc.).

These studies have identified a number of operational problems and simulated exploitation processes for various situations that may occur in the water supply system

Particular importance for the correct and optimal functioning of the components and installations within the pipeline network is the monitoring of the whole system as a whole, as well as the monitoring on each component.

GIS models can monitor functional and time-related parameters (flow, pressure, residual chlorine content, turbidity etc.).

At the same time, the quantities of water distributed in the localities served by the water supply system and the accurate assessment of the water losses can be correctly read (Luca M., Alexandrescu S. A., 2010).

CASE STUDY FOR DISTRIBUTION NETWORK MONITORING

Documentary studies and researches conducted nationally and internationally in various watercourses and literature have shown the need to develop a more complex GIS model for monitoring the operation of water supply systems (Lates I., 2017).

The water supply system is a complex of buildings, installations and measures designed to ensure water quality and quantity required by a user (NP-133/2013).

For a better understanding of this complex it is necessary to schematize it, which includes: capture, pumping stations, treatment stations, adduction, storage tank, distribution network (Figure 1).

Figure 1. General scheme of water supply

The GIS model for an urban cadastre system is a schematic representation of all components of the water supply network and elements forming part of the real estate cadastre.

The elements that make up the network are transposed into the GIS environment using ArcMap to help integrate, interpret and simulate them.

The study area was located in the eastern city of Iasi. The water supply network introduced in the GIS model has attached site information, structural parameters (diameters, lengths, materials, groundwater presence, ground geotechnics etc.), functional parameters (flows, pressures, turbidity, concentration residual chlorine etc.), network installations and specific parameters (hydrants), network construction, reservoirs, pumping stations.

The study area has cadastral-related information about street names, landing numbers, parcel, address, coordinates x, y, z, level curves, building height regime, owners etc.

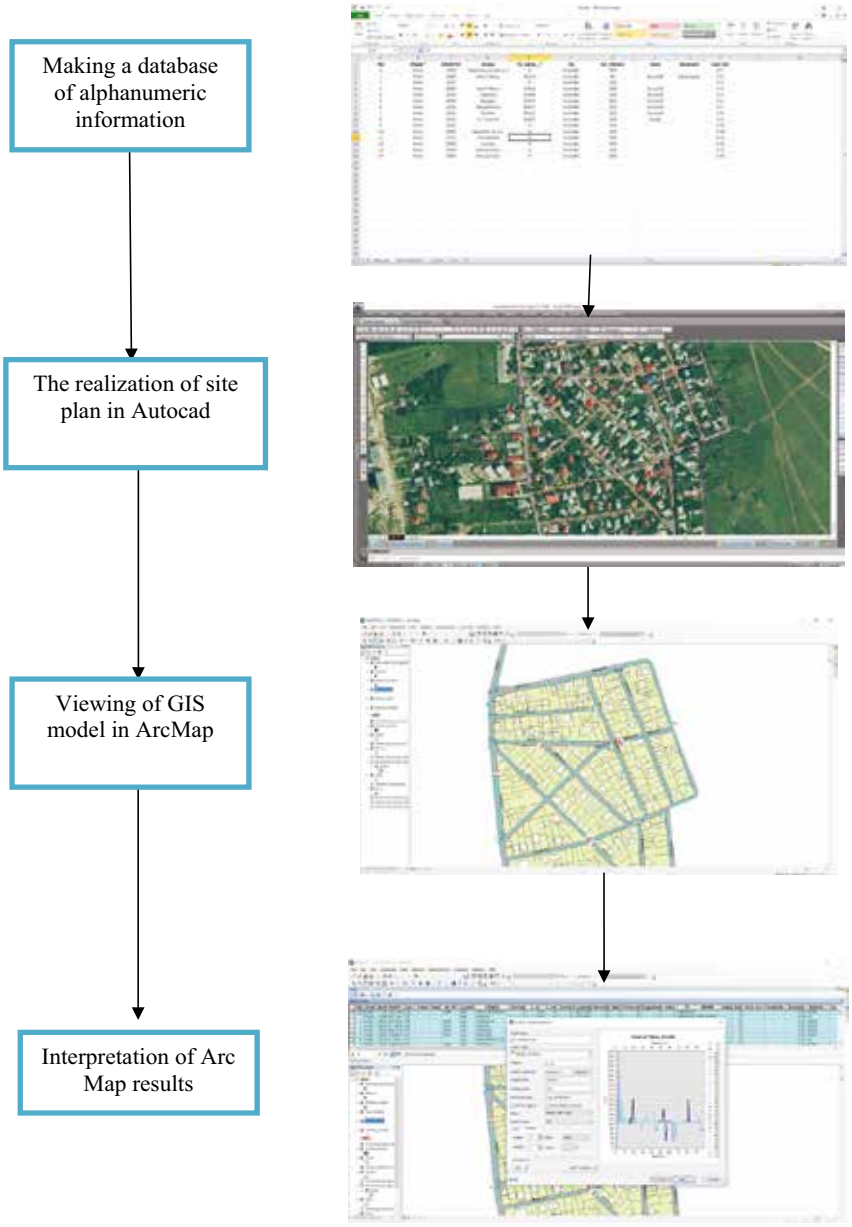

Figure 2. Scheme for the realization of a GIS model of a real estate

Several types of analyses have been carried out in the study area, which looked at different aspects of the social, economic, political and environmental aspects. The analyses were carried out for different components: distribution network, hydrants, manhole, street network, buildings etc.

In the case of the distribution network, it was considered the analysis of the materials in the pipelines and the installations; this is important in knowing the structural and functional parameters (component life, behaviour over time etc.). The analysis carried out showed that three types of materials are present in the

pipeline network; polyethylene, steel and cast iron.

Figure 3. Viewing the pipes in ArcMap according to the used material

The analysis of the diameters that are part of the pipeline network for the transport and distribution of water is of great importance because it influences water speed, pressure losses, rehabilitation and modernization costs etc.

Figure 4. Viewing the pipes in ArcMap according to their diameter

For the manhole on the pipeline network, an analysis was carried out according to the constructional characteristics (material, installation rate in the field and on the surface, location) and the type of hydraulic installation (bypass, branch, ventilation, drainage, subtraction etc.)
In order to optimize pressure management in the pipeline network, the height regime of the constructions (P, P + 2, P + 4, P + 10 etc.) was identified. In figure 6 it shows the height regime of the constructions in the study area; there is a large proportion of buildings P + 1 (shown in blue).

Figure 5. Viewing manholes in ArcMap according to the depth of location

The analysis shows the arrangement of plots of buildings with different regime of height and the influence on the functional parameters of the pipeline network (for example: in the plot CC 257 there is a P + 3 building on Marginii street, but also a P + 2 building).
The height regime of buildings is important in case of fire, in order to know the parameters of the pipeline network and the specific fire-fighting intervention measures (P118/2-2013).

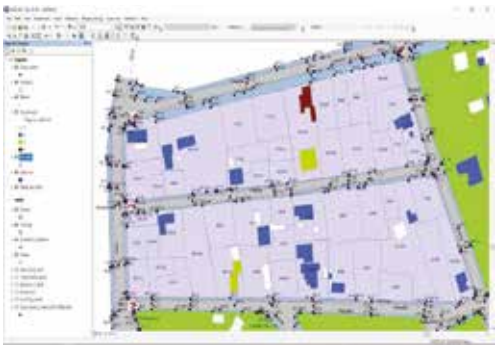

Figure 6. Identifying the height regime of buildings in ArcMap

Identifying buildings by number of occupants is of great importance, as fire intervention teams can approximate rescue measures and necessary equipment.
Buildings with tenants with different functions are classified by fire category and their importance in saving people and goods. All data is stored in specialized layers (Lates I., 2017).

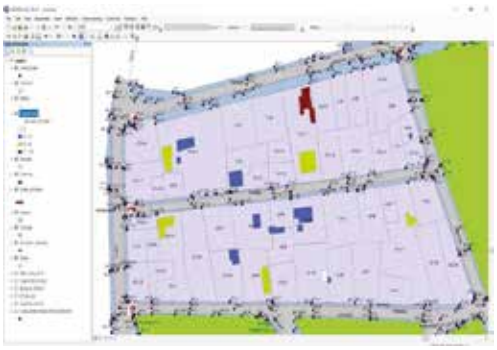

Figure 7. Identify the number of occupants in ArcMap

The identification of the constructions after the observation field, as can be seen in Figure 8, is done by colour code. For example, the green code indicates buildings with children or clusters of children; the red colour code indicates the buildings where people with locomotor disabilities are located. These categories of people move much harder and require special measures in the internal and external fire action. There is also a priority in how to save people in the area and buildings affected by fire.

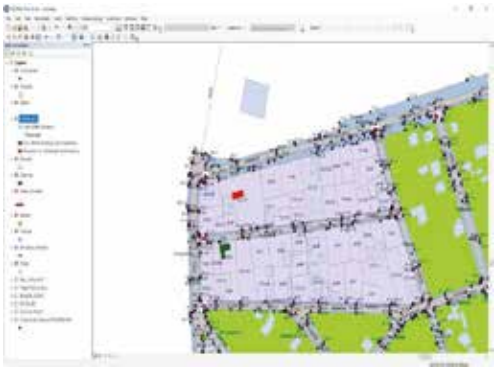

Figure 8. Identifying by the ArcMap observation field

The identification of the buildings embedded in the study area (Figure 9) was done by considering two sectors. In the analysed case the existence of nine buildings registered in the land register was found.
The analysis of this situation results in the need to accurately complete the real estate cadastre, with data acquisition and import into the GIS monitoring model.

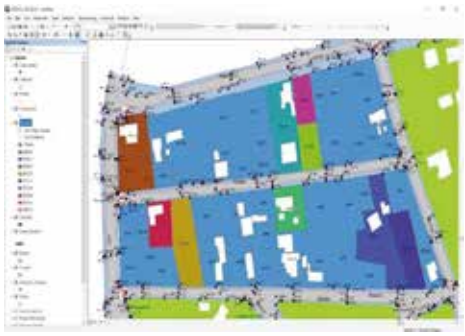

Figure 9. Identify buildings in ArcMap

Making a street name query is necessary if a particular street in the GIS model is to be identified, or you want to know how it is arranged (asphalt/unpacked). The map outlines the streets that cross the study area by colour code for a faster identification, but also their classification. You can also set the name of the streets or other attributes of interest in water distribution management in the program interface.

Figure 10. Identifying of the streets by colour

The monitored GIS model allows data to be imported continuously, but also processed by using specialized programs in the field of water supply.
A water supply system becomes effective through rehabilitation, refurbishment, upgrading and automation work. Improving the process is made easier by creating a database to facilitate the design/redesign and management of water networks.
With the help of analysis functions, GIS models facilitate the inspection, maintenance and monitoring of water supply systems (Ramesh H. et al. 2012).

CONCLUSIONS

GIS models are used both for the entire water supply system and separately for each component of the system, with structural and functional features.

The analysis of the special urban constructions and installations is made according to the data attached to them.

GIS models for monitoring water supply systems need to be improved by interconnecting different databases and updating work schedules at the level of modern technology.

The presented GIS models use a series of programs to identify structural and functional problems, to predict operational situations, and to simulate water supply system components in the process.

GIS models use queries to create digital maps and reports that facilitate communication between the water channel and the administrative authorities as well as with customers.

GIS models identify problems and help find solutions to solve them by working with hydraulic models specific to water supply systems design, while addressing and interpreting real estate issues.

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RESULTS OF THE STUDY ON INTEGRATING URBANISM INFORMATION INTO THE CADASTRE AND LAND BOOK SYSTEM

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Abstract

The real estate development, the increase in the number of constructions made in the past years brings a complex problem, that of urban agglomeration, and implicitly all other problems deriving from it, environmental, social and economic issues. At the base of real estate development and the default of urban development is the system of cadastre and land book. By the very object of activity „the immovable" the cadastre and the urbanism activity are closely related. The aim of this study, is to find the method that brings together cadastre and urbanism information, to make the best decisions by the authorities responsible for these activities but also by citizens who want to achieve certain investment.

Key words: *cadastre, urbanism, immovable, management, GIS.*

INTRODUCTION

Urban development of localities leads to an increase in the quality of life if this development is controlled and respects the rules and restrictions imposed by urbanism.
Urban development represents a complex process involving material and human resources, involving the participation of several institutions in creating the framework necessary for the implementation of urban planning projects.
This study aims to analyse an area located in Ilfov County, developed from an urban point of view.
Ilfov County had a rapid development in the years after 1989, the restitution of the land of the old landowners by applying the 18/1991 law and subsequently the other Land Laws paved the way for a new, upward, real estate development area.
In Romania, the integrated cadastre and land registry system is functioning today. Land with or without construction is registered in this system on request or through systematic registration.
To obtain building permits, utilities connection, real estate transactions or drafting of notarial documents, it is mandatory for the immovables to be registered in the cadastre and land registry system (Figure 1).

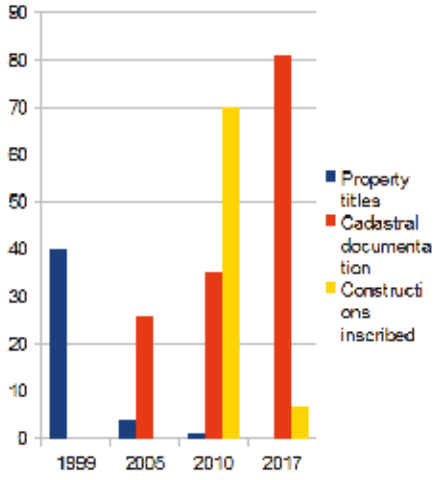

Figure 1. Evolution of buildings in the period 1999-2017

The area under study is situated in locality Popesti-Leordeni, Ilfov County. On 01.01.1990, this land area of 26 ha represents land with extravilandestination, category of arable land use. According to the graph presented in Figure 1 until 1999 the land was retroceded in percent of 85.1%. In 2000, by approving the general urban plan, this land area was introduced into the urban area. The number of cadastral documentation and real estate transactions has been increasing over the period

1999-2017. On the area of 26 ha were built 77 buildings, the clear majority, of type condominium, which subsequently were divided (Table1) (eterra3, ancpi.ro).

Table 1. Evolution of individual units during the period 1999-2017

Specifications	1995	2005	2010	2017
Number of individual apartment units	0	0	614	219

Ilfov County has benefited from a number of advantages that have led to its development. The geographical location, Bucharest's ring road, the large unoccupied land area at the level of 1991 was among the most important aspects that contributed to the interest for the development of this county. Today large areas in Ilfov are real towns, the proportion of land occupied by construction compared to free land leads to a worrying conclusion "urban agglomeration" (Figure 2).

Figure 2. Locality of Popesti-Leordeni newly built area

Urban agglomeration due to the uncontrolled development of a locality brings about a few inconveniences on various levels:
a) Narrow traffic due to workforce migration, an issue faced by almost all localities in Ilfov County, or due to improper road infrastructure that was not designed for such intense trafficking;
b) Environmental issues, noise, noxes, pollution;
c) Economic and social problems raised by delays due to heavy traffic;
d) Visual discomfort, strenuous environment, noise, lack of rest.
Uncontrolled urban development will create discomfort and inconvenience to people (Neacsu, 2010).
A map of buildings using GIS is an important and necessary tool for urban development in terms of urban planning.

MATERIALS AND METHODS

The most effective way to reduce chaotic urban development situations is to discipline the participants in this activity and to optimize this process by creating a legislative and informational framework that covers the whole range of situations in this field.
An important aspect to be mentioned is the tendency of land fragmentation. Agglomerated areas have plots with small areas, 300, 500 mp and less frequently 1000 mp or more. Land division involves compliance with certain urban planning rules (eterra3, ancpi.ro).
From this point of view, the integration of urbanism information along with cadastre system and land book registry using a GIS is an optimal and effective approach to making the best decisions.
A first step in this direction would be to include urban regulations and restrictions in the cadastre and land book system. These data should be used by those responsible for these cadastre and urban planning activities.
Being an activity the results of which result in building what implies the realization of long-term investments, it is important that the solutions adopted to optimize this process lead to making the right decisions. In the process of decision making it is necessary to know the expectancies and preoccupations of the different interested parties as well as to determine whether and how they will have any influence in strategic decisions on the long run (Minea, 2016).
At the basis of the urbanization activity is found P.U.G. - the general urban plan of the locality (Attico Barter Club S.R.L., 2000).
This documentation contains the urbanization regulations and restrictions for the entire locality.
The locality is divided into territorial reference units, U.T.R. Each UTR contains several

specific regulations. Besides the different construction possibilities, P.O.T. and C.U.T. are key elements of urbanism in urban planning (Davidescu, 2003).

These elements of urbanization P.O.T. - occupancy rate of land and C.U.T. - the land occupation factor, the limit of the territorial reference unit, introduced in the real estate map, is a solution that will help in making the decisions.

For each territorial unit a P.O.T. and a C.U.T. maximum admitted. P.O.T. and C.U.T. are the specific urban work tools needed to control the design and sustainable development of urban areas.

POT - the occupancy rate of the land is the ratio of the built area (ground footprint or ground projection of the upper floors perimeters) and the plot area included in the reference territorial unit.

CUT - the land use coefficient represents the ratio of the built-up area to the plot area (Law 350/2001).

The cadastre and land registry system contain information on the built area, the surface area and the land surface.

Thus, you can calculate the P.O.T. and C.U.T. urbanistic indicators.

In the cadastral system the real estate is a closed polyline defined by the inflection points of the property limits of the immovable.

Will be introduced in the map of the immovables of a locality and the territorial reference units, these will be closed polylines. By accessing a polyline of this kind, we will have in the list of information about the imposed town planning restrictions.

For each plot of land belonging to a reference territorial unit, P.O.T. and C.U.T. must be less than or equal to the reference unit indicators.

RESULTS AND DISCUSSIONS

This immovable map containing property in the land book, buildings with or without construction if completed with the necessary urban planning elements if using GIS then can be used for the current work as well as for the PUG assessments, change needs, company requirements in relation to the actual development possibilities of the respective locality.

Using a G.I.S. can be performed statistics on the number of building permits, the number of constructions with a certain number of levels, the type of construction, an analysis of the relationships between datasets that are in the same area can be performed. Different types of overlapping analysis can be used to solve complex spatial analysis problems (Herbei, 2010).

From the point of view of real estate development can be used to study market requirements.

The effects felt by adopting these measures can be immediate by creating the possibility that the decisions taken are as correct as possible, as well as long-term effects through the achievement of sustainable urban development.

Used efficiently and responsibly this solution will have long-term, on multiple plans effects in society. Investments in this area are long-term investments, remain inheritance to future generations.

The result of using this type of map containing the properties registered in the cadastre and land registry system and urban planning regulations brings benefits both the authorities responsible for these activities and the citizens through access to correct information.

Using this type of map, responsible decisions can be made to ensure a fair relationship between built-up land and green areas for the benefit of all citizens. Green areas are multifunctional resource that improves the quality of life in the community and support its sustainability (Jovanovic, 2012).

The problem that occurs at county level is a perspective issue. Local development independently of neighbouring localities is a solution that no longer meets the needs of society. The urban way of life is not limited to cities (Wirth, 1938).

CONCLUSIONS

This presentation is only a part of a more complex work on the study of the integration of urban planning information into the cadastral system. The proposed solution can be extended to other urban regulations. Any urbanistic restriction if is measurable exist the possibility of registration in the cadastre and land registry system.

For this solution to be put into practice, clear legal regulations, discipline and accountability are needed.
Urban investment is long-term investmentand remains an inheritance to future generations.
Integration of urban planning information into the cadastral system will lead to property management.

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DETERMINATION OF CUTANEOUS LEISHMANIASIS PREVALENCE AND INCIDENCE, BETWEEN 2009-2014 IN ADANA BY USING GEOGRAPHICAL INFORMATION SYSTEMS

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Abstract

We aimed to calculate the incidence and prevalence values of cutaneous leishmaniasis (CL) between 2009-2014 for all the districts of Adana and also to produce the maps by using Geographical Information Systems (GIS) via incidence and prevalence to show the distribution of the disease.
After geographic correction, the borders of Adana were drawn using by ARCMAP 10.2. (ARCMAP; Esri, New York, United States of America) In order to make independent interpretations for all districts, boundaries were divided into separate layers. Prevalence and incidence between 2009-2014 were entered into the GIS database and interpreted.
Our maps were created with the geographically corrected cartographic map and a database were evaluated based on the aim of the study. Although Kozan was the district where the most reported case of CL was seen (23.14%), the highest prevalence (0.345%) and incidence (0.1761‰) were detected in the province of Imamoglu in 2011. However, it has been found that the incidence and prevalence of CL tend to increase in regions where Syrian refugees lived.
Creating maps based on the prevalence and incidence of CL commonly seen in the Eastern Mediterranean and especially in Adana, will have an important role in improving the measures to be taken against the disease.

Key words: *cutaneous leishmaniasis, prevalence, incidence, Geographical Information Systems, Adana.*

INTRODUCTION

Leishmaniasis is a zoonotic/anthropogenic protozoon parasitic infectious disease infected with vector sand flies, which spreads all over the continent except Antarctica. The disease that caused by *Leishmania* parasites were first identified and named in 1901 by William B. Leishman. Various *Leishmania* species that are not morphologically different cause different diseases, such as systemic infection, which are relatively non-lethal and spontaneously healing skin infections, involving internal organs and causing thousands of epidemics to die (Marquardt et al., 2000). Until now, the presence of leishmaniasis has been reported in 88 countries, and 350 million people live at risk every year. Cutaneous leishmaniasis (CL) is disabling and presents with a remarkable variability of the clinical manifestations such as multiple lesions, which are frequently self-healing in the old world. These lesions leave a permanent immunity that protects the person from new infections for life after treatment or spontaneous resolution (Ozbel, 2007).

The incidence value, that meanwhile expressing the number of new occurrences of a specific disease or disease within a given period of time for a given population, used to determine the epidemiology, distribution and possible risks of diseases. Prevalence value refers to the proportion of all cases with a specific disease or illness within the scope of the study within a specified period of time. In addition, GIS-based prevalence and incidence maps play an important role in determining disease trends in society (Ozdamarci, 2010; Ostad et al., 2016).

Cutaneous leishmaniasis is seen in a wide area in Turkey. It is estimated that climate change will expand the breeding areas of the vector and thus spread the disease to the more northern regions. Also, the civil war and the resultant migrations from Syria to Turkey, which have taken place in recent years, cause the disease to be seen more frequently in the cities which are bordered on Syria, located in the southern part of Turkey (Saylan et al., 1986; Momeni et al., 2007; Ozkeklikci et al., 2017).

Geographic Information System (GIS) is a system based on databases that are effective in determining spatial information in vector-borne diseases. Environmental factors such as altitude, climate, emission and vegetation are effective in shaping the geographical

distribution of sand flies and infectious diseases. Equipped with new technologies, GIS enables researchers to generate risk maps that include relationships between vector-borne diseases, environmental factors, and vector arthropods (Kahime et al., 2016; Ebrahimi et al., 2016).

The first aim of our study was to obtain the incidence and prevalence values. These values are calculated in relation to the number of CL patients and the total population in 15 provinces of Adana between 2009-2014. Then we produced the 6 years incidence and prevalence maps using Geographic Information System (GIS) instruments.

MATERIALS AND METHODS

Study Area

Adana is located in the eastern part of the Mediterranean Region of Turkey andit is the fifth major city of Turkey. The city has a human population of 1.7 millions. Its basin is 14,032 km^2 in area. Adana has fifteen districts and it is located at 37.002 latitude and 35.329 longitude (UTM Zone 36N– WGS84) (TSI, 2016) (Figure 1).

Figure 1. Map of Turkey, Adana province.

Obtaining Data and Map Producings

The population data and CL patient numbers of 15 districts of Adana between 2009-2014 were obtained from related institution's databases and used to calculate the incidence and prevalence values (Table 1).

All obtained data were processed in ARCMAP 10.2 software and CL maps of the city were produced. In the study, it was aimed to evaluate the incidence and prevalence values in the districts of Adana in GIS environment (Table 1). Adana province and its district borders are digitized in the GIS software as polygons. ARCMAP 10.2 software was used for this purpose.

The topographic maps included in the software in question are used as cartographic bases. Because of the software works based on layer, every attribute obtained is evaluated as a layer. First of all, the boundaries of the study area are digitized by geographical correction.

The entire border is divided on a provincial basis as a separate layer so that the questioning of Adana can be carried out independently of its territories. Similarly, the districts of Adana are divided into district boundaries as a separate layer. All obtained data were evaluated by ARCMAP 10.2 program and CL maps of Adana province were produced.

RESULTS AND DISCUSSIONS

A total of 1646 CL patients was reported in fifteen provinces of Adana between 2009 and 2014. Although the Kozan district has the most

CL cases with 384 patients in the following 6 years, no CL patients were reported between these years in the Tufanbeyli district. When considering the years, the most patients with CL were reported in 2010. The highest number of CL cases over the years was reported in the Kozan district in 2010 (Table 1).

Table 1. Cutaneous Leishmaniasis Cases in Adana Districts between 2009-2014

Districts/Years	2009	2010	2011	2012	2013	2014	Total	%
Kozan	94	149	67	22	21	28	381	23.14
Sarıcam	37	27	55	31	95	64	309	18.77
Seyhan	58	32	34	14	40	49	227	13.79
İmamoglu	26	51	53	32	29	17	208	12.63
Yüregir	33	28	26	24	17	46	174	10.57
Karaisali	33	31	33	14	2	14	127	7.71
Ceyhan	19	17	21	26	5	6	94	5.71
Cukurova	13	16	11	10	5	8	63	3.82
Yumurtalik	9	16	7	4	3	0	39	2.36
Aladag	2	4	6	2	0	0	14	0.85
Karatas	5	0	2	0	0	0	7	0.42
Feke	1	0	0	0	0	0	1	0.06
Saimbeyli	0	0	0	0	1	0	1	0.06
Pozanti	0	0	0	0	1	0	1	0.06
Tufanbeyli	0	0	0	0	0	0	0	0
TOTAL	330	371	315	179	219	232	**1646**	**100**

According to the case numbers reported in Adana between 2009-2014, when the prevalence values are calculated, it is determined that the highest prevalence value is in the province of Imamoglu and in 2011 (0.345%). The lowest prevalence value was found to be "0" in the provinces of Aladag, Karatas, Feke, Saimbeyli, Pozanti and Tufanbeyli (Table 2).

Table 2. Prevalence values of cutaneous leishmaniasis between 2009-2014 in Adana Districts

District/Year	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)
Kozan	0.136	0.191	0.169	0.07	0.033	0.038
Saricam	0.032	0.053	0.066	0.065	0.091	0.063
Seyhan	0.011	0.012	0.009	0.006	0.007	0.011
Yüregir	0.023	0.013	0.013	0.012	0.010	0.015
İmamoglu	0.103	0.252	0.345	0.286	0.205	0.158
Karaisali	0.277	0.278	0.282	0.210	0.072	0.074
Ceyhan	0.017	0.023	0.024	0.030	0.019	0.007
Cukurova	0.005	0.008	0.008	0.006	0.004	0.004
Yumurtalik	0.073	0.134	0..126	0.061	0.038	0.016
Aladag	0.011	0.035	0.059	0.047	0.012	0
Karatas	0.023	0.024	0.009	0.010	0	0
Feke	0.010	0	0	0	0	0
Saimbeyli	0	0	0	0	0	0
Pozanti	0	0	0	0	0.005	0.005
Tufanbeyli	0	0	0	0	0	0

According to the six year incidence data based on population and CL case numbers in Adana province, the highest incidence value was determined for the year 2011 in the province of Imamoglu (0.1760‰).

In addition, the lowest prevalence value was determined as "0" in Yumurtalik, Aladag, Karatas, Feke, Saimbeyli, Pozanti and Tufanbeyli districts within 6 years (Table 3).

Table 3. Incidence values of cutaneous leishmaniasis between 2009-2014 in Adana Districts

District/Year	2009 (‰)	2010 (‰)	2011 (‰)	2012 (‰)	2013 (‰)	2014 (‰)
Kozan	0.747	1.172	0.524	0.172	0.164	0.217
Saricam	0.321	0.224	0.443	0.233	0.688	0.446
Seyhan	0.080	0.044	0.045	0.018	0.052	0.063
Yüregir	0.079	0.066	0.061	0.057	0.040	0.110
Imamoglu	0.840	1.669	1.761	1.077	0.975	0.584
Karaisali	1.428	1.349	1.454	0.626	0.090	0.646
Ceyhan	0.120	0.107	0.133	0.164	0.031	0.038
Cukurova	0.039	0.046	0.033	0.029	0.014	0.023
Yumurtalik	0.468	0.857	0.383	0.223	0.162	0
Aladag	0.114	0.233	0.351	0.118	0	0
Karatas	0.231	…..0	0.094	0	0	0
Feke	0.052	…..0	0	0	0	0
Saimbeyli	0	0	0	0	0.060	0
Pozanti	0	0	0	0	0.048	0
Tufanbeyli	0	0	0	0	0	0

After the year 2011, when Syrian refugees started to migrate to Turkey, the incidence and prevalence values of Seyhan Yuregir and Saricam districts where intensive migration occurred were increased. The prevalence and incidence value in the Seyhan district in 2014 were calculated as 0.011% and 0.063‰ respectively. The prevalence value in Yuregir district is 0.015% in 2014 while the incidence value is determined as 0.010‰. The prevalence value of the refugee camp in Saricam province, which was established in 2013, was 0.091% and the incidence value was 0.688‰ in 2013. The incidence and prevalence values calculated for the Yuregir and Seyhan districts in 2014 were higher than in the past years, while the values in the Saricam province were found to be the highest in the year 2013 (Tables 2 and 3).

CL is a vector-borne protozoan disease that transmitted by sand flies (Ozbel, 2007; WHO, 2010). Adana province is known as a viable area for the vector sand flies of the CL in terms of climate, location and other environmental factors. The number of CL cases in the Adana, especially Kozan, which is accepted as endemic in terms of CL disease, is high enough to be underestimated (TMoH, 2016). It is known that *Phlebotomus tobbi*, the vector of *Leishmania infantum*, which was caused by CL, in the previously carried out vector sand fly fauna studies, was identified as the dominant species in Karaisali, Imamoglu and Kozan districts (Alptekin et al., 1999; Ok et al., 2002; Svobodova et al., 2009; Kavur et al., 2015).

Our findings suggest that in Adana, CL case numbers have recently declined. This situation is explained as the result of planned and conscious vector control strategies. Between the years 1990-2010 a total of 46 003 new cases have been reported in Turkey, 96% of these cases are reported from Sanliurfa, Adana, Osmaniye, Hatay, Icel, Mersin and Kahramanmaras. While, in recent years, the number of cases in Sanlıurfa, Osmaniye, Adana, Diyarbakir, Mersin and Kahramanmaras tended to decrease compared to the previous years. In Aydin, Antalya and Hatay provinces, an increase tendency is observed (TMoH, 2016). Prevalence and incidence values show a declining trend in

recent years, they were determined changeable in the following years. The highest prevalence values were observed in 2011 and the lowest values were determined in 2014 (Figures 2c, and 2f).

Feke, Saimbeyli, Pozanti and Tufanbeyli are not considered as habitats preferred by sand flies because they differ than the other district in terms ofaltitude and climate conditions (Svobodova et al., 2009; Belen et al., 2011; Kavur et al., 2016).

No CL cases were detected in the observed years,except 2009 and 2013 in these districts which don't have viable conditions in terms of vector sand flies (TSMS, 2016). The prevalence value was recorded as "0" in the province of Aladag in 2014 and in the province of Karatas between 2013-2014.

The prevalence of CL was found to be highest in İmamoglu in 2011, 2012, 2013 and 2014 (Figure 2c, Figure 2d, Figure 2e and Figure 2f) in Karaisali in 2009 and 2010 (Figure 2a and Figure 2b). Because of the reported new cases in Pozanti and Saimbeyli districts showed an increase in prevalence values in 2013 and 2014 (Figure 2e and Figure 2f).

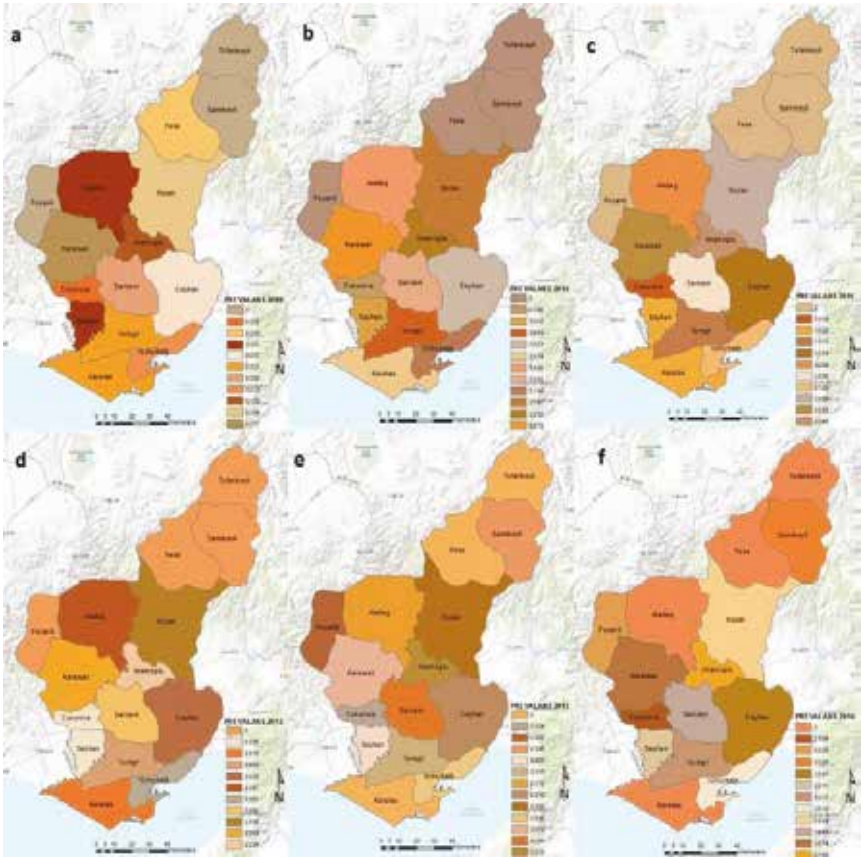

Figure 2. Maps produced for Adana due to cutaneous leishmaniasis prevalence values between 2009-2014: a) 2009 b) 2010 c) 2011 d) 2012 e) 2013) f) 2014

The incidence values in parallel with the prevalence values were the highest in 2011 and the lowest in 2014 (Figure 3c and Figure 3f). The incidence of CL was constantly low over the six year period followed in the provinces of Feke, Pozanti, Saimbeyli and Tufanbeyli except for the increases in 2009 and 2013.

It is observed that the incidence values of the Aladag and Karatas districts have fallen to the lowest level between 2013 and 2014 (Figure 3e and Figure 3f).

Karaisali district was identified as having the highest incidence value in 2009 and 2010 (Figure 3a and Figure 3b), and the highest incidence values were also recorded in the İmamoglu district between 2011-2014 (Figure 3c, Figure 3d, Figure 3e and Figure 3f).

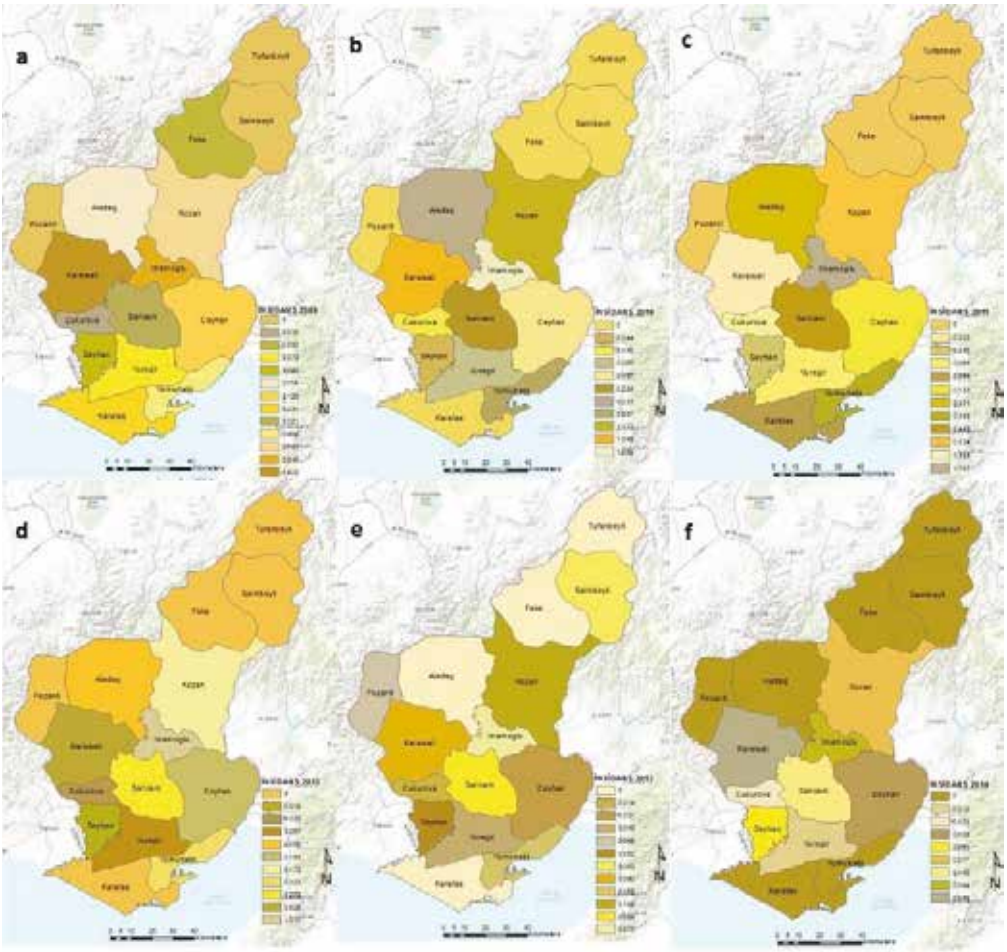

Figure 3. Maps produced for Adana due to cutaneous leishmaniasis incidence values between 2009-2014: a) 2009 b) 2010 c) 2011 d) 2012 e) 2013) f) 2014

In addition, despite the decrease in the prevalence and incidence values calculated according to case numbers, contrary to what is expected after the year 2011 when Syrian refugees throughout Adana started to emigrate, there is a significant increase in the number of migrants in Yüregir and Seyhan, especially in the districts of Yüregir and Seyhan, It is seen that there is an upward trend in the province (Figure 2e, Figure 2f, Figure 3e and Figure 3f). We think that our findings can be accepted as one of the reasons forthe change in the frequency of CL in our country after the civil war in Syria (Saylan et al., 1986; Ozkeklikci et al., 2017).

In conclusion the decrease in the prevalence and incidence values indicates that the probability of development of CL disease in Adana and the incidence of CL has a decreasing tendency. On the other hand, the refugees in the central districts need to take measures to increase the prevalence and incidence values in areas where the Syrians live intensively. In order to control the distribution

of the disease, it is necessary for the health institutions in the provinces to intensify the work of the registered patients, especially the registered patients in the refugee camps, and the identification of possible unregistered patients.

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LAND SURFACE TEMPERATURE MONITORING THROUGH GIS TECHNOLOGY USING SATELLITE LANDSAT IMAGES

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Abstract

Global warming is a factor that has widened over the last period of time, so monitoring ground temperature is needed to take measures to prevent this phenomenon. In the hope of preserving life on earth and bring balance in our life, as we use to have it, it is up to our civic duty to share the essentials of the scientific research done, for the doctoral thesis and came with some ideas and suggestion, to help our community to reach our goal. The objective of the study will describe a methodology used for estimating the terrestrial surface temperature by means of the geographic information systems technology, using the two Landsat thermal bands, acquired by the Thermal Infrared Sensor (TIRS) installed on the Landsat 8 satellite platform. A case study on the administrative area of Cristuru Secuiesc, located in the South-West part of Harghita County, will be approached in the paper. The primary data base consists of thermal bands (band 10 and band 11) and multispectral bands (2, 3, 4, 5) from the Landsat 8 mission, taken with OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) sensors. To carry out the study, the NDVI index will be calculated using the multispectral bands, while the thermal bands will be converted to several physical quantities in order to obtain the desired result. The paper describes the process of collecting data and processing it, to obtain valuable information on the surface temperature experienced by a computer, without the need for field measurements.

Key words: *GIS (Geographic Information System), Global warming, Landsat, NDVI, surface temperature.*

INTRODUCTION

The purpose of this study is to develop image capture methodologies to determine terrestrial surface temperature using satellite imagery from the Landsat 8 mission taken with the Thermal Infrared Sensor (TIRS) and the OLI (Operational Land Imager) multispectral sensor via system technology geographic information. The article brings novelty elements both for the field of satellite remote sensing and for the field of geographic information systems. This study presents also theoretical and experimental information for the implementation of a geographic information system in order to provide standard products (Ferencz Z. et al., 2017).

The most important goal of this article is not the carrying out of a quantitative analysis, much being structured in the form of a seminar, addressing in particular those who are attracted by the wonderful field of remote sensing and geographical information systems.

The geographical information systems allow the user not only to obtain some information about the Earth but also help to correlate this information with ground aspect (Maracineanu F. et al., 2013).

MATERIALS AND METHODS

The graphics software used for spatial raster spatial data geoprocessing is the ArcMap 10.1 program.

Primary digital remote sensing data are obtained free of charge from the USGS official website (earthexplorer.usgs.gov), where the area of interest is selected first, after which the type of data is selected and after filtering the results, can be downloaded online. The spatial resolution of these images is desirable, but they can be used successfully for general research.

First of all, Landsat satellite images must be purchased/downloaded using the above mentioned website.

GIS technologies have pronounced methods to analyse the relationship between several geographical and environmental data (Artun O. et al., 2017).

The study was carried out through two steps that are linked to each other, namely the first step is the calculation of the NDVI

(Normalized Difference Vegetation Index) index, while the second step is represented by a methodology/step sequence, for actual estimation of the surface temperature, and in the following, we will briefly describe the method used.

By downloading the desired Landsat scene, we will find an archive containing several files named with the spectral band number. To achieve such a study, we will need 6 spectral bands, namely bands B2 (blue), B3 (green), B4 (red), B5 (infrared) taken by the OLI (Operational Land Imager) sensor to produce the NDVI (Normalized Difference Vegetation Index) and thermal bands B10 and B11 taken over by the TIRS (Thermal Infrared Sensor) sensor installed on the Landsat satellite platform for the proper estimation of ground surface temperature.

For this article, we chose as a study area the 3rd administrative district of Cristuru Secuiesc in Harghita County, purchased in vector format *.shp from the website geoportal.ancpi.ro, maintained by the National Agency of Cadastre and Real Estate Publicity of Romania (ANCPI).

In this case study, all Landsat images were imported into the ArcMap window and clipped out using the 3rd order administrative limit of Cristuru Secuiesc through working toolbox in the Arc Toolbox window, where we select Data Management Tools > Raster > Raster Processing > Clip. The screen capture with the Clip function window is represented in the figure below (Figure 1), where there are two input data, namely the image to be cut and the clipping contour in vector format.

Figure 1. Clip Raster function window

Using the Image Analysis window (Figure 2), we create the RGB (Red Green Blue) color composite (Figure 3) and select all the 4 spectral bands, then press the Composite bands button under the Processing submenu.

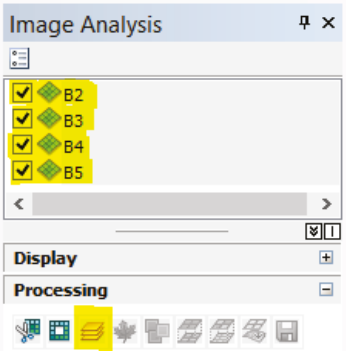

Figure 2. Image Analysis window

Figure 3. RGB composite color fake using infrared, red and green strips

Note that images that were obtained through the Image Analysis window have an on-the-fly character, and to make it a permanent layer, it is necessary to select the provisional image in the current start-up table by right-clicking save, using Data > Export Data (ESRI, ArcGIS Help, 2012). After we have obtained the colour composite, we move to creating the NDVI (Normalized Difference Vegetation Index) image. Creating the NDVI (Normalized Difference Vegetation Index) colour is greatly facilitated by using the Image Analysis window, where we select the colour composite obtained in the previous step and using the button that takes the form of a leaf under the Processing submenu (Figure 4) NDVI (Normalized Difference Vegetation Index).

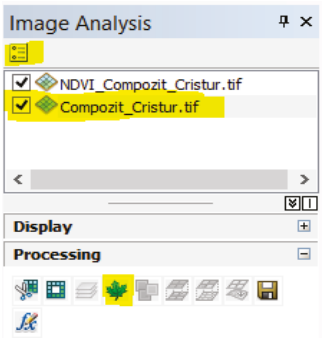

Figure 4. Creating NDVI (Normalized Difference Vegetation Index) using Image Analysis function

The calculation formula used to determine the Normalized Difference Vegetation Index (NDVI) is given by the ratio between the infrared and red band differences, respectively the sum of the infrared and red bands. The image obtained shows us the areas of land covered with healthy and dense vegetation (Figure 5).

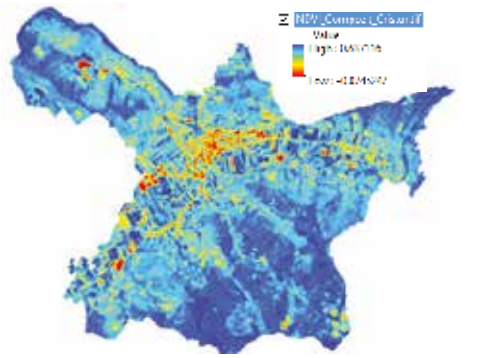

Figure 5. NDVI (Normalized Difference Vegetation Index)

Once we have the Normalized Difference Vegetation Index (NDVI), we can pass the ground surface temperature estimation by concatenating the two thermal bands (with different wavelengths) with the Normalized Difference Vegetation Index (NDVI).

The first step is to convert the digital numbers into radiance, followed by the conversion of the radiance into the temperature measured by the satellite, and the last step is the actual calculation of the surface temperature. In the following we will describe the steps taken. Note that all processes/transformations will be done using the Raster Calculator function, located between ArcToolbox work tools, in the Spatial Analyst Tools class, the Map Algebra submenu. In the following, we will briefly describe the steps to be taken to conduct the study.

1) Converting digital numbers into radiance is done according to the official USGS page (landsat.usgs.gov/using-usgs-landsat-8-product), where we find that the data acquired with the TIRS (Thermal Infrared Sensor) can be converted into radiance Spectral TOA (Top Of Atmosphere) by the formula:

$$L\lambda = M\_L \times Qcal + A\_L \quad (1)$$

where:

Lλ - TOA (Top Of Atmosphere) spectral radiance (Watts/(m^2 × srad × μm));

M_L - the rescaling factor specific to each spectral band described in the metadata file;

A_L - add-on factor specific to each strip in the metadata file;

Qcal - Calibrated pixel values in the standard product (DN - Digital Numbers).

To apply this formula, open the Raster Calculator utility (Figure 6) and enter the formula below "0.0003342*"B10" +0.1".

Figure 6. Raster Calculator function window

After executing this calculation we obtained the image with thermal band no. 10 in radiance, similarly to the second thermal band by replacing the phrase "B10" with "B11" in the calculation formula, thus "0.0003342*"B11"+0.1". After these steps we can move on to the next step, which is to convert the radiance to the temperature recorded at the sensor level on the Landsat satellite platform.

2) Conversion to At-Satellite Brightness Temperature, is also done according to the guidelines presented on the website (landsat.usgs.gov/using-usgs-landsat-8-product, using the formula below.

$$T = \frac{K_2}{\ln(\frac{K_1}{L_\gamma} + 1)} \quad (2)$$

where:
T - the temperature measured by the satellite (K);
Lλ - TOA (Top Of Atmosphere) spectral radiance (Watts / (m^2 x srad x μm));
K1 - the first transformation constant specific to each thermal strip (extracted from the metadata file);
K2 - the second transformation constant specific to each thermal strip (extracted from the metadata file).
Similar to the previous step, using the same Raster calculator function, we write the equation "1321.0789/{Ln[774.8853/"Banda10_radianta"]+1}" (where "Banda10_radianta" is the image obtained in the previous step). This formula applies exactly like the first stage of both thermal bands in part, first for the band 10, and then for the 11th band.
As mentioned above, the result obtained is expressed in Kelvin, and if we want to convert it to another unit of measurement, the Raster Calculator and transformation factor (eg: 0 K = -273.15°C, the value obtained in Kelvin degrees decreases to 273.15).
At this step, we obtained two images in (°C), and using Cell Statistics (Figure 7) we calculate the average of the two images, so we get a single image from a set of two images.

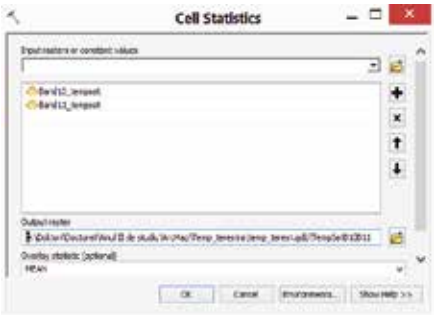

Figure 7. Cell Statistics window

3) Estimation of the ground surface temperature, is the last untreated step, where we will calculate the surface temperature using the following relationship:

$$TS = \frac{BT}{1+(\lambda \times \frac{BT}{p}) \times \ln(e)} \quad (3)$$

where:
TS – terrestrial temperature;
BT – measured satellite temperature (obtained from the previous step);
λ – radiant wavelength emitted (11.5 μm);
p=h×c/k; p = 14380
h – Planck's constant (6.626×10^{-23}Js);
k – Boltzmann constant (1.38×10^{-23}J/K);
c – the speed of light (2.998×10^{8}m/s);
e – emissivity of the land surface,
e = (0.004×Pv+0.986)
Pv – the proportion of vegetation,
$Pv = (\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}})^2$.

In theArcMap program language, the formula for calculating the terrestrial surface temperature thus appears in the Raster Calculator window ""TempSatB10B11"/(1+(11.5*"TempSatB10B11"/14380)*Ln("0.004*(Square(("NDVI_Cristur.tif"-(-0.0745247))/(0.637116-(-0.0745247))))+0.986"))".
After running this calculation, we obtained the result below (Figure 8).

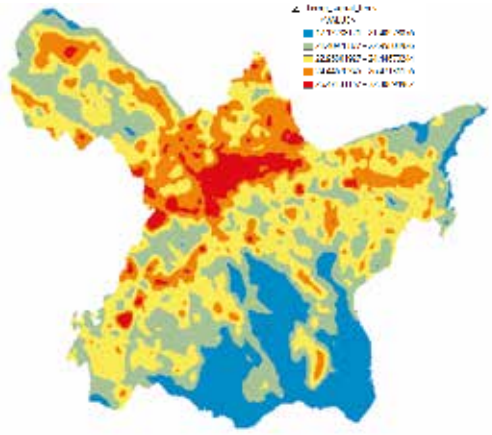

Figure 8. Land surface temperature estimation using Landsat image satellite

RESULTS AND DISCUSSIONS

As can be seen in the obtained picture of the terrestrial surface temperature of Cristuru Secuiesc, hot-stained areas are fairly high temperatures, while the cold-colored areas have a medium temperature.
Since the image was obtained on July 11, 2016, temperatures are roughly normal for that region. The red spot in the center of the image is an urban area, more specifically the city of Cristuru Secuiesc, while the orange color surrounding the red patch represents residential areas in the suburban area.
By looking at the image of the temperature (Figure 8) and the image with the fake colored infrared image (Figure 3), it can be noticed that the vegetation areas have a lower temperature than the inhabited urban areas that abound in the construction.
Analyzing the image, it can be seen that the forested area in the southern part of Cristuru Secuiesc has the lowest temperature value.
It is also worth mentioning that the two lakes located in the North-West part of the locality have temperatures close to that of the inhabited areas, being in the same class.

CONCLUSIONS

This case study presents the key to research on global warming, providing both theoretical and practical aspects, with the main purpose of education. The article has been shown how to obtain a Normalized Difference Vegetation Index (NDVI), with several image processing operations obtained by remote sensing.
Using this methodology, it is possible to estimate the temperature of the terrestrial surface anywhere on the earth globe in a very comfortable and light manner.
This method is very fast, and does not require any cost to acquire primary data. Any user can estimate the terrestrial surface temperature with a computer with normal parameters and a spatial data processing program in vector and raster format. The disadvantage of this method is the cost of the acquisition of the processing programs, but there are Open Source alternatives, with which most analyzes can be carried out, but the computing power of these programs is not at the level of the ArcMap decrypted military software, nor neither acquisition costs nor the multitude of integrated tools.

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ANALYSIS OF LST-NDVI SPARSE/DENSE VEGETATION RELATIONSHIP: A CASE STUDY OF IASI COUNTY

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Abstract

Although we often take the trees and plants around us for granted, almost every aspect of our lives depends upon them. They clothe us, feed us, provide us with oxygen, absorb carbon dioxide and give us building materials and medications. Vegetation, in Iasi County - the study area in this paper, is predominantly of forest-steppe. In this study is investigating correlation LST - sparse/dense vegetation extraction from NDVI, in three different moments of 2017. Landsat 8 images, which have undergone pre-processing, were used as based date. A lot of papers showed that the surface temperature of the work was confirmed from Landsat 5/7/8. Many researches indicated that between LST and NDVI is a linear relationship. It is noticeable that correlation coefficient has closer values to 1 for relationship LST - NDVI dense; R2 is about 0.9, while R2 is about 0.7 for relationship LST - NDVI sparse. In conclusion, this correlation can be used to study vegetation health, drought damage, and areas where Urban Heat Island can occur.

Key words*: NDVI, LST, sparse/dense vegetation, R^2.*

INTRODUCTION

Although we often take the trees and plants around us for granted, almost every aspect of our lives depends upon them. They clothe us, feed us, provide us with oxygen, absorb carbon dioxide and give us building materials and medications. If drastic changes occur to the vegetation around us, our economy, health and environment are all affected (USGS).

Vegetation, in Iasi County, is predominantly of forest-steppe. Due to the rugged relief and the appreciable difference in altitude between the lower valleys and the upper level of the dominant hills, the vegetation has a layered arrangement (steppe, silvosteap, forest), in close connection with the pedo-climatic levelling (PUG Iasi).

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and evaluate whether the aim being observed contains live green vegetation or not (Rousse J. et al., 1973).

Remote sensing, according to Orhan, is useful for comprehending the spatial-temporal LC (land cover change) in relation to the elementary physical properties as regards of the emissivity data and surface radiance (Orhan, 2016). Start the seventies of the twentieth century, satellite-derived (like Landsat-5 TM/ 7 ETM +/8 OLI) surface temperature data have been utilized for local and regional climate study on different scale (Carlson, 1977). Landsat data have medium-resolution in the only source of land surface temperature (LST) in worldwide since 1972. Consequently the Landsat-5/7/8 imaginary were used in research. A lot of papers showed that the surface temperature of the work was confirmed from Landsat 5/7/8 (Mallick et al., 2012; Macarof et al., 2017).

Nowadays LST is used to discover the temperature distribution at the change global, regional and local scale. Also, in particular, it is used in climate change model. LST, determined from remote sensing data can be use in a lot of sphere of science, like: agriculture, climate change, oceanography, hydrology, forestry, urban planning etc. (Orhan et al., 2014).

Many researches indicated that between LST and NDVI is a linear relationship. According to Carlson, this negative correlation between them is valuable for urban climate studies and another circle of science (Carlson et al., 1994).

In this paper is investigating correlation LST - sparse/dense vegetation extraction from NDVI,

in three different moments of 2017. As based date were used Landsat 8 images.

MATERIALS AND METHODS

Study area

Iasi County is considered as study area in this research. Study Area is geographically situated on latitude 46°48'N to 47°35'N and longitude 26°29'E to 28°07'E. Neigh borings Iasi County are Botosani to the north, Neamt to the west, Vaslui to the south and Republic of Moldova to the east.

Landsat data

Landsat 8 measures different ranges of frequencies along the electromagnetic spectrum a colour, although not necessarily a colour visible to the human eye. Each range is called a band. Landsat 8 has 11 bands and the tenth and eleventh band are in the thermal infrared (TIR). These bands see heat. Instead of measuring the temperature of the air, such as weather stations do, it report on the ground itself, which is often hotter (NASA Landsat Science). Landsat data was offered free by USGS. Table 1 shows Landsat data that was used in this research.

Table 1. Landsat data

Nr. Crt.	Path	Row	Date
1	182	27	2017-05-04
2	182	27	2017-06-05
3	182	27	2017-09-09

Data processing

Image preprocessing

Preprocessing of Landsat-8 OLI images stage represent that operations that prepare images for subsequent analysis that attempts to compensate/correct for systematic errors. The images are subjected to several corrections like radiometric and atmospheric. In order to be used by some image processing application, the 90 m resolution TIR bands were resampled to "fit" to 30 m spatial. Resampling is used to "keep" the original pixel values in the resampled images nearest neighbour (miningeology.blogspot).

Radiometric correction is done to decrease/correct errors in the digital numbers (DN) of images. This process improves quality of remote sensed data. The process of eliminating the effects of the atmosphere to obtain surface reflectance values represents the atmospheric correction. Atmospheric correction can significantly enhance the interpretability and usage of images. Perfectly for this process would be to have knowledge about the aerosol properties and the atmospheric conditions at the time the remote sensing data was acquired (miningeology.blogspot).

Normalized Difference Vegetation Index

NDVI, according to Rouse, is a numerical indicator that uses the visible (Vis) and near-infrared (NIR) bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the aim being observed contains live green vegetation or not (John Rouse, 1973). The NDVI algorithm subtracts the red reflectance values from the near-infrared (NIR) and divides it by the sum of them.

$$\mathrm{NDVI} = \frac{(NIR - RED)}{(NIR + RED)} \quad (1)$$

Generally, healthy vegetation will absorb most of the visible (Vis) light that falls on it, and reflects a large portion of the NIR light. Unhealthy / sparse vegetation reflects more visible light and less near-infrared (NIR light) (Holme et al., 1987).

Land surface temperature (LST)

To estimate the LST from thermal infrared (TIR) band data of Landsat-8 OLI, digital numbers (DN) of sensors were transformed to spectral radiance using equation (Barsi et al., 2014).

$$L_l = M_L \times Qcal + A_L - Q_i \quad (2)$$

where:

- ML = rescaling factor
- Qcal = the Band 10/11 image
- AL = the band-specific additive rescaling factor
- Qi = the correction for Band 10/11

Spectral radiance is converted to brightness temperature by assuming the earth of surface is a black body (Chander et al., 2009; Coll et al., 2010):

$$Tb = \frac{K_2}{\ln((\frac{K_1}{L\lambda}) + 1)} - 273.15 \quad (3)$$

where:

- Tb = the brightness temperature
- Lλ = the cell value as radiance
- K_1, K_2 = Calibration constant of Landsat 8 calibration

There are algorithms applied to transfer Brightness Temperature (BT) for LST:

$$LST = BT/[1+(\lambda x E/\rho) x \ln(LSE)] \quad (4)$$

where:

- ρ = 14380;
- LSE is Land Surface Emissivity.

NDVI was used to extract Land Surface Emissivity (LSE), which is an adjustable parameter in correcting Land Surface Temperature in the next step. Values of LSE were calculated based on the proportion of vegetation (Jiménez-Muñoz et al., 2014).

$$LSE = 0.004PV + 0.986 \quad (5)$$

where:

Pv is the proportion of vegetation, based on a normalized NDVI value of each pixel.

$$PV = (\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}})2$$

RESULTS AND DISCUSSIONS

Figure 1 and tables 2 and 3 shows NDVI, LST maps and data statistics.

Analyzing the statistical data of NDVI and LST, the maximum temperature is 40.1°C and the minimum temperature is 1.76°C. The mean NDVI parameter indicates the high vegetation level in June.

NDVI values range from +1.0 to -1.0. Areas of barren rock, sand, or snow usually show very low NDVI values (for example, 0.1 or less). Sparse vegetation such as shrubs and grasslands or senescing crops may result in moderate NDVI values (approximately 0.2 to 0.5). High NDVI values (over 0.6) correspond to dense vegetation such as that found in temperate forests or crops at their peak growth stage (Ferri et al., 2016).

For generated sparse/dense vegetation map (Figure 2) was applied a filter. Sparse vegetation map was extracted from NDVI map, putting condition to extracted areas with values which ranged between 0.2-0.5, respectively over 0.6 for dense vegetation. For areas resulted was extracted and LST maps area.

Table 4a and 4b shows LST data statistics for sparse/dense area vegetation and figure 3 LST and NDVI maps for sparse/dense area vegetation and correlation between NDVI and LST for that area.

Next step was studied correlation between LST and NDVI sparse/dense vegetation for three moments of year. Figure 3 shows scatter plot and correlation coefficient between LST and NDVI sparse/dense vegetation.

It is noticeable that correlation coefficient has closer values to 1 for relationship LST-NDVI dense; R^2 is about 0.9, while R^2 is about 0.7 for relationship LST-NDVI sparse.

Table 2. NDVI data statistics

Date	min	max	mean	Variation
2017-05-04	-0.33	0.84	0.51	1.17
2017-06-05	-0.82	0.92	0.60	1.74
2017-09-09	-0.36	0.77	0.40	1.13

Table 3. LST data statistics

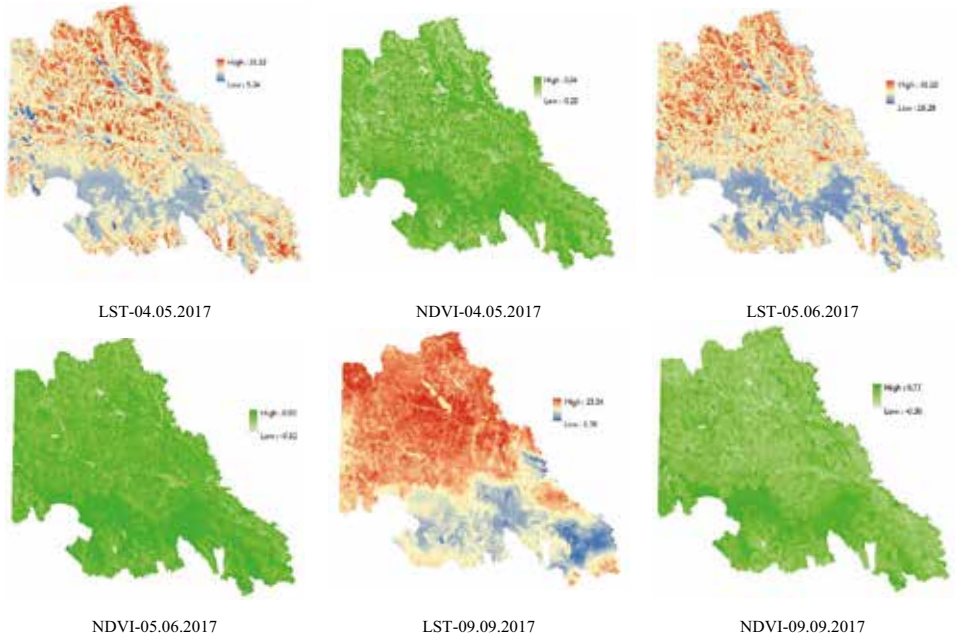
Date	min	max	mean	Variation
2017-05-04	5.34	35.33	24.47	29.99
2017-06-05	18.28	40.10	26.60	21.82
2017-09-09	1.76	25.05	16.84	23.29

Table 4a. LST data statistics for sparse areas vegetation

Date	min	max	mean	Variation
2017-05-04	7.40	34.88	26.77	27.48
2017-06-05	19.43	37.54	29.98	18.11
2017-09-09	1.81	24.86	17.56	23.05

Table 4b. LST data statistics-for dense areas vegetation

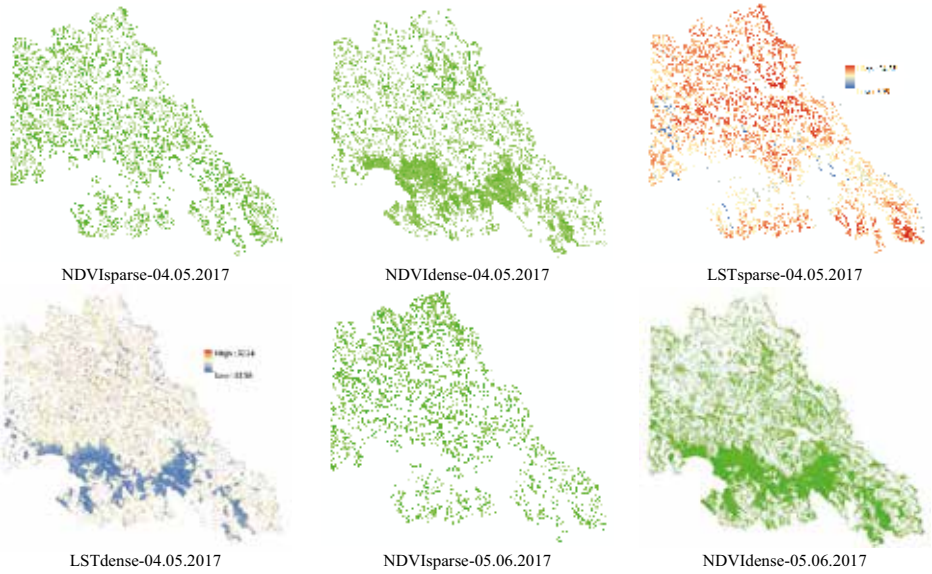
Date	min	max	mean	Variation
2017-05-04	11.50	32.15	22.22	20.65
2017-06-05	19.21	34.75	24.67	15.54
2017-09-09	3.18	24.17	14.23	20.99



LST-04.05.2017 NDVI-04.05.2017 LST-05.06.2017

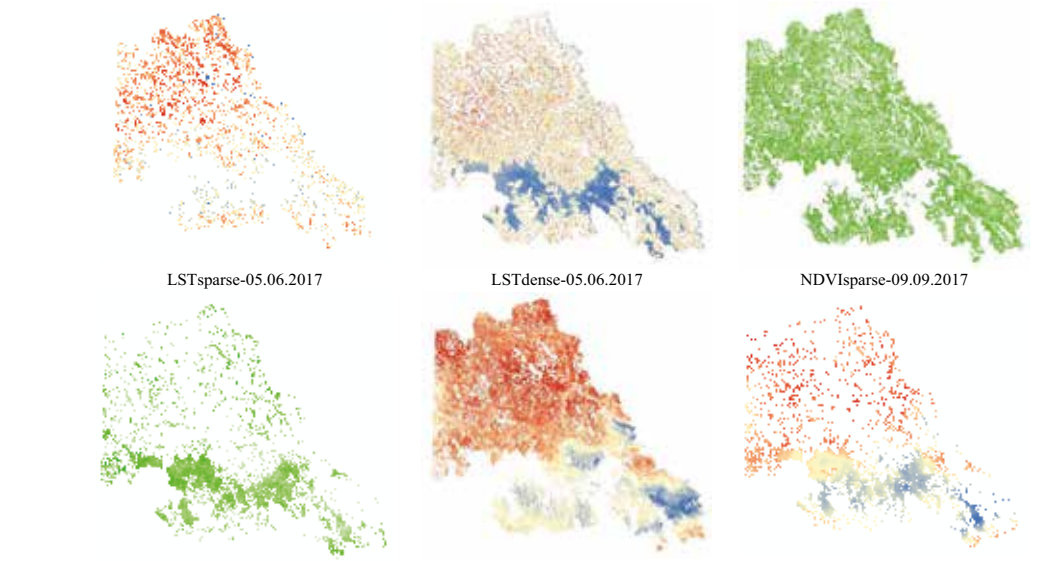
NDVI-05.06.2017 LST-09.09.2017 NDVI-09.09.2017

Figure 1. NDVI and LST maps



NDVIsparse-04.05.2017 NDVIdense-04.05.2017 LSTsparse-04.05.2017

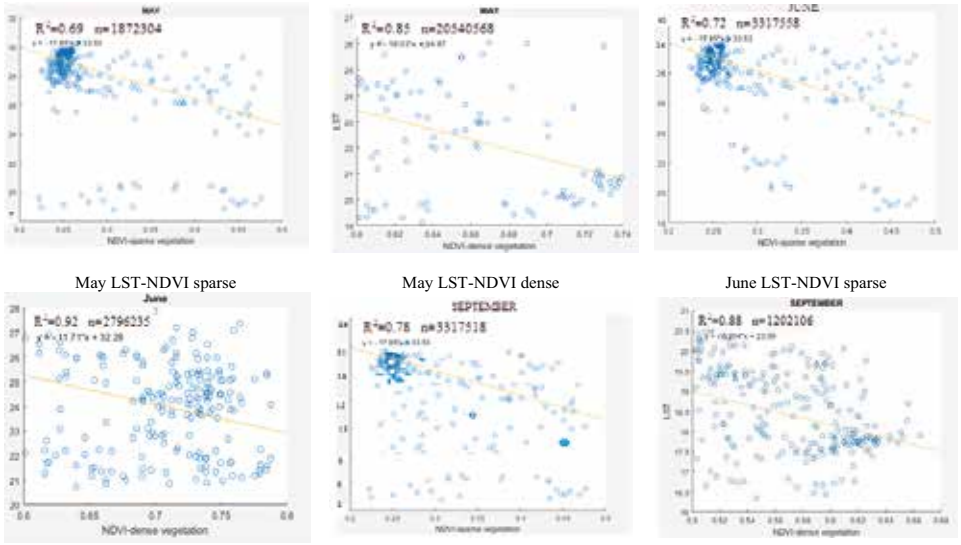
LSTdense-04.05.2017 NDVIsparse-05.06.2017 NDVIdense-05.06.2017



LSTsparse-05.06.2017 LSTdense-05.06.2017 NDVIsparse-09.09.2017

NDVIdense-09.09.2017 LSTsparse-09.09.2017 LSTdense-09.09.2017

Figure 2. LST and NDVI maps for sparse/dense area vegetation



May LST-NDVI sparse May LST-NDVI dense June LST-NDVI sparse

June LST-NDVI dense September LST-NDVI sparse September LST-NDVI dense

Figure 3. Scatter plot and correlation coefficient between LST and NDVI sparse/dense vegetation

CONCLUSIONS

In this paper was studying relationship LST-NDVI sparse/dense using Landsat 8 OLI data. An analysis based on statistical data indicates that, from the three times surveyed, the highest vegetation is in June, while in September vegetation is declining according to statistical data. LST data indicates that the maximum temperature is 40.1°C, in June, and the minimum temperature is 1.76°C in September.
It is noticeable that correlation coefficient has closer values to 1 for relationship LST-NDVI dense; R^2 is about 0.9, while R^2 is about 0.7 for relationship LST-NDVI sparse.

In conclusion, this correlation can be used to study vegetation health, drought damage, and areas where Urban Heat Island can occur.

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AN OVERALL VIEW OF LIDAR AND SONAR SYSTEMS USED IN GEOMATICS APPLICATIONS FOR HYDROLOGY

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Abstract

The paper presents an overall view of LiDAR and Sonar systems used in geomatics applications for hydrology, this branch of science concerning with the properties of the earth's water, and especially its movement in relation to land. LiDAR sensor provides an efficient, rapid, and low cost tool for hydrological application, especially for coastal and river water management. For example, in Romania the hydrographic organizations need accurate bathymetric maps for near coastline area of the Black Sea, for the Danube River and the inner riversides. Nowadays, airborne LiDAR bathymetry is an accurate, capable, and highly cost-effective alternative to traditional waterborne Sonar in areas with appropriate depth and water clarity Water hydrology modelling and watershed management is based on constant monitoring of the water volume over a long time for modelling water dynamic behavior. Flood prediction and flood extend modelling is one of the most important issues in the watershed management and usually the primary interest would be coastal area and rivers hydrodynamic modelling especially in the event of the flood. Using echo sounders would be dangerous, not accurate enough in shallow waters, time consuming, and do not give a continuous water depth. Alternatively, using bathymetric LiDAR system provide accurate, continuous, fast depth information from a large region, without a contact directly with the water body and this ability resolves many of the industrial and military needs for accurate and precise geospatial information from water body in shallow area in a very rapid manner.

Key words*: bathymetry, geomatics, hydrology, LiDAR, sonar.*

INTRODUCTION

LiDAR is a light detection and ranging sensor that uses a laser to transmit a light pulse and a receiver with sensitive detectors to measure the backscattered or reflected light. Distance to the object is determined by recording the time between transmitted and backscattered pulses and by using the speed of light to calculate the distance travelled. In addition to mapping of land and water surfaces, LiDAR systems can be used to determine atmospheric profiles of aerosols, clouds, and other constituents of the atmosphere.

In general, LiDAR systems used for gathering geographic information can be classified in the following ways:

- measurement techniques;
- target scanning techniques;
- sensed phenomena.

There are three main types of laser sensing systems (Figure 1). They include pulsed and continuous wave (CW) laser ranging systems as well as light-striping/video-profiling systems. A pulsed laser system transmits laser pulses, senses the light that is scattered back through an optical telescope and amplifies the returned signal using a photomultiplier tube. The time required for the transmitted pulse to travel to the target and back is recorded and used with the speed of light to determine the distance to the object.

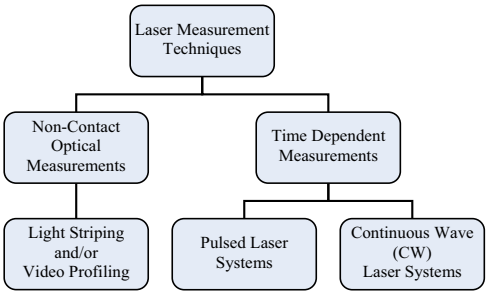

Figure 1. The basic laser measurement techniques

On the other hand, the CW laser system transmits a continuous signal. Ranging can be carried out by modulating the light intensity of the laser light. Typically, the modulated signal is sinusoidal and that sinusoidal signal is received with a time delay. The travelling time

is directly proportional to the phase difference between the received and transmitted signal.
Currently, the pulsed laser systems are most widely used because they can produce high power output at a very high pulse repetition rate.
There is one type of laser measurement that is based on a combination of a laser light stripe generator and a video camera. It is so-called „non-contact" optical measurement. The laser source is apart from the video camera, which can be digital. The laser light is visible on the target surface as a continuous line. This line is considered as a surface profile. Then, during the movement of a carrying platform, the profiles are registered to a 3D coordinate system by an iterative surface-matching algorithm. The digital image processing is based on a projective transformation between the image plane of the camera and the plane of the laser sheet, and also the direction of the scanning with respect to the plane of the laser sheet. The refinement is obtained through weighted least squares matching of multiple profile maps acquired from different points of view, and registered previously using an approximate calibration.
Sonar is a sound transmittal and detection sensor that uses one or more transducers to transmit sound pulses with one or more receivers that measure the reflected sound pulses along with backscatter information (signal to noise ratio). The calculated depth is determined by recording the time interval between transmitted and received sonar pulses. The speed of sound as described in sound velocity profiles is used to calculate the travel distance. By combining the known velocity of sound (c) in water with the time the echoes were received (t), the sonar can calculate the distance the sound has travelled (d). As sound must travel from the Sonar to the target object and then back again, the range (r) between the Sonar and target is half of the total distance travelled, shown in formula 1.

$$d = c \times t \quad \Longrightarrow r = d / 2 = (c \times t) / 2 \qquad (1)$$

Typically, the velocity of sound (c) is about 1500 m/s, but this can vary depending on the water temperature, water salinity and sonar operating depth. To calculate this, Sonar contains a sensor that continuously measures the operating depth and water temperature, and combines this with an appropriate salinity value for the body of water that it is operating in, entered by the user in the control software.
Sonar can also determine bottom types (mud, gravel, rock, sand etc.) by using backscatter as a measure of hardness determined by comparison to classification catalogues. Multiple pulses transmitted and received by multibeam sonar create 100% coverage surfaces of the sea bottom. The sonar error footprint is dependent on depth and sound frequency. Sonar systems achieve the following measurements:

- Time taken for the emitted pulse of sound to travel from the sensor to the ground and back (in milliseconds);
- Backscatter - measure of the reflective intensity of the reflected sonar pulse;
- Sonar footprint - usually represented by measurements in square meters.

Usually, for classical detailed bathymetric survey, there is echo sounder and GNSS equipment with continuous recording papers or recordable digital devices. This has some inconveniences because includes: mounting and demounting the equipments on each site; transporting the equipments to the site and between the working places; accommodation and daily allowance for the staff etc.
In this context, the paper present an overall view of LiDAR and Sonar systems used in geomatics applications for hydrology, this branch of science concerned with the properties of the earth's water, and especially its movement in relation to land.

MATERIALS AND METHODS

Nowadays, LiDAR/LaDAR and Sonar have been accepted as ones of the important sensors providing accurate and dense 3D point cloud from earth surface terrain and water bathymetry. The basic idea of using LiDAR stems from the problem of measuring water depth without direct contacting with the water body or without any instrument mounted on the water surface in shallow regions. Bathymetric LiDAR that uses two different laser beam mounted on a flying aircraft/drone above the water surface has proved to be a good solution.

This ability resolves many of the industrial and military needs for accurate and precise geospatial information from water body in shallow area in a very rapid manner. This technology has been used in the cases which would be solved with serious difficulties using alternative solutions. In addition to hydrology and oceanography, there are other important application areas which mainly are urban mapping, forestry, and photogrammetry. In this paper, an overview to the use of LiDAR technology in the hydrology is discussed. In hydrography, various subjects are tackled such as: dunes and tidal flats measurement, coastal change and erosion, flood mapping and prediction, snow and ice measurement, water bathymetry in depths up to 70 m. Airborne LiDAR systems are rapidly developing and expanding in new applications. Integration of LiDAR with imaging sensors, efficient using of waveform information and better processing algorithms would make a great development in obtaining more realistic and accurate 3D models of the geospatial objects (Mohammadzadeh and Valadan Zoej, 2008).

RESULTS AND DISCUSSIONS

LiDAR systems can be classified on the basis of scanning techniques as is shown below in the Figure 2.

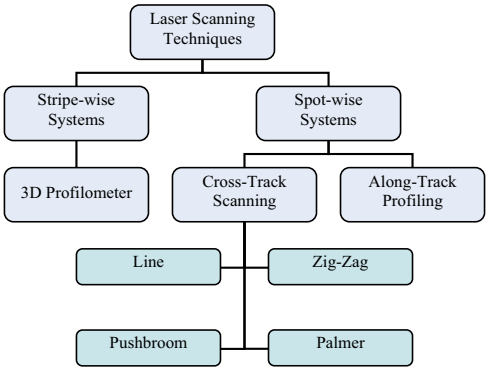

Figure 2. The laser scanning techniques of LiDAR

Laser scanners are typically cross-track or push broom scanners. An airborne laser profiling system is a laser altimeter.

In the same time, all LiDAR systems can be classified on the basis of the different physical phenomena that they are designed to detect.
So, we have the following main types of LiDAR:

- **Aerosol LiDAR** directly measures the optical properties of atmospheric aerosol distributions.
- **Coherent Doppler LiDAR** is usually used for remote sensing of the distribution of wind velocity and aerosol backscatter within three-dimensional volumes in the troposphere and lower stratosphere. Coherent LiDAR is considered to be more sensitive and to provide better wind measurements at aerosol levels consistent with the boundary layer and lower troposphere, as well as from atmospheric ice and water clouds.
- **Differential absorption LiDAR (DIAL)** transmits two closely spaced wavelengths. One of these wavelengths coincides with an absorption line of the constituent of interest, and the other is in the wing of this absorption line. During transmission through the atmosphere, the emission that is tuned to the absorption line is attenuated more than the emission in the wing of the absorption line. The concentration of the species can be determined based on the relative optical attenuation.
- **Raman LiDAR** uses the Raman-shifted component that is a transition that involves a change in the vibrational energy level of molecules. Since each type of molecule has unique vibrational and rotational quantum energy levels, each has a unique spectral signature.
- **Rayleigh LiDAR** measures the intensity of the Rayleigh backscatter, which is used to determine a relative density profile. This is used in turn to determine an absolute temperature profile.
- **Resonance LiDAR** uses the resonant scattering that occurs when the energy of an incident photon is equal to the energy of an allowed transition within an atom. As each type of atom and molecule has a unique absorption and fluorescent spectrum, this effect can be used to identify and measure the concentration of a particular species.

The resolution of a sensor is distinct from the resolution of an image. The resolution of a

sensor is the smallest difference that can be detected by a sensor. Sensor resolution is a measure of the ability of a sensor to detect differences between sensed objects and it may be expressed in many ways depending on the sensor.

The immediate outputs of a digital sensor are digital numbers (DNs). Prior to deployment, a sensor is calibrated in a laboratory using standard radiation sources. Using a calibration curve, DNs are mathematically converted to sensor input radiances.

The resolution of a sensor is defined by several quantities. The band structure for a sensor determines its spectral resolution. The radiometric sensitivity of a sensor for a specific band is the radiance increment for a single bit change in the DN. The spatial resolution of the sensor is the solid angle for which the sensor measures radiances.

Sensor descriptions are organized by the type of energy sensed by the sensor: optical, microwave, LiDAR and Sonar for example.

With the use of aerial drones with LiDAR or Unmanned Surface Vessels (USV) and Sonar technology, it is able to construct georeferenced point clouds from which accurate water body volume estimations can be created. This is a safe and cost efficient alternative to manual or aerial bathymetric surveys that may not be feasible for smaller water bodies.

Recent developments in sensor technology yielded a major progress in airborne laser bathymetry for capturing shallow water bodies. Modern topo-bathymetric small foot print laser scanners do no longer use the primary near infrared (NIR) signal (λ=1064 nm) but only emit and receive the frequency doubled green signal (λ=532 nm). For calculating correct water depths accurate knowledge of the water surface (air-water-interface) is mandatory for obtaining accurate spot positions and water depths. Due to the ability of the green signal to penetrate water the first reflections do not exactly represent the water surface but, depending on environmental parameters like turbidity, a certain penetration into the water column can be observed (Gottfried Mandlburger et al., 2013).

In Figure 3, is shown below LiDAR bathymetry which is used to measure water depth for shallow water with depth not more than 30 m.

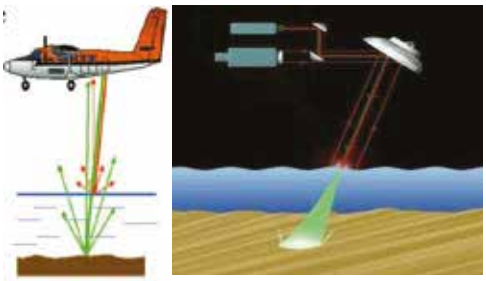

Figure 3. Green pulses (532 nm) reflected from bottom, NIR (1064 nm) laser pulses reflected from water surface (Elhassan I., 2015)

As against LiDAR and photo bathymetry, the disadvantages of echo sounding are:

- measurements are the time and cost associated with making measurements from a ship in deep waters or a small vessel in shallow waters;
- in order to build up coherent images at high resolution many survey lines with overlapping tracks must be run;
- because the swath width decreases in shallow water, many more ship or glider tracks are required in large rivers' confluences or rivers flowing into the sea, in coastal bays with shallower water.

Detailed surveys in coastal regimes require considerable time and effort to cover relatively small portions of the sea bed. Ship time is costly even in deep water and because of increasing time and effort to operate in shallow waters, acoustic systems are not ideal for such tasks as monitoring bathymetric changes and shoreline.

Airborne laser scanning technology to survey both land and coastal waters in a single approach, employing a technique known as Airborne LiDAR Bathymetry (ALB) or Airborne LiDAR Hydrography (ALH) which uses state of the art LiDAR technology to measure sea bed depths and topographic features rapidly and accurately (Figure 4).

Airborne LiDAR bathymetry is an accurate, capable, and highly cost-effective alternative to traditional, waterborne sonar in areas with appropriate depth and water clarity. With the production of high-density, three-dimensional digital bathymetric data, it offers a number of important products, services, and applications

in coastal waters. It can also survey safely in areas where Sonar cannot, including, for some systems, above-water structures and dry land.

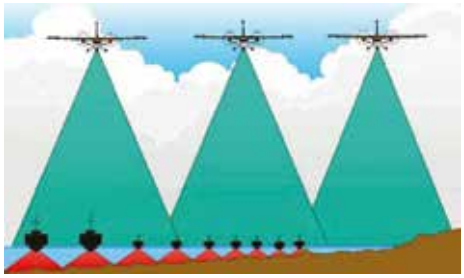

Figure 4. A graphic comparison of LiDAR and Sonar operations in shallow water (Guenther, 2004)

Airborne LiDAR bathymetry is, however, not a substitute for sonar because airborne LiDAR bathymetry surveys are limited by water clarity and depth. The maximum scanner nadir angles in use are 15° - 20° and larger angles would cause unacceptably large pulse timing errors in both surface and bottom returns due to the more extreme geometry. Coverage is dense and surveys are performed with soundings spaced in a regular pattern. The densities vary from system to system used.

LiDAR applications provide to hydrologists with one of the most advanced methods of visualizing river speed profiles. The data can be provided as 2D cross sections or 3D velocity fields. This data can be combined with LiDAR data to generate and analyze complete surfaces above and below the water surface.

The geopositioning of data collected with a sensor is made by a mathematical relationship between the position of an object on Earth and its image as recorded by a sensor. In order to algorithmically describe the data flow beginning with measurements by an individual sensor and ending with a geopositioned product, it is necessary to introduce Coordinate Reference Systems (CRSs). These CRSs are each defined with reference to a physical entity. They serve as a reference for related metadata and describe the steps required to convert the sensor measurements into geographical data. The flow of coordinate transformations, required to relate image coordinates to coordinates referenced to the Earth, is: Image CRS --> Platform CRS --> Global geodetic CRS --> National geodetic CRS --> Projected CRS (map grid).

We use as global geodetic reference system, and for vertical reference too, the WGS-84 ellipsoid, which is independent of the water surface. In the past, differential corrections for coordinates were applied during post-flight processing of recorded user data, but now DGPS systems not only generate the corrections but also utilize some type of wireless transmission system for getting the correctors to users in near real time. This communication may be VHF systems for short ranges (FM broadcast), low-frequency transmitters for medium ranges (beacons), and geostationary satellites (L-Band) for coverage of all continents.

In the figures below, are shown two types of Sonar systems, with single beam (Figure 5) and multi beam (Figure 6), which use GNSS for accurate measurements location.

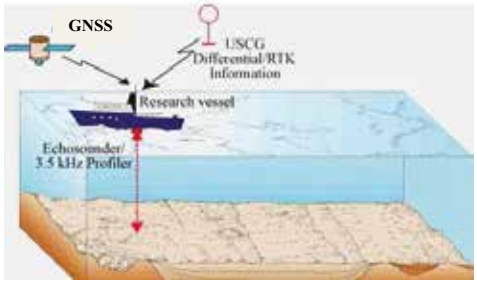

Figure 5. Single beam Echosounder (Elhassan I., 2015)

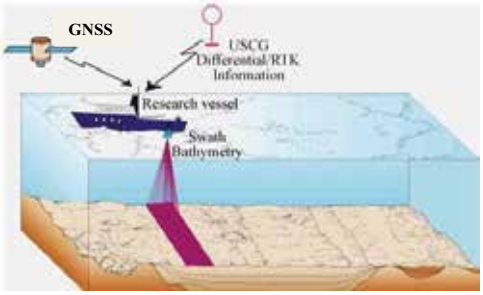

Figure 6. Multi beam Echosounder (Elhassan I., 2015)

As opposed to traditional single beam bathymetric survey techniques that produce soundings on discrete profiles, multi beam bathymetry affords the end user with a highly detailed, densely spaced grid of soundings in the form of a geographically referenced digital

terrain model. This model can support engineering design, construction, and dredging projects. The key advantages to multi beam bathymetry, as opposed to single beam bathymetry, are: increased data coverage, greater data density, and greater survey production capacity.

Side scan sonar (Figure 7) is one of the „swath mappings" methods commonly used to map large areas of the seafloor. It consists of two transducers both of which produce a thin fan-shaped beam that is concentrated on a line that runs from below the transducer perpendicular to the direction of travel. The maximum range of the signal is determined by the frequency, power and transducer design. After processing, the resulting acoustic backscatter provides seabed. Side scan sonars are normally deployed within a towed body that is towed at a fixed height above the seafloor, although it can also be mounted on the hull of a vessel, or on the body of Remotely Operate Vehicles (ROVs) or Autonomous Underwater Vehicles (AUVs). Traditional side scan sonar provides only backscatter data and little information about depth. In the recent years, interferometric or bathymetric side scan sonar has been developed that provide accurate backscatter and bathymetry across a wide swath.

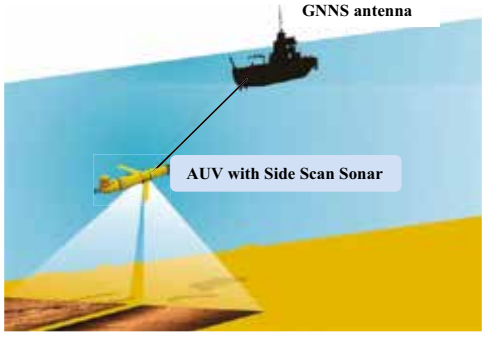

Figure 7. Schematic diagram of an AUV with a Side Scan Sonar
(https://hiveminer.com/Tags/archaeology%2Csonar)

Like traditional bathymetric surveys, side scan sonar surveys produce data that are geographically referenced. The image-data are post-processed to create image mosaics that highlight bottom conditions and produce nearly seamless imagery. The image mosaics can be fed into a variety of computer-aided design (CAD) and geographic information system (GIS) packages, even ubiquitous visualization software such as Google Earth so that engineers, contractors, and even less technically experienced personnel may view the data and better understand underwater conditions.

In 1989, the International Maritime Organization (IMO) adopted a resolution adding a footnote to its resolution on Ships' Routeing Measures which states that „The minimum standards to which hydrographic surveys are to be conducted, to verify the charted depths in the traffic lanes are those defined in Special Publication No. 44 of the IHO" (Chris Howlett, 2010). So, „S-44 Edition 5", was published in 2008 and it is the International Hydrographic Organisation's standard for hydrographic surveys.

The maximum errors allowed by International Hydrographic Organisation (IHO) standard are: 0.25 m for depths between 0 m and 30 m; 0.5 m for depths between 30 m and 100 m; and 1 m for depths greater than 100 m. For harbours areas and associated critical channels, the minimum horizontal accuracy (with 95% confidence level) is 2 m. Principal aim for hydrographic surveys standard is that hydrographic data collected according to these standards is sufficiently accurate and that the spatial uncertainty of data is adequately quantified to be safely used by mariners (commercial, military or recreational) as primary users of this information. In the next figures are shown few examples of bathymetric maps from the Danube River (Figure 8) and the Romanian Coast of Black Sea (Figure 9).

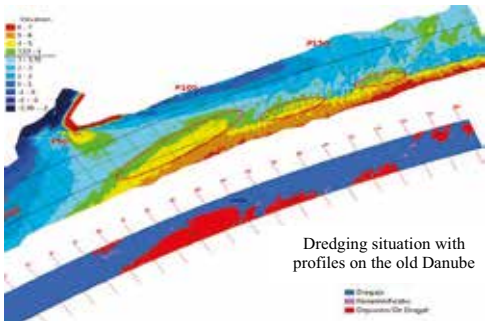

Figure 8. Bathymetric map on Danube River with cross profiles for dredging (Tehnogis Grup S.R.L., 2014)

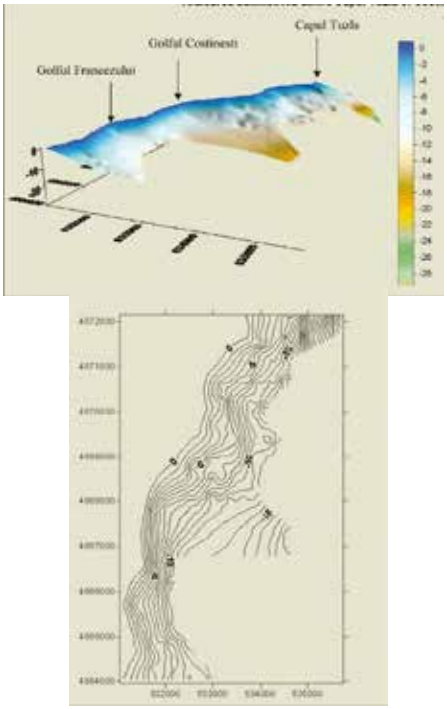

Figure 9. Bathymetric maps (3D and 2D) of the South Romanian Coast of Black Sea (Constantinescu Stefan et al., 2008)

For performing scanning sonar surveys, it is necessary to utilize high-resolution scanning sonar units when very specific conditions require assessment, particularly in the vicinity of bridge piers, dams, and vessel mooring facilities. We must focus specifically on acquiring top-notch imagery and presenting it with interpretations or above-water imagery so that the images have perspective and are easily viewed and understood by lay personnel unfamiliar with the technique. Imagery can be qualitative (but scaled properly for dimensions) or quantitative in the form of high-resolution bathymetric datasets that can be integrated into 2D or 3D models of structures.

CONCLUSIONS

In conclusion, we can say that information that can be derived from Sonar sensor data includes:

- depth - time taken for the emitted pulse of sound to travel from the sensor to the ground and back, interpreted in meters;
- sound velocity profiles (m/s);
- digital elevation models;
- tide/current models;
- sea bottom texture maps based on backscatter;
- storm surge models;
- coastal erosion maps;
- free-air gravity maps (fusion of gravity and bathymetric maps);
- coastal flooding models and sea level rise;
- seabed classification;
- sediment's thickness.

Traditionally, old sonars were mechanical devices that operated by rotating their transducers (transmitters and receivers) to scan the sector in front of or around them. At each transducer position, a sound pulse would be transmitted into the water, and the echoes collected by the receiver before being plotted onto the display. Depending on the required resolution an image could tens of seconds to update, and any movement of the sonar during this period could smear and distort the imagery. Unlike mechanical sonars, which have moving parts, multi beam sonar has no moving parts, and an array of receivers collects echoes from a single transmission pulse and mathematically combines the data into an image using a process known as "beam-forming". This allows images to be produced many times per second and viewed in real time like the output from a video camera.

Another conclusion is that LiDAR sensor provides an efficient, rapid, and low cost tool for hydrological application, especially for coastal and river water management. But, there are still some weaknesses on the LiDAR data segmentation, visualization, very shallow depth measurement, water wave estimation etc.

Integration of LiDAR with imaging sensors and better processing algorithms would make a great development in obtaining more realistic and accurate 3D models of the geospatial objects. The most important factor for the combination of image and LiDAR data is the improvement of the accuracy of the flight trajectory of an UAV for example, which would lead to the real-time capability of data processing of such UAV platforms and the combined processing of the data. In this combination, first the images have to be oriented. In a second step using the enhanced image orientation the trajectory of the LiDAR

data can be improved. Thirdly, the registered LiDAR point cloud can then be projected back into the images. Finally, in a combined adjustment the trajectory can be further improved and a DSM can be generated both from the LiDAR and image data. So, we can increase the real accuracy of the final mapping product.

As a conclusion, beside hydrographic measurements (e.g. bathymetry), typical applications of LiDAR systems can include:

- atmospheric monitoring and studies (e.g. aerosol profiling and ozone measurements);
- 3D terrain mapping [e.g. urban areas (3D city modelling), power lines, and mining];
- forestry and forest management (e.g. biomass, stem volume, tree heights);
- environmental monitoring (e.g. water quality and phytoplankton);
- pollution detection (e.g. pipeline leak detection like oil or gas);
- mapping organic pollution (e.g. oil and petroleum products on soil or in water);
- measuring industrial structures (e.g. bridges and tanks) and homeland security.

For many of these applications, LiDAR systems are flown together with other optical sensors such as photogrammetric cameras.

The latest trend in the development of LiDAR technology considers a different approach to aerial laser scanning point clouds, one that can create land cover maps more effectively than typical topographic methods, providing a tool for high-density topographic surveying which can be useful for land cover and land use classification. Such a data source can even be an alternative or a supplement to photogrammetric data collection and the potential of multispectral airborne laser scanning in land cover mapping was presented in few publications (Bakula, 2015; Wichmann et al., 2015).

Multispectral LiDAR system is a new promising research domain, especially in applications of 3D land cover classification, seamless shallow water bathymetry, forest inventory and vegetative classification, disaster response and topographic mapping. Further research is needed to combine multispectral LiDAR point clouds with other ancillary data such as digital surface model (DSM) and imagery in order to improve the associated precision.

All light and imaging techniques are dependent on the water clarity. So, all light and imaging techniques are susceptible to error with murky water. The disturbing restriction is the limited water depth that can be measured. This is due to the fact that optical light cannot penetrate even pure water for a depth more than 30m.

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USING CLIMATIC SCENARIOS AS A SUPPORT FOR A SUSTAINABLE AGRICULTURE IN THE ROMANIAN PLAIN

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Abstract

The Romanian Plain, covering a surface area of about 52 600 sq.km and stretching along the Danube, is one of the largest agricultural regions in the European Union. It presents diverse ecological conditions in four major zonal units, steppe, silvo-steppe, forest zone and its large Danube floodplain. In this context, the assessments of climate change, specifically of those climatic elements like temperature and precipitation which may have an important impact on various economic sectors, represent a necessary scientific support for end-users to envisage sustainable development strategies. This paper presents 1) the evaluation of the regional climatic model RCA4 driven by the ERA-Interim reanalysis and five general climatic models under historical forcing, 2) the adjustment of the bias identified in the simulations compared to the observation data using the Delta Change method, and 3) the projected changes of seasonal mean temperature and precipitation in the Romanian Plain for the mid-term period 2021-2050 under the RCP4.5 scenario compared with the reference period 1971-2000 of ROCADA observations.

Key words*: regional climate model, climate scenarios, Romanian Plain.*

INTRODUCTION

The need for climate change information at regional-to-local scale is one of the central issues within the global change debate. The users, including policy-making communities have long sought reliable regional and local scale projections to provide a solid basis for guiding response options (Giorgi et al., 2009). Climate impact assessments and the development of regional to local-scale adaptation strategies require the availability of high-resolution climate change scenarios, including an assessment of their robustness and inherent uncertainties. The exploitation of the vast amount of available data derived from the climate models became therefore a challenge for a wide range of users. The Coordinated Regional Downscaling Experiment (CORDEX) initiative to produce improved regional climate change projections for all land regions world-wide provides a platform for a joint evaluation of model performance, along with a solid scientific basis for impact assessment and other uses of downscaled climate information (Giorgi et al., 2009). EURO-CORDEX is the European branch of the international CORDEX initiative, to produce high-resolution climate scenarios for Europe. An increasing number of studies have dealt with the evaluation of EURO-CORDEX regional climate model (RCM) performance over different regions in Europe (Jacob et al., 2014, Kotlarski et al., 2014, Smiatek et al., 2016, Dyrrdal et al. 2018).

Previous studies on climate change have shown that southern and eastern regions of Romania, including the large agricultural areas of the Romanian Plain (RP), are increasing vulnerable to different kinds of drought: meteorological, hydrological or pedological (CLAVIER, 2009; Sima et al., 2015). This is particularly relevant as the environmental constraints on agriculture are overlapping particular socioeconomic conditions. The transformations in the first decades of the transition and post-transition period in the type of land property and in the type of farms (e.g. fragmentation of farm land, the emergence of numerous individual farms of subsistence agriculture, poor agricultural infrastructure and services (degraded irrigation systems, inappropriate farming practices etc.) were profound, yielding numerous economic and social implications. Conversely, over the last decade, the trend underlined a shift from individual/family-oriented farms and highly fragmented lands towards agricultural holdings with a strong commercial focus (Balteanu et al., 2010). This situation is highly spatially

different, as in many parts of the RP, the agricultural resources are still unexploited and/or impacted by drought and desertification, land degradation, water stress, confusion about property rights, etc. The effects of climate change on agriculture coupled with diverse land management practices in the area call for integrative, regionally specific land management options for a sustainable use of land resources (Balteanu et al., 2017). In this context, climate change scenarios and climate change impact assessments hold a central role, while the new generation of scenarios provide enhanced opportunities for the evaluation of the projected climatic changes relevant for the society, in general, and the agriculture, in particular.

The aim of the paper is to assess future projections of temperature and precipitation changes over the RP with the regional model RCA4 (Rossby Centre Atmosphere version 4), for improving communication of climate knowledge to end-users. To reach this objective, a number of specific objectives should first be completed: (i) evaluate the performance of RCA4 driven by „perfect boundary conditions" in terms of reproducing the annual cycle and mean seasonal temperature and precipitation features in comparison with different observational datasets; (ii) assess the overall bias in the ensemble of five GCM-driven RCA4 temperature and precipitation simulations compared to observations; (iii) bias-correction of RCA4 temperature and precipitation simulations and assessment of the seasonal mean temperature and precipitation projections and their uncertainties from different driving GCMs and emission scenarios on mid-term timescale; (iv) assess future changes of seasonal temperature and precipitation and their uncertainties over the RP.

MATERIALS AND METHODS

Study area

The Romanian Plain, also known as the Lower Danube Plain, with 10 m to 200 m altitudes extends from west to east over 500 km, with the municipality of Bucharest, Romania's capital, located in its central part. It is bordered by the Danube in the south and east and the Getic Piedmont, the Bend Subcarpathians and the Moldavian Plateau in the north. The Romanian Plain is divided into four subdivisions (Figure 1): the Oltenia Plain situated to the west of the Olt River, the Central Romanian Plain, between Olt and Arges rivers, the East Muntenia Plain with large loess covered non-fragmented tabular plains, and the Danube floodplain of 1-4 km width in the west and up to 15-20 km in the east (Balteanu, 2006). Each subdivision comprises different geomorphological subunits, shaping the land use particularities.

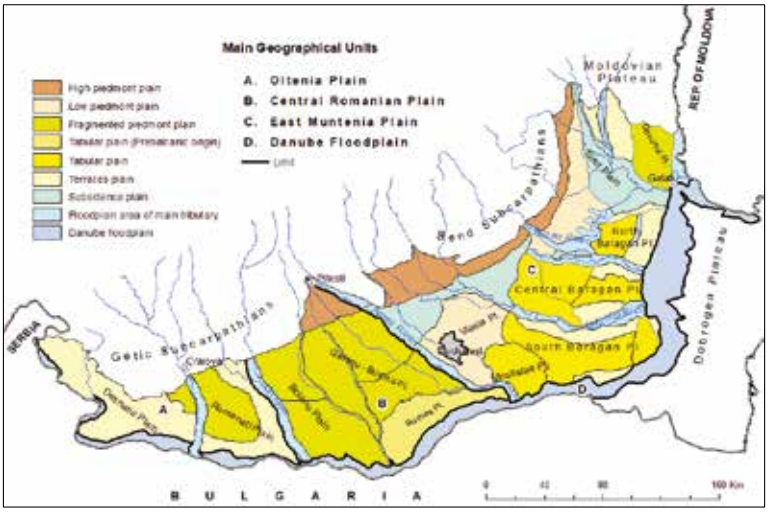

Figure 1. The geomorphological units of the Romanian Plain

Datasets

The simulations of the regional climate model RCA4 available from the EURO-CORDEX framework have been used in this study. The RCM is based on the numerical weather prediction model HIRLAM (Undén et al., 2002). The choice of RCA4 is supported by the good validation results of the RCA3 (Samuelsson et al., 2011) and RCA4 (Kotlarski et al., 2014; Strandberg et al., 2014) in different regions of Europe and, particularly, in a pilot study in the south-eastern RP (Sima et al., 2015). In the high resolution experiment design carried out in the EURO-CORDEX framework, RCA4 was setup on a rotated latitude-longitude grid over Europe with a horizontal resolution of 0.11°, corresponding to approx. 12.5 km. The integration domain includes all Europe, and for this study, the RP (22.3˚E– 28.3˚E, 43.5˚N–46.2°N) was extracted as study region.

For the evaluation run, the RCA4 model was driven by „perfect boundary conditions" provided by the ERA-Interim reanalysis (Dee et al., 2011) covering the period 1981-2010. To evaluate the RCM performance over the RP, the RCA4 driven by ERA-Interim was compared to three observations datasets presented in Table 2.

As a next step of evaluation, the RCA4 has been given boundary conditions from five different GCMs: CNRM-CM5, EC-EARTH, HadGEM2-ES, IPSL-CM5A-MR, MPI-ESM-LR. All of them are fully coupled atmosphere–ocean General Circulation Models forced by different emission scenarios. The list of the GCMs and the RCM references is presented in Table 1.

The simulations have been performed for i) 1971–2005 period with historical forcing, and ii) 2006–2100 period under different Representative Concentration Pathway (RCP) scenarios (Moss et al., 2010).

GCMs may simulate quite different responses to the same forcing, simply because of the way certain processes and feedbacks are modeled. For this reason, it is important to evaluate the performance of different GCMs under historical forcing. In these simulations (historical runs) time-varying external forcing such as GHG and aerosol concentrations, solar inputs applied based on historic records from a given year up to the present. As these forcing elements change over time, the GCM simulates the evolution of the climate over this period in these historical runs.

For the future (scenario runs) the external forcing varies according to one of the future scenarios, e.g. the Representative Concentration Pathways (RCP) applied in the latest IPCC report (AR5). The RCP scenarios are expressed as changes in equivalent carbon dioxide concentrations (Kotlarski et al., 2014). In this study only the RCP4.5 pathway is used, assuming GHG peak by 2040.

Methods

Regridding

Before starting the analysis, the gridded datasets and model outputs were transformed from their native grids to a common regular grid of 0.1° (ROCADA grid) using the bilinear interpolation (Nikulin et al., 2012).The RCM simulations (driven by the ERA-Interim and by GCMs with historical forcing) were compared to three observation datasets listed in Table 2.

Table 1. Overview on the models used in this study.

Climate model	**Acronym in EURO-CORDEX**	**Institute (country)**	**Acronym in thisstudy**	**Website**
RCM	RCA4	Swedish Meteorological and Hydrological Institute (Sweden)	RCA4	www.smhi.se
	ICHEC-EC-EARTH	Irish Centre for High-End Computing and EC-Earth consortium of weather services and universities in Europe	ICHEC	www.ec-earth.org
	MOHC-HadGEM2-ES	Met Office Hadley Centre (UK)	HADGEM2	www.metoffice.gov.uk
	IPSL-IPSL-CM5A-MR	Institute Pierre Simon Laplace (France)	IPSL	www. icmc.ipsl.fr
	MPI-MPI-ESM-LR	Max-Planck-InstitutfürMeteorologie (Germany)	MPI	www.mpimet.mpg.de

Table 2. Reference datasets for the evaluation of the model simulations

Dataset	Description	Time resolution	Space resolution	Reference
ROCADA	Romanian daily gridded climatic dataset (version 1.0)	daily	0.1°	Dumitrescu & Birsan (2015) https://doi.pangaea.de/10.1594/PANGAEA.833627
E-OBS	European, gridded from observations (version 17.0)	daily	0.25°	Haylock et al. (2008) www.ecad.eu
CRU	Climate Research Unit, gridded from observations (version CRU TS v. 4.01)	monthly	0.5°	Harris et al.(2014) https://crudata.uea.ac.uk/cru/data/hrg/

Validation

To quantify the bias originating from different sources, the validation of the RCM was carried out in three phases: 1) RCM driven by reanalysis („perfect boundary conditions") vs. observations, 2) RCM driven by GCMs vs. observations, and 3) ensemble mean of five GCM-driven RCA4 vs. observations. Phase 1 estimates the bias of RCM, i.e. to what extend the RCA4 distort the large-scale flow imposed by the „perfect boundary conditions" compared to observations. Phase 2 estimates the additional contribution of GCMs to the overall bias structure and, the Phase 3, the overall bias of the ensemble mean of five GCM driven RCA4 simulations compared to selected observation dataset. Through the RCM experiments assessed here it is not possible to separately quantify the uncertainty originating from different sources like the imperfection of reanalysis data or the internal climate variability inherent in model simulations, thus present results on the model biases are interpreted and discussed accordingly. To study the annual cycle and spatial patterns in the temperature and precipitation simulations monthly and seasonal mean values were calculated in every grid point and compared to reference datasets. The climatologies of air temperature and precipitation for the evaluation period 1981-2010, historical period 1971-2000 and mid-term future 2021-2050, for winter and summer were calculated and analyzed.

Metrics and bias assessment

To compare the model outputs against gridded observational data (i.e., reference) the bias was defined as the difference for temperature and ratio for precipitation of spatially averaged climatological seasonal mean values for the domain. In the case of five GCMs driven RCM, after evaluating the mean seasonal biases of each GCM-driven run, seasonal means of the ensemble were also calculated.

Bias correction

The bias correction (BC) techniques are needed to ensure a better agreement between models and observations. For this study the delta-change approach has been used (Teutschbein and Seibert, 2012) and, it was done on a monthly basis. This approach uses observations as a basis and, thus, it is a stable and robust method that produces future time series with dynamics similar to current conditions. The base-line climatology corresponds to the observed climate. An additive correction was used to adjust temperature whereas multiplicative correction was used for precipitation.

RESULTS AND DISCUSSIONS

Evaluation of RCM reanalysis-driven simulation vs. observations

First, the evaluation was carried out on the RCM simulation driven by the ERA-Interim reanalysis data (so-called evaluation run) against three observational datasets, using the 0.1° regular grid of ROCADA for the comparisons. The annual cycle of both simulated mean temperature and precipitation totals averaged over the RP were compared to the ROCADA, CRU and E-OBS observations datasets. The spatially averaged values of mean monthly temperature over the RP during the evaluation period 1981-2010 and the corresponding mean biases calculated as RCA4 – obs are shown in Figures 2 a) and b), respectively. Compared to the observations, the RCA4 model tends to underestimate the temperature with a cold bias during February to June (between -0.5˚ and -1.2˚, depending on the reference data set) and to overestimate the observations with a warm bias from July to December (between 0.1˚ and 2.1, depending on the reference data set).

Similarly, the spatially averaged monthly precipitation totals and the corresponding mean biases calculated as ratios RCA4/obs are shown in Figures 2 c) and d). Compared to the observations, the RCA4 model tends to systematically overestimate the observed precipitation (January to May and October to December) except during summer (July to September) when precipitation is underestimated. The ratios RCA4/obs ranges from 1.1 to 2.1 showing that the model overestimates the simulated precipitation by 10% to 110%, depending the reference data set, whereas the ratios 0.6 to 0.9 means that the simulated precipitation represents 60% to 90% of observation, respectively, depending on the reference data set.

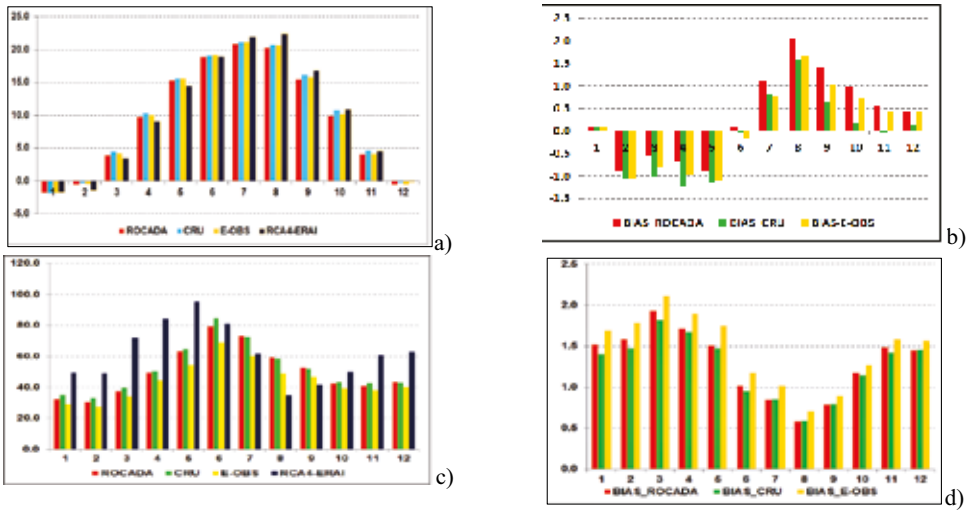

Figure 2. Mean annual cycle of the RCA4 evaluation run (1981-2010) compared with three observation data sets (ROCADA, CRU and E-OBS). Spatially averaged monthly mean temperature: a) the corresponding mean biases; b) the same for precipitation in c) and d) the mean biases were calculated as RCA4/ obs. for temperature and, RCA4/obs. for precipitation, respectively

Evaluation of GCM-driven RCM simulations vs. observations

Because the ROCADA observations dataset (Birsanand Dumitrescu, 2014) provides the highest available resolution (0.1°) of homogenized series over Romanian territory, based on 150 stations for temperature and 188 stations for precipitation, further on, this data set will be used as reference for comparison in this study.

The historical runs (RCA4 simulations driven by five GCMs with historical forcing) were compared with the ROCADA data set over the period 1971-2000. In this way, the bias introduced by the GCM in the RCM model output could be estimated.

First, the annual cycle was analyzed, in order to gain an overview on the model bias averaged over the RP for each month. Then, the seasonal spatial patterns of mean temperature and precipitation biases (GCM-RCM historical runs vs. ROCADA obs) were described in the form of difference and ratio maps, respectively. The comparison was carried out on the native high-resolution grid (0.1°) of the ROCADA data set, after regrinding the RCA4 model simulations from their native resolution of 0.11° to 0.1°.

The monthly means of air temperature spatially averaged over the RP domain compared with the ROCADA observations and, the corresponding mean biases calculated as RCA4/ obs. are shown in Figures 3 a) and b), respectively, for the five historical runs of the GCM-driven RCA4 model for the period 1971-2000.

During July to November all the models overestimate the mean temperature with 0.7°C (HadGEM2) in October up to 3.1°C (HadGEM2) in July. Zero bias comparing to observations shows EC-EARTH model in September and November, MPI model in April and June and IPSL model in June. Negative biases of all five GCM-driven RCA4 are evident in May with values ranging from -0.6°C (MPI) and - 2.5°C (EC-EARTH). During the months of the cold season (December to March) three models overestimate temperature with values ranging from 0.1°C (HadGEM2) to 2.2°C (MPI) whereas the others underestimate the mean temperature with values ranging from -0.1°C to - 1.5°C (CNRM).

Likewise in the evaluation run, in the historical runs most of the GCMs-driven RCA4 tends to systematically overestimate the observed precipitation (January to May and October to December) except during summer (July to September) when precipitation is underestimated. The ratios (GCM-RCA4)/obs. ranges from 1.1 to 1.9 showing that the model overestimates the observed precipitation by 10% to 90%, depending on the driving GCM, whereas the ratios 0.4 to 0.9 means that the

simulated precipitation represents 40% to 90% of observation, respectively, depending on the driving GCM.

The patterns of seasonal temperature and precipitation biases are analyzed over the RP based on seasonal gridded data averaged over the historical period 1971–2000. The main focus was to assess the ability of the regional model to simulate the surface climate in response to large-scale forcing imposed by the GCMs-driving RCA4 model and by local topographical features. In this study, the cold and warm season of the year were analyzed. To quantify the average bias over the whole domain, evaluation metrics were calculated in each grid point as the difference (GCM-RCA4) – ROCADA obs., for temperature and, as the ratio (GCM-RCA4)/ROCADA obs., for precipitation, respectively. Figures 4 and 5 show the seasonal mean temperature bias for winter and summer, respectively, for the five GCM-driven RCM historical runs and for the ensemble mean of these models.

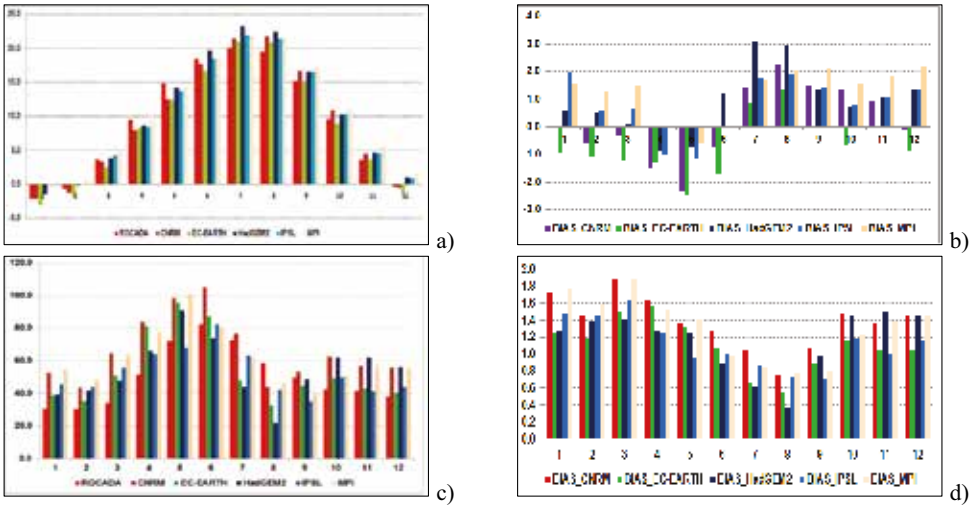

Figure 3. Mean annual cycle of five GCM-driven RCA4 historical runs (1971-2000) compared with ROCADA data set. Spatially averaged monthly mean temperature: a) and the corresponding mean biases; b) the same for precipitation in c) and d). the mean biases were calculated as RCA4/obs. for temperature and, RCA4/obs. for precipitation, respectively

In winter (Fig. 4), most of the GCM-driven RCA4 runs show warm biases in the region with low altitude (RP) and cold biases in the region with higher altitudes (Sub Carpathians and Carpathians).

In the RP, the lowest positive bias ranges between 0°C and 2°C (CNRM and EC-EARTH) and the highest positive bias ranges between 2°C and 3°C (IPSL and MPI).

In the Carpathian and Subcarpathian region the values of negative biases range between -1°C and - 6°C (CNRM and EC-EARTH) and -1°C and -4°C (HadGEM2, IPSl and MPI). The ensemble mean shows warm biases of 1°C to 2.5°C in the RP and cold biases of -1°C to -4°C in the Carpathian and Sub-carpathians.

For summer, likewise for winter, the sign of the bias depends on the altitude. The highest warm bias, up to 3°C in the RP and Sub-Carpathians is shown in the HadGEM2-RCA4 simulation whereas the lowest warm bias up to 1.5°C in the RP is shown in the EC-EARTH-RCA4 simulation. At high altitudes, the cold biases are less than -2°C.

The maps of spatial distribution of seasonal precipitation bias based on the ratios of five GCM-driven RCA4 historical runs and ROCADA observations reveal that, in general, the models overestimate precipitation at higher altitude and underestimate precipitation in the plain region. The maps of monthly biases between each GCM-driven RCA4 and ROCADA observations for the reference period 1971-2000 for both temperature and precipitation have been used to adjust both historical and scenario runs using the delta-change approach (Teutschbein and Seibert, 2012).

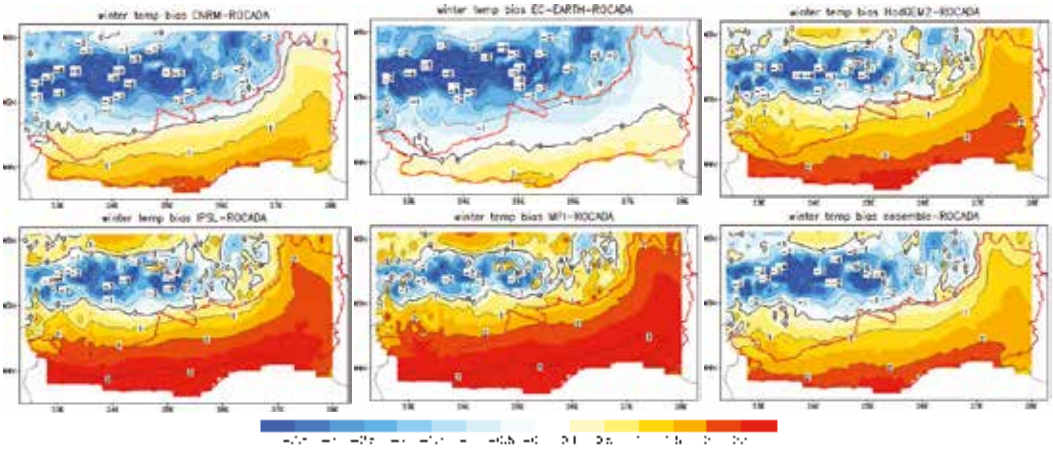

Figure 4. Winter mean temperature bias of the five GCM-driven RCA4 historical runs (1971-2000) versus ROCADA observations. The bias map of the ensemble mean is also added. Unit: °C

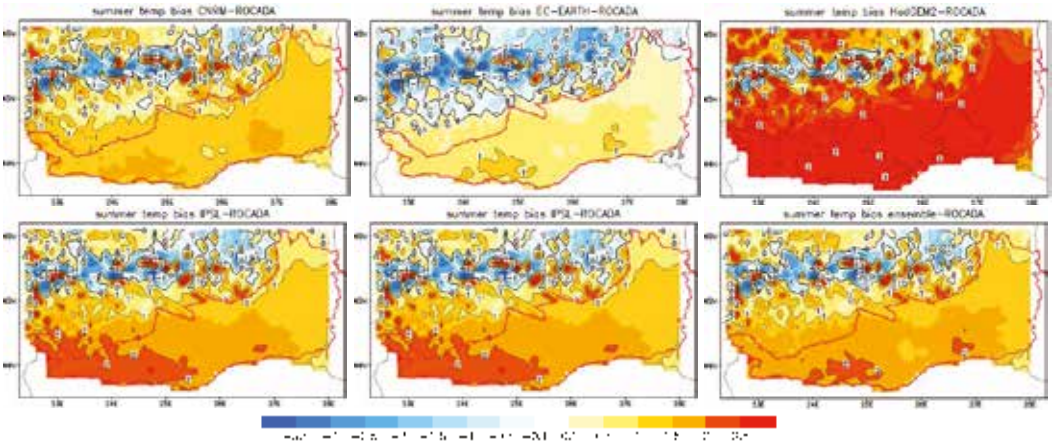

Figure 5. The same as Figure 4 but for summer

Projected changes under RCP4.5 scenario

After the bias correction of both temperature and precipitation simulations, the projected changes of seasonal temperature and precipitation for the RP have been assessed for the RCP4.5 pathway for the mid-term future 2021-2050 using as reference the ROCADA observations for the period 1971-2000. Figures 6-7 and Figures 8-9 present the spatial patterns of winter and summer temperature and precipitation changes, respectively, for the RP. The five GCMs project quite similar patterns of temperature changes for the RP. The spatial differentiation of each model depends on the altitude. Therefore, in general, the models project higher positive winter temperature changes in the Carpathians and Sub-Carpathians than in the whole RP where the winter temperature is expected to increase with 1°C to 2.5°C compared to the ROCADA reference. The highest winter temperature increases (+2°C to +2.5°C) for the RP are projected by the EC-EARTH and IPSL models while the lowest (+1°C to +1.5°C) are projected by the CNRM and MPI models. The ensemble mean projects winter temperature increase with 1.5°C - 2°C for the RP and with 2°C - 2.5°C in the higher altitudes (Figure 6). For summer, the projected temperature changes in the ensemble mean range between +1.5°C and +2.0°C in the RP and up to +2.5°C at higher altitudes. The highest summer temperature increase (>2.5°C) is projected by the HadGEM2 model over the whole domain, MPI model in the western half of the domain and IPSL in the south-western RP and higher altitudes (Figure 7).

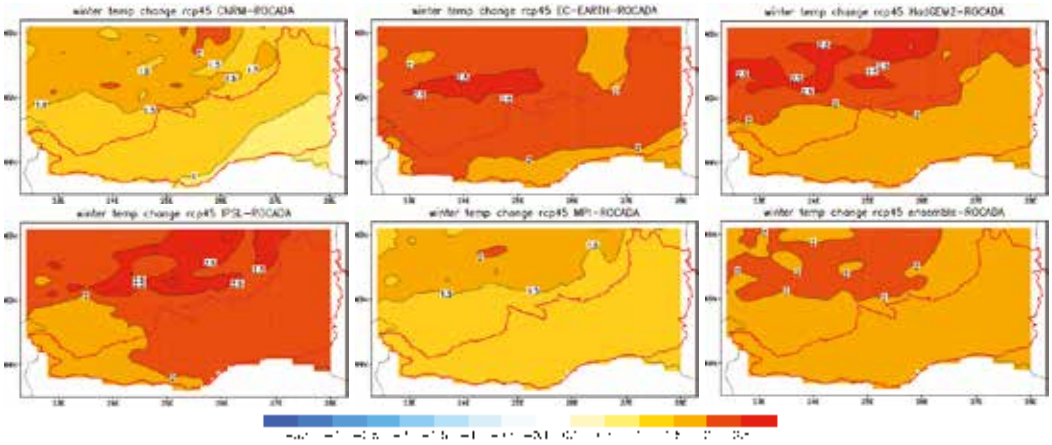

Figure 6. Projected temperature changes for winter with five GCM-driven RCA4 for the mid-term future (2021-2050) under rcp 4.5 scenario compared to the reference period 1971-2000 of the ROCADA observation dataset. Unit: °C

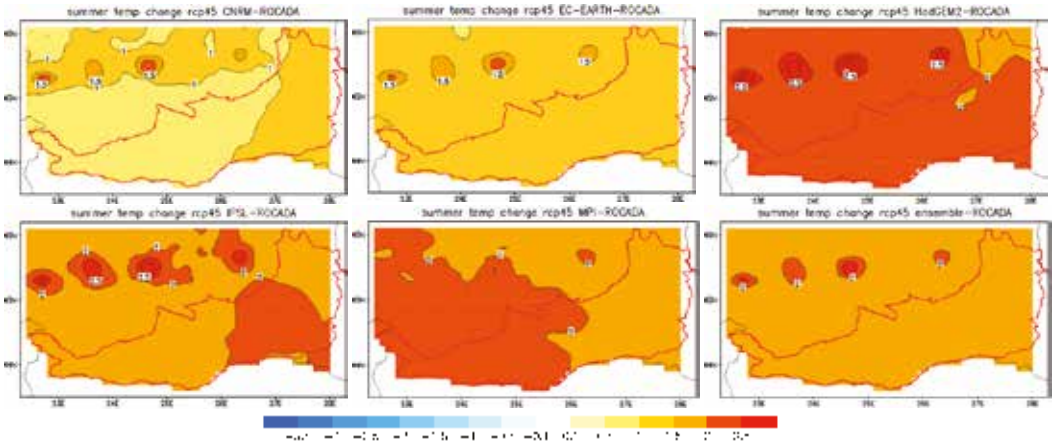

Figure 7. The same as Figure 6 but for summer

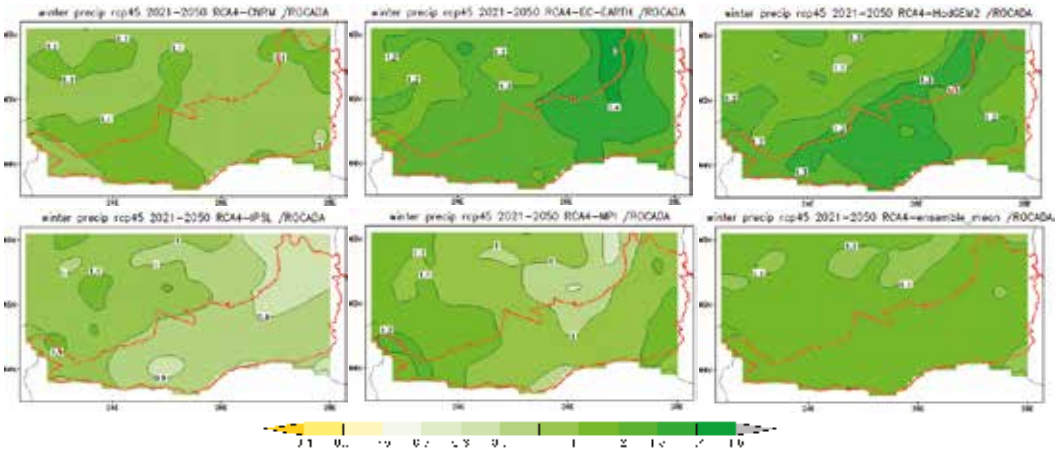

Figure 8. Projected precipitation changes for winter with five GCM-driven RCA4 for the mid-term future (2021-2050) under rcp 4.5 scenario compared to the reference period 1971-2000 of the ROCADA observation dataset

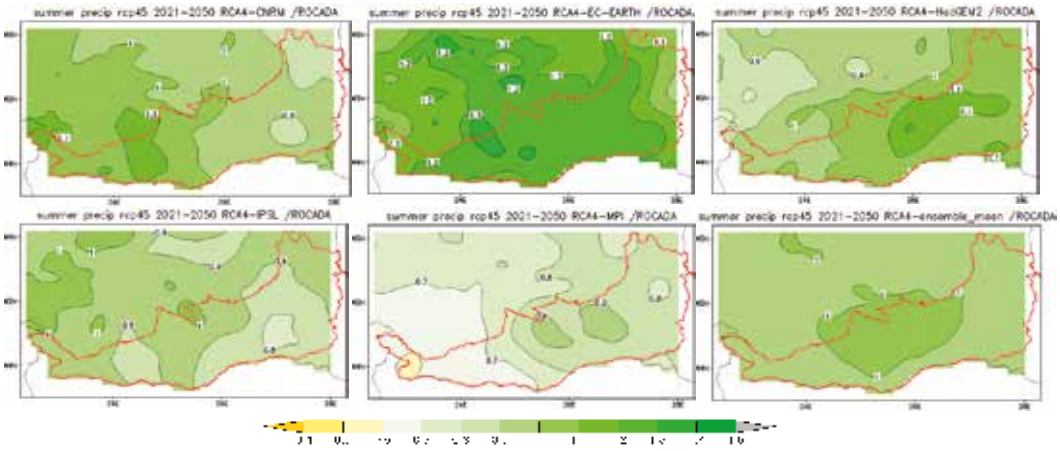

Figure 9. The same as Figure 8 but for summer

The changes in winter and summer precipitation regime for the RP are represented as ratios between simulated seasonal precipitation under the RCP4.5 scenario for the mid-term future 2021-2050 and the observed seasonal precipitation for the reference period 1971-2000, in Figures 8 and 9, respectively. For winter, two models (EC-EARTH and HadGEM2) project an increase of winter precipitation over the whole RP domain with 20% to 40% compared with the observed reference period, whereas the CNRM and MPI models project precipitation increase up to 10% in western an eastern RP. In the ensemble mean, an increase up to 10% of winter precipitation is projected over the whole domain. For summer, two models (IPSL and MPI) project the decrease of seasonal precipitation in the RP with 20% to 40%, in the western RP (MPI) and eastern half (IPSL). The other three models (CNRM, EC-EARTH and HadGEM2) project relatively slight increase, up to 10% in the western (CNRM) and eastern RP (HadGEM2). The EC-EARTH model projects increase of summer precipitation up to 30% in most of the RP domain. The ensemble mean projects the decrease of summer precipitation up to 10% in most of the RP whereas any change in the center of RP is projected.

CONCLUSIONS

The assessment of RCM performance and the bias correction are necessary before using the simulations for climatic projections and impact studies.

The assessment of the annual cycle for temperature and precipitation totals simulated by the RCA4 model in the „perfect boundary condition" experiment against three observation datasets, shows that the model systematically underestimates the mean temperature during February to May and overestimates the mean temperature during July to November, while the precipitation is overestimated during January to May and underestimated during July to September.

The annual cycle of mean temperature and total precipitation simulated by the RCA4 model forced by five GCMs with historical forcing compared to ROCADA observations show that the models underestimate temperature during April to June and overestimate temperature during July to September, while the precipitation is overestimated during January to June and October to December, and underestimated during June to September as compared to observations.

The patterns of the GCMs-driven RCA4 biases depend on the orography: the models underestimate the winter temperature over the Carpathians and sub-Carpathian region and overestimate the winter temperature with 1°C - 3°C over the RP. This bias characteristic appears, also, for summer temperature.

The RCP4.5 scenario projects increasing winter and summer temperature with 1-2°C comparing with the ROCADA observations for the reference period 2071-2000, in the RP.

The projected precipitation during winter will increase with 10% to 30% according to four GCM-driven RCA4 and will decrease with 10% according to IPSL-driven RCA4 comparing to the ROCADA observations for the reference period 1971-2000.
The projected precipitation during summer will decrease with 10% to 30% according to three GCM-driven RCA4 and will increase with 10% to 20% according to two GCM-driven RCA4, comparing to the ROCADA observations for the reference period 1971-2000. The ensemble mean does not indicate any change.

ACKNOWLEDGEMENTS

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VIRTUAL WATER VALUES - A PROJECT FOR GLOBAL AND REGIONAL ASSESSMENT OF AGRICULTURAL YIELDS AND WATER USE EFFICIENCY

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Abstract

Virtual Water Values (ViWA) is an interdisciplinary research project of geographers, remote sensing scientists, agro-economists, computer scientists and landscape planners. It aims at supporting the implementation of water and food related SDGs by first developing a global, high resolution monitoring system for agricultural yields, water use efficiency and actual virtual water contents of agricultural products based on COPERNICUS Sentinel-2 time series. This data is used as input to GCE simulations of global agricultural trade and to identify global hot-spots of unsustainable (inefficient) water use and trade (both green and blue) by agriculture. Scenarios of trade incentives and regulations will be analyzed for their potentials and effectiveness to improve the sustainability of global agricultural water use. The Danube river basin is one regional case study of ViWA.
Here the role of irrigation water use as well as upstream-downstream water conflicts is studied. First results of the continental and regional monitoring and simulations of actual yields, water use efficiencies and virtual water contents are shown and discussed.

Key words*: SDGs, COPERNICUS, Danube, water-use-efficiency, sustainable water use.*

INTRODUCTION

The United Nations through their Sustainable Development Goals (SDGs, UN 2015) have set out the ambitious goal to achieve sustainable global development by 2030. Food and water security are systemic for cultural development and among the most critical issues addressed by the SDGs. Agriculture constitutes approx. 92-99% of global green and blue water use (Mekkonen et al., 2014; Hoekstra et al., 2012). It differs from domestic and industrial water use, which both extract blue water from rivers or aquifers, change its property and largely release it back to rivers and aquifers for further downstream re-uses.

Agricultural water use is largely evapotranspiration of green (rainfall) or blue (irrigation) water into the atmosphere in the course of plant production and its removal from the place of use through atmospheric mixture and circulation. Re-use is thus impossible. A holistic view of the water use by agriculture and its sustainability therefore has to take into account both green and blue (and in some places even the small grey) water flows that enable crop growth. This is obvious e.g. for blue water use in irrigation but it also holds for rain-fed green water use.

Especially high intensity rain-fed agriculture harvests soil water to maximize evapotranspition and plant production at the expense of soil-moisture, which may not be available to recharge rivers or aquifers thereby allowing further downstream water uses. This has large consequences for water availability to different users and makes agricultural water use a conflicting issue related to land use and land use intensity.

The efficiency with which water is used around the Globe to produce an agricultural commodity (expressed in kg harvest / m³ evapotranspiration) varies by roughly by a factor of 5. There is a clear and general tendency towards increasing water use efficiency with increasing farming intensity (Zwart and Bastiannsen, 2004). Since water is a renewable resource low WUE and the related waste of water to agriculture is not an issue of sustainability as long as sufficient water is available to all users (including natural habitats and biodiversity).WUE nevertheless indirectly determines the amount of land that is required to satisfy growing food demands and thereby low WUE fosters expansion of cropland, which puts pressure on natu-

ral ecosystems. Low WUE becomes an issue of sustainable water use whenever water is a scarce resource and e.g. aquifers are overdrawn, conflicts arise between different water uses and natural ecosystems are eliminated in favor of cropland.

The global agricultural commodities market does not reflect agricultural WUE. It also does not consider whether and to what degree the water was used sustainably at the place of production. The global agricultural commodities market in its current form therefore inefficient and unsustainable water use in agriculture.

Central aims on the way to achieving the SDGs therefore are to develop ways to identify in a transparent way inefficient and unsustainable agricultural water use on the local, regional and global level, to identify hot spots, where coordinated action to increase WUE should start and to develop alternatives how global trade can foster efficient and sustainable water use in agriculture.

The research project Virtual Water Values (ViWA, viwa.geographie-muenchen.de) was established within the research initiative Global Resource Water (GROW) of the German Ministry for Education and Research to follow these aims. Researchers from hydrology, agroeconomics, remote sensing and landscape planning team up to for the first time carry out a detailed and spatially explicit analysis of the relation of global agricultural yields and water use efficiencies based on crop modeling and the now available Sentinel satellite Earth observation capabilities. This information is used in ViWA to simulate global agricultural trade and related virtual water flows. For the first time the selected trade model (CGE) considers the shortage and inefficiency of the water that is used locally for agricultural production. Scenarios are developed and analyzed on how global trade, water competition and prioritization of local hot spots of agricultural development can help increase agricultural water use efficiency in a sustainable way. ViWA thereby aims at supplying valuable information to decision makers in public administration, industry and society and at contributing to achieving the UN Sustainable Development Goals (SDGs). The paper gives and outline of the research framework and goals of ViWa, introduces to its global approach and its two regional pilot regions with special emphasis on the Danube basin and shows first results on the continental scale.

MATERIALS AND METHODS

The high-resolution monitoring system for water-related SDGs

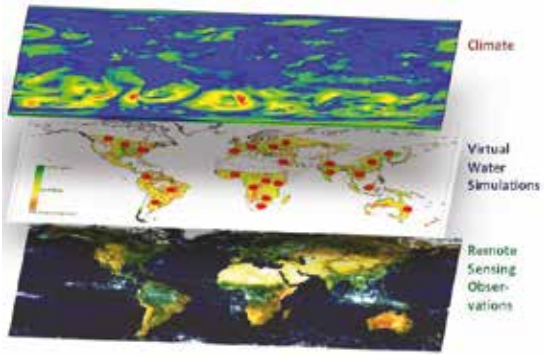

Figure 1. The ViWA-concept of a global monitoring approach for water use efficiency and actual yield. Global climate data drives ensemble of high resolution global crop growth simulations representing existing farming practices. At randomly selected global sites (exemplary red dots) for each pixel of the Sentinel time series (see bottom layer) the best-fitting ensemble member is selected is taken to determine from the model runs actual green and blue water flows, water use efficiency and actual agricultural yield are determined from the model runs. The results from the test sites are then scaled up to the global cropland

So far missing are timely, spatially explicit, high-resolution combined data on quantity, efficiency, scarcity and sustainability of the water resources used for agriculture in order to determine and assess the local and regional

water use, especially in crop production and for virtual water trade.

The availability of unprecedented data streams from the European COPERNICUS satellite observation system (Zitat) opens up new possibilities to observe growth of individual crops down to the plot scale by looking e.g. at the change in leave area, which can be accurately derived from the Sentinel-2 images. Weather and a-priori unknown farming-practices (cultivar selection, fertilization, irrigation, pest control) lead to different leaf-area development, that is associated with different yields, water consumption and water use efficiencies (Figure 2). The observation time series of Sentinel-2 images therefore contains information about the actual plot management and the resulting yields and water use efficiencies for green and blue water. To be able to extract these information satellite observation alone are not conclusive. It is first vital to separate the impact of climate and weather on crop development from the impact of the farming practices and second mandatory to indirectly infer yield and water use efficiency, which cannot directly be measured from satellite. Plant growth models that make crops grow under given weather conditions with a wide range of different farming practices allow this separation. They can be used for cultivation ensemble simulations, which cover the agricultural management space but they are, without external information not able to reproduce the actual crop development in each specific field. The actual crop development though can be determined by selecting from the cultivation ensemble that member that fits best leave development measured by the satellite observation time series.

This framework has already successfully been applied by Hank et al. (2015), it allows obtaining large coverage and high-resolution information on actual yields, water use efficiency and water scarcity in a timely manner. The schematic representation of the approach is shown in figure 1. The monitoring system in ViWA uses the complex, numerically expensive land surface processes model PRO-MET (Mauser et al., 2015). It is driven globally by downscaled weather data (ERA-Reanalysis Uppala, 2005, CORDEX-10 km data) at high temporal (1 h) and spatial (1 km) resolution. Large amounts of satellite data also have to be processed to automatically derive the leave development for each 10 x 10 m pixel in the selected.

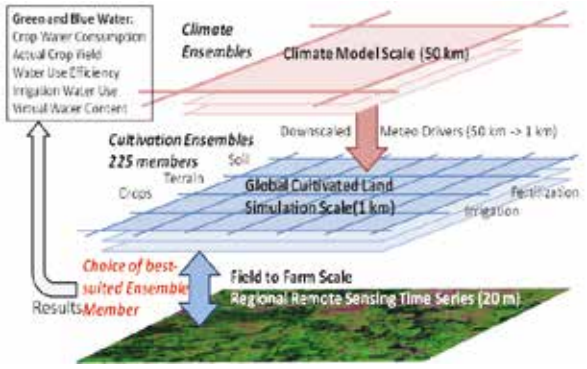

Figure 2. The scaling and simulation concept of ViWA. Meteorological inputs dynamically down-scaled from climate models drive a 225 member ensemble of hourly simulations representing the major crops and cultivation practices (fertilization, irrigation, cropping intensity) for each 1km pixel on the global cropland plus 1 member for each non cropland class. The resulting growth curves are compared with high resolution time-series of Sentinel remote sensing data to identify local water use efficiency, actual yield and virtual water content.

The ensemble data on crop growth resulting from the simulations, which contains local, detailed information on the potentials of different farming practices and related water-use efficiency forms the basis for extended scenario analyses in which e.g. water use efficiency is improved and different irrigation techniques are installed.

Figure 3 shows an example of a cultivation ensemble member. The leaf area for maize in

Europe for August 14, 2016 is shown at a spatial resolution of 0.008333 degree (in Europe app. 900x500 m) for the following management parameters: seeding: standard date for regions, fertilizer: 200 kg/ha, no irrigation.

Regional high-resolution case studies for validation

The monitoring data is also used to simulate and analyze in detail the ecological, agricultural and societal water flows in selected watersheds in order to study the competition for water among the different sectors (domestic and industrial use, ecosystems, agriculture and irrigation) and the sustainability of water use in terms of groundwater and surface water extraction e.g. for irrigation. Evapotranspiration, lateral flows and groundwater recharge rates for managed and natural ecosystems, near-surface groundwater flow and base flow as well as water use efficiency and yields are simulated using a PROMET to generate river flows.

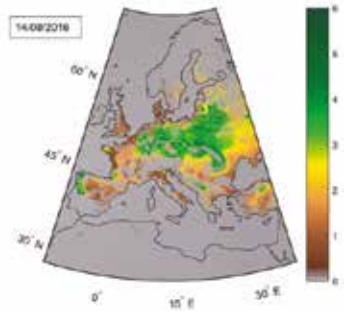

Figure 3. Sample of the distribution of the simulated leaf area [m^2/m^2] from a cultivar ensemble member of Europe for maize on August 14, 2016. Standard seeding date, 200 kg/ha N-fertilization and no irrigation is shown

The Danube and Zambezi were selected as regional case studies. They form the basis for a detailed upstream-downstream and local-to-global economic analysis of the virtual water flows, which includes the available information on quantity, efficiency, scarcity and sustainability of the managed water resources.

The Danube River Basin as a pilot region of ViWA

The Danube Basin is an ideal regional case study for ViWA in the sense that it 1) covers a palette of climate and hydrological condition from high-Alpine to dry Mediterranean. 20 countries with very different cultural and economic backgrounds, of which 11 are members of EU, share the Danube waters. Farming practices and farming intensities differ largely in the Danube basin and range from high intensity mostly in the upstream countries to often small-scale low-intensity further downstream. Rainfall shows a gradient from the NW to the SE leaving the Romanian plain and large parts of Bulgaria with a structural water deficit for agriculture. There large potentials exist for yield increase through deficit irrigation. In the Danube basin special emphasis is put on the evaluation of the potentials for increasing water use efficiency through different irrigation options, their water demand their yield potentials and on ways to sustainably supply the necessary irrigation water by the upstream countries and regions. ViWA intends, for the first time, to model in detail the related water and commodity production and flows and the related economic aspects.

The economic evaluation of virtual water flows in ViWA

In the past the economic analyses of the use of scarce water resources have concentrated on the efficiency or inefficiency of local rules of water allocation. In parallel, the importance of international trade for the exchange of virtual water and the resulting possible reduction of local water scarcity was analyzed. Both the analytical and the action level nevertheless were not previously linked. First attempts explicitly examine the economic importance of water with the help of CGE-models (Beritella, et al., 2007; Calzadilla et al., 2010; Taheripur et al., 2013), however, limited to the agricultural sector. In these, the scarcity of water is represented, at a high level of regional aggregation (GTAP AEZ, 2008), by shadow prices arising from the difference between the yields of irrigated to non-irrigated agriculture. In a study of the implications of water scarcity and economic growth, the relevance of other sectors (households, energy production, industry, and environment) is emphasized (OECD, 2014).

ViWA combines the high resolution water-food monitoring concept described above with detailed CGE-simulations of the world market with special emphasis on agricultural commodities and the role of water, its scarcity, its efficiency in the use for agriculture and the competition for water between different economic sectors. Thereby the project identifies and quantifies in unprecedented detail the international trade in virtual water. The coupling of monitoring data with CGE-simulations also makes it possible to model and derive scarcity measures for regional water resources. Scarcity of water resources can be defined in various dimensions, as competing uses between crops and between regions within a watershed, between sectors and between countries. These aspects are examined in the model compound by deriving shadow prices for water use from the econometric analyzes for water productivity. Using the shadow price of water in different uses regional inefficiencies of water use within a country as well as in the distortions in international trade will be identified.

These activities provide the conceptual framework for the analysis of scenarios for an efficient and sustainable water use.

Sustainability assessment and Governance of water resources and SDGs in ViWA

The real and virtual water flows and their governance are examined in light of the water-related SDGs. For this purpose a sustainability assessment is carried out based on the monitoring approach and the economic evaluations. The project addresses numerous proposed UN-SDG-indicators (UN 2015). It will specifically contribute to quantify the proposed global indicators No. 13,15,16,48, the national indicator 2.11 and it will contribute to quantify global indicators 83 and 85. It specifically identifies and evaluates with the involvement of stakeholders trade-offs in achieving the SDGs food security (SDG 2), water (SDG 6), bioenergy (SDG 7), climate (SDG 13) and protection of ecosystems (SDG 15). This contributes to the refinement and application of existing indicator systems to monitor progress of SDGs. From these results water shortage areas with unsustainable water use (hot spots) and areas with abundance of water (cold spots) are delineated globally based on the trade-offs between potentially affected area units and available water / energy / land use. Trade-offs between ecosystem services and agricultural production (food security, bioenergy) are analyzed for different ecosystem types using the simulated changes in water flows and yields in the representative watersheds with the aim to classify sensitivities (e.g. organic matter, water-dependency) and assignments (e.g. case studies on the Red List of Ecosystems, IUCN) by means of a GIS-based "environmental risk assessment". The water supply situation is analyzed in high resolution with indicators of Vörosmarty (2010), data from 3.1 and global population data (LandScan (2015), 1km^2) and validated using FAO and Aquastat NEESPI data. The result represents areas and residents affected by different degrees of a lack of water.

For the hot-spots of unsustainable water use "spatial problems of fit" are determined (asymmetry between the spatial extent of ecological processes and political decision spaces). They are the starting points for case studies (literature based) on potential institutional obstacles to a sustainable and efficient water use (target 5).

Analysis of scenarios for sustainable water use

The outcome of the high-resolution monitoring system for water-related SDGs, the integrated economic evaluation of virtual water flows and the sustainability assessment and governance of water resources and SDGs will be discussed with stakeholders using the approach outlined in Mauser et al. (2013).

Together scenarios are formulated and implemented to identifying effective and efficient control instruments for a more sustainable and efficient water management that go beyond the ones that are already identified, which are: 1) investigate the vulnerability of water use by looking at the natural climate variability represented by the El Nino event 2015/16 as well as the years 2017 and 2018. They are compared and analyzed specifically with regard to hot-spots of water shortage and the impact on water use and economic feedback effects on the global agricultural markets; 2) scenarios to simulate

options for a globally efficient and sustainable water management. For this purpose local water use efficiency are changed by improving farming practices. They are introduced into the model compound similar to the approach in Mauser et al. (2015); 3) similar methods are used to simulate the effectiveness and efficiency of control instruments, such as usage restrictions of fossil groundwater or water pricing. The scenarios analyses allows to identify and highlight the potential benefits and trade-offs of different regulatory instruments for water use.

All project partners, including the stakeholders, participate in the review and evaluation of the results of the scenarios. Here, e.g. the potential yield increases that go along with increased water use efficiency and the welfare effects of a more efficient water use and appropriate management options are demonstrated and the economic distribution effects of sustainable water use in intra-regional and inter-regional level are assessed. In addition trade-offs between different SDGs related to water are discussed and evaluated based on results.

CONCLUSIONS

ViWA consequently uses the new opportunities that the globally available data streams from the European COPERNICUS satellite observing systems offer. The combination of detailed high performance computing simulations of environmental processes, like crop growth, with the satellite observation lead to new data driven monitoring approaches, which allow to realistically quantifying important sustainability indicators like yield, water use efficiency both in rain-fed and irrigated agriculture and the degree of sustainability with which water is used locally to produce agricultural commodities. This allows identifying priorities for action and their respective trade-offs on the way towards reaching the water related SDGs.

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WATER USE EFFICIENCY OF SELECTED CROPS IN THE ROMANIAN PLAIN – MODEL STUDIES USING SENTINEL-2 SATELLITE IMAGES

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Abstract

The Romanian Plain is dominated by intensively used, fertile cropland with large agricultural potentials. Nutrient supply and water availability are major determinants of crop yields. Achievable yield is strongly influenced by fertilization and irrigation - depending on the local conditions. Increasing water use efficiency (WUE) is an important objective for distributing the limited water for irrigation. We present a study which determines scenario-based yields and WUE of winter wheat and maize throughout the Romanian Plain (2015–2017). The study compares results of the biophysical crop growth model PROMET with data on actual plant development derived from Sentinel-2 time series. Actual crop yields and WUE are compared to their potentials which are determined by assuming optimal fertilization for both rain-fed and optimal irrigated agriculture. The winter wheat simulations show that, under rain-fed conditions, optimal fertilization can more than double yields and maximize WUE, whereas irrigation hardly affects yield. Since maize is more affected by water stress in the Romanian Plain, optimal fertilization can double maize yields and maximize WUE under irrigation only.

Key words*: crop modeling, irrigation, Sentinel-2, water use efficiency, yield.*

INTRODUCTION

Implementing sustainable ways to secure food supply for a growing and wealthier global population is among the most important sustainable development goals (UN, 2015). In this objective, it is estimated that biomass production will have to roughly double by the year 2050 (Alexandratos and Bruinsma, 2012; Bruinsma, 2009). It has been shown that food production increase can be achieved globally through lifting the potentials of existing cropland rather than expanding into other land use categories (Mauser et al., 2015). The most important factors determining crop yield are climate, soils, water availability and agricultural management (esp. cultivar selection, timing of seeding, fertilization, irrigation, pest/weed control). In large agricultural regions, available rainfall limits yield either structurally (climate) or episodically (droughts). Good farm management adapts to the structural deficit by either limiting fertilizer inputs to the achievable rain-fed yields or by introducing irrigation to compensate the deficit and increase fertilizer inputs to the potential irrigated yields (or some solution in between). The second choice, introduction of deficit irrigation, can therefore considerably increase yields in many regions around the globe. On the farm scale, irrigation is a straightforward strategy as long as water is available. For water suppliers or administrative bodies, the question arises how much irrigation water is required to fulfill the cumulative irrigation water demands of a certain area. This question is complex, mainly because the conditions in terms of climate, soil and management are spatially heterogeneous and the profitability of irrigation may vary with farm size and crop type. Since deficit irrigation generally applies to regions with already scarce water resources, the main goal should be to allocate additional irrigation water to crop production in the most efficient way. Agricultural water use efficiency (WUE) is defined here as kg crop yield per m^3 evapotranspiration during the vegetation period. In general, agricultural WUE increases with yield, as unproductive evaporation from the soil and inter-

ception from the leaves is minimized and productive transpiration is maximized to the extent possible when lifting yields (Zwart and Bastiaanssen, 2004). Irrigation WUE may also vary widely depending on irrigation technology, with flood irrigation being the least water efficient followed by sprinkler irrigation and drip irrigation being the most water efficient (Jägermeyr et al., 2015).

In this paper, we present first results of yield and related WUE simulations for winter wheat and maize in the Romanian Plain. The conducted simulations form an ensemble with scenarios of varying nutrient availability for the rain-fed case and an optimal nutrition scenario for both the rain-fed and irrigated case. Model simulations are carried out for the period 2015–2017. The potential role of increasing fertilization as well as additional irrigation on yields including corresponding WUE is analyzed for the comparatively dry years 2015 and 2017. In a first attempt, the simulated leaf area index (LAI) development of the ensemble simulations is compared to observed time series of the Sentinel-2 Earth Observation satellites for selected fields in the study region.

MATERIALS AND METHODS

The study region

The Romanian Plain, roughly the area between the Danube river and the Carpathian Mountains downstream the Iron Gate (Figure 1), is one of the most fertile agricultural regions in Europe.

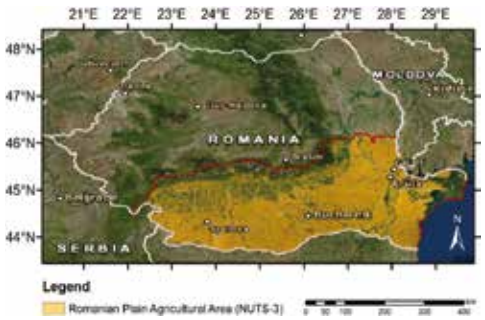

Figure 1. Agricultural area within the Romanian Plain (NUTS: Nomenclature of territorial units for statistics)

Efforts are currently underway to revitalize irrigation, which has been widespread during communist times and decayed in the first two decades after the end of the communist period in 1990. Furthermore, there are spatially diverse situations in the Romanian Plain, where fragmented agricultural lands alternate with large cropland areas belonging to major agricultural commercially oriented holdings (Balteanu and Popovici, 2010). Thus, a great variety of land use management practices is present implying diverse situations of resource allocation and use, especially in terms of water and fertilization.

Climate in the Romanian Plain is warm-semiarid with average temperatures ranging from above 9°C in the North to above 11°C in the South and annual rainfalls from 600–700 mm in the North to 500–600 mm in the South. Aridity increases from North to South with Thornthwaite aridity index values in the range of 40–55% (Dragota et al., 2011).

The conceptual approach of yield scenarios and agricultural WUE determination

WUE connects yield with either productive plant water consumption (transpiration) or both productive and unproductive water losses (evapotranspiration). It is straightforward to consider total evapotranspiration within the crop vegetation period for WUE assessment as true water losses from the agricultural system should be considered. Concerning yield, we closely relate to the definitions of yield scenarios given by van Ittersum and Rabbinge (1997) (Figure 2), who differentiate between potential, water-limited, water and nutrient-limited and actual yield. In the Romanian Plain, we assume that actual yield is mainly limited by both water and nutrient availability.

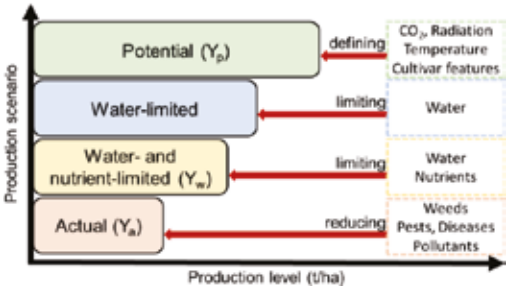

Figure 2. Yield definitions and limitations for the Y_a, Y_w and Y_p scenarios used in this paper (adapted from: van Ittersum and Rabbinge, 1997)

We therefore investigate yield and WUE for three cases: i) potential (Y_p: abundant water and nutrient supply), ii) water-limited (Y_w: only water supply limiting) and iii) actual yield (Y_a: water and nutrient supply limiting).

There is no direct way to map WUE since its determining parameters, evapotranspiration and yields are hardly accessible in a spatial way. Their interrelation though can be modeled with mechanistic crop growth models giving insight into the coupled processes of yield formation and water flows. Simulating potential and water-limited yield as well as corresponding WUE is straightforward by assuming that either nutrients and water or only nutrients are abundant. Models though need additional information to simulate actual yields and related WUE. In this objective, a combination of crop growth ensemble simulations using the model PROMET (Mauser and Bach, 2009) and information from Sentinel-2 satellite data is used. Sentinel-2 offers new observational capabilities to determine time series of crop leaf development with high temporal and spatial resolution. The PROMET ensemble member's represent variety of farm management options regarding fertilization. Actual yields, WUE and water scarcity are determined from a comparison of measured and simulated crop leaf development. This approach (schematically shown in Figure 3) was already successfully applied by Hank et al. (2015) and allows obtaining information of large coverage and high-resolution in a timely manner.

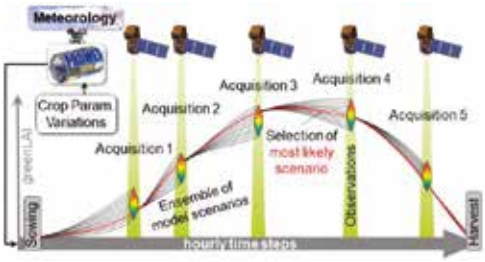

Figure 3. The approach to combine an ensemble of PROMET crop growth simulations with Sentinel-2 observations to determine actual yields and WUE (Hank et al., 2015)

The COPERNICUS Sentinel-2 satellites

The data stream created by the European COPERNICUS satellite observation system (ESA, 2018) opens up new possibilities for the observation of growth of individual crops down to the plot scale by monitoring the development of LAI. Sentinel-2 observes the land surface with 9 spectral bands at a spatial resolution of 10/20 m and a revisit time of 5 days at the equator. LAI can accurately be derived from the Sentinel-2 images by applying atmospheric corrections and subsequent inversion algorithms for the radiative transfer in the canopy of the crops, which includes all available spectral bands of Sentinel-2 (Migdall et al., 2009; Verhoef and Bach, 2012). The LAI time series are available at a spatial resolution of 10 m and, depending on cloud cover, a temporal resolution of ~10 days.

The Crop Growth Model PROMET

The dynamic biophysically based and spatially explicit agro-hydrological model PROMET (Mauser and Bach, 2009; Hank et al., 2015) simulates actual and potential agro-ecological yields and water flows. It is used to model the development of winter wheat and maize, which represent more than 50% of the acreage in the Romanian Plain (INS, 2018). PROMET simulates net primary production with a dynamic first order plant-physiology approach (Farquhar et al., 1980) and uses a canopy model to allocate assimilate to plant organs. In this study, geographical data on topography (Farr et al., 2007), soil (FAO, 2012) and acreage (EEA, 2012) is used at a spatial resolution of 30"; actual sowing dates and information on the long-term course of phenology were derived from JRC AGRI4CAST (2015).

As meteorological input driver, the ERA-Interim reanalysis product of ECMWF (Dee et al., 2011) was used. Within PROMET, ERA-Interim data was downscaled from 0.5° to 30" spatial resolution and disaggregated from six-hourly to hourly temporal resolution. Meteorological driver data was simultaneously bias-corrected using spatially distributed monthly correction factors derived from the WorldClim climatology (Hijmans et al., 2005).

Crop growth and water balance was simulated on an hourly basis and at a spatial resolution of 30" for winter wheat and maize being in each case cultivated on the whole acreage of the Romanian Plain. Simulations were carried out-

from 1 September 2014 to 31 October 2017, thereby covering most of the period in which Sentinel-2 data is available. Crop specific water, nutrient and temperature stress as well as actual CO_2 concentrations are physiologically considered. These factors influence agro-ecological yields through phonological development, CO_2 fertilization and yield formation and finally lead to a successful or failed harvest.

Yield ensemble simulations for winter wheat and maize comprise scenarios of a systematical variation of the PROMET nutrition factor (NF) in the rain-fed case. The NF represents nutrient availability (nitrogen and phosphorus) to the crops and was logarithmically increased from 0.2 (very low nutrient level) to 0.55 (no nutrient deficit). In addition, an optimal nutrition scenario is simulated for both the rain-fed and the irrigated case. In this model study, irrigation is conceptualized through a total elimination of plant water stress by holding soil water content permanently at field capacity. For all scenarios, LAI, evapotranspiration and crop water stress were aggregated to daily values and were analyzed together with annual yields.

RESULTS AND DISCUSSIONS

The LAI ensemble

The nutrient ensemble results of the LAI development courses for an exemplary location in the eastern part of the Olt sub-unit within the Romanian Plain are depicted in Figure 4 for winter wheat (top) and maize (bottom). LAI development varies strongly with nutrient availability. For winter wheat, nutrient supply does not alter the length of the growing season, which is rather weather dependent. In contrary, maize simulation results show that the length of the growing season is influenced by both weather conditions and nutrient availability as higher nutrition status may trigger crop water stress. Yearly variability's can be noticed in both cases.

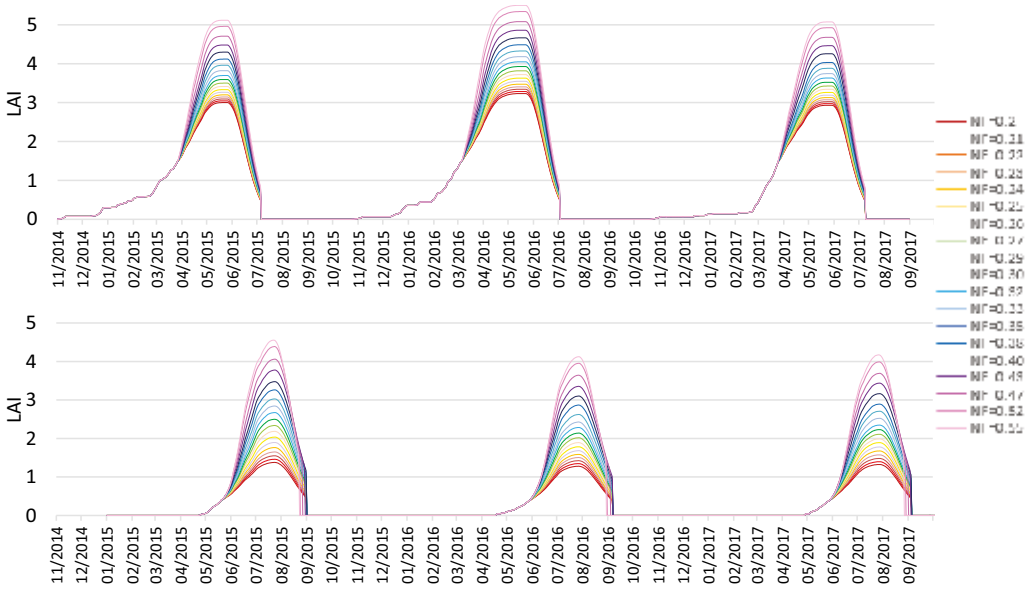

Figure 4. Simulated LAI development from 1 November 2014 to 30 September 2017 for winter wheat (top) and maize (bottom) at an exemplary location in the Romanian Plain for an ensemble of nutrient availability (NF) ranging from 0.2 (very low nutrient supply) to 0.55 (no nutrient limit)

Winter wheat and maize sensitivity to water stress

The reason for the difference in behavior of the two crops becomes evident in Figure 5. Here, sensitivity functions of simulated yield, crop water stress and WUE to nutrient availability are shown in a spatial average of the Romanian Plain for winter wheat (Figure 5, top) and maize (Figure 5, bottom) for an ensemble of the water-limited nutrient supply scenarios. The drought year 2015 was chosen for this assessment to shed light on the crop's reaction on comparatively severe water stress within the period of study. Crop water stress is detected by the model as soon as the plant experiences transpiration deficits due to soil water shortages and is expressed by a normalized index ranging from 1 (no water stress) to 0 (max. water stress: no transpiration possible) over the whole vegetation period. A water stress index value of 0.8 is in the magnitude of severe water stress with considerable yield losses as a consequence.

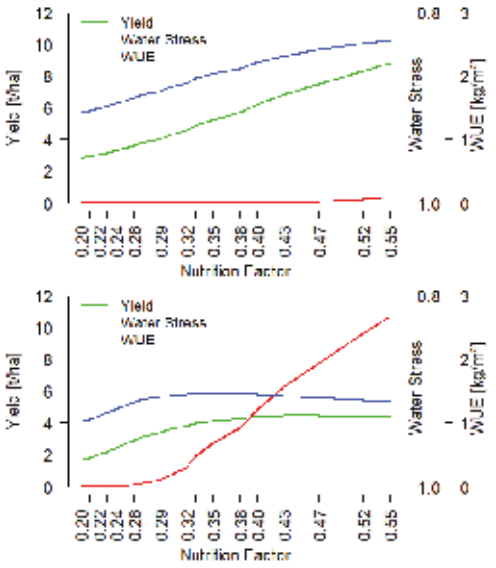

Figure 5. Sensitivity functions of simulated yield, crop water stress and WUE to nutrient availability of winter wheat (top) and maize (bottom) for the drought year 2015 in spatial average for an ensemble of nutrient availability scenarios ranging from NF=0.2 (very low nutrient supply) to NF=0.55 (no nutrient limit)

Increasing fertilization of winter wheat leads to a yield increase from 2.83 t/ha to 8.83 t/ha in spatial average. Fertilization and increasing yields coincide with a WUE, which increases from 1.42 kg/m³ to 2.57 kg/m³. Due to its early development, winter wheat does not show any water stress signal for NF < 0.43. Simulations therefore suggest that winter wheat yield is solely limited by the nutrition supply in the Romanian Plain even during the drought year 2015. The situation for maize is completely different. Yield level rises with increasing fertilization from 1.68 t/ha to a saturation level of 4.49 t/ha at NF = 0.47. Similarly, WUE increases from 1.01 kg/m³ to a saturation level of 1.46 kg/m³ at NF = 0.33. Water stress already sets in at NF = 0.25 and reaches a maximum stress level of 0.82, making additional fertilizer application increasingly useless until the impact of water stress finally overrides benefits from increasing fertilization. At higher fertilization levels, maize yields and WUE decrease down to 4.37 t/ha and 1.33 kg/m³. This is due to an earlier development of the crop caused by water stress, which consumes available water for leaf development and leads to diminished fruit formation. Water stress accelerates phenology call development and also leads to earlier harvests as a result of premature ripening (Figure 4, bottom). Therefore, simulations show that maize yield is limited by both nutrition and water supply in the Romanian Plain during the drought year 2015.

Yield scenarios for winter wheat and maize in 2017

From the findings of Figures 4 and 5, appropriate NF values were selected representing the actual, water-limited and potential yield scenarios (Table 1).

Table 1. Selected NF values for the yield scenario simulations for 2015–2017 in the Romanian Plain

Scenario	NF Winter Wheat	NF Maize
Y_a	0.27	0.33
Y_w	0.55 (rain-fed)	0.55 (rain-fed)
Y_p	0.55(irrigated)	0.55(irrigated)

NF values for actual yield levels represent fertilizer application levels assumed to be approx. 45 kg/ha for winter wheat and 55 kg/ha for maize (GFA Terra Systems, 2004; NISCAD, 2018). NF values for water-limited yields (rain-fed) and potential yields (irrigated) represent

high intensity farming with fertilizer application levels of approx. 250 kg/ha.

Figure 6 shows the spatial distribution of the actual (top), water-limited (center) and potential yields (bottom) for winter wheat (left) and maize (right) in the whole Romanian Plain exemplary for the year 2017.

The simulated actual winter wheat yield amounts to a low value of 3.74 t/ha in average; its patterns form a very slight, but general gradient from East to West, which is caused mainly by decreasing radiation. The Northern Piedmont regions of the Plain generally show slightly lower yields due to reduced air temperatures and thus lower temperature sums. Winter wheat yields sharply increase with increasing fertilizer application to 8.97 t/ha in average (Figure 6, left, center), but there is hardly any difference between water-limited (Figure 6, left, center) and potential (Figure 6, left, bottom; 8.98 t/ha in average) yield as winter wheat did not experience any water stress in the Romanian Plain in 2017.

Likewise, the situation for maize differs largely from the winter wheat findings. The simulated actual maize yield amounts to 4.23 t/ha in average. It shows a more pronounced but similar pattern as winter wheat with a gradient in yield from NE to SW. Both water stress and waste of fertilizer is avoided by keeping the nutrition status on a relatively low level. Reducing nutrient stress by optimal fertilizer application in the rain-fed case, water-limited maize yield (Figure 6, right, center) shows only a mild increase to an average of 5.59 t/ha and a strong differentiation in yield according to the underlying soil conditions in the model inputs. Soils with high water holding capacities like in the alluvial plain in the East tend to allow higher yields than sandier soils in the West, where fast percolation enforces water stress. Removing water stress through additional irrigation (Figure 6, right, bottom) leads to a simulated potential maize yield to an average level of 10.18 t/ha and a spatial homogenization of yield levels.

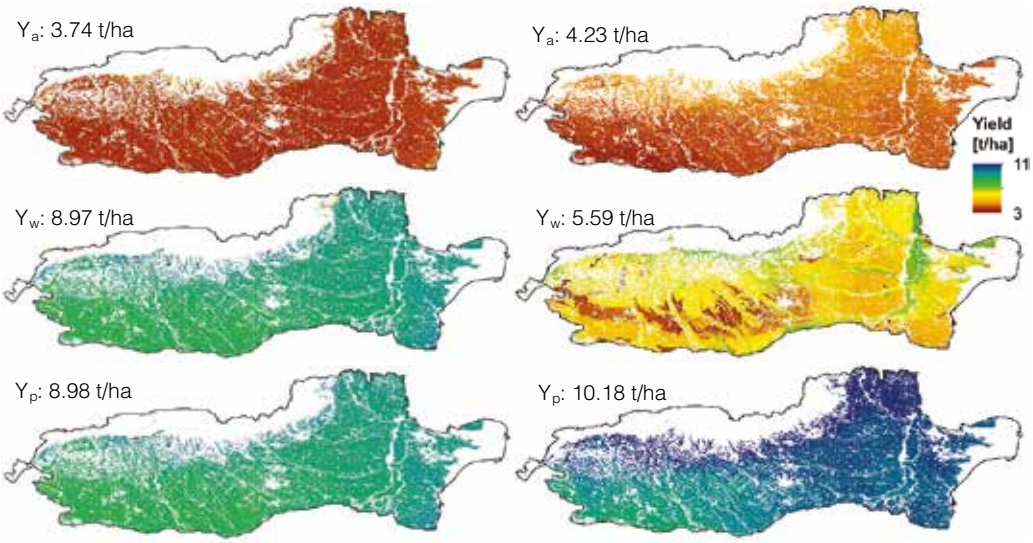

Figure 6. Spatial distribution of simulated actual (top), water-limited (center) and potential (bottom) yield of winter wheat (left) and maize (right) in 2017 in the Romanian Plain

This demonstrates the very high potential for increasing winter wheat and maize yields in the Romanian Plain. Simulations show that in the case of winter wheat, increasing fertilization and in the case of maize, increasing fertilization and additional irrigation is the key to lift yield levels.

WUE scenarios for winter wheat and maize in 2017

Hereafter, WUE assessments are shown in correspondence to the achieved scenario yields. Figure 7 depicts the spatial distribution of the related WUEs for the actual (top), water-

limited (center) and potential scenarios (bottom) for winter wheat (left) and maize (right) in the Romanian Plain exemplary for the year 2017.

Actual winter wheat WUE reaches 1.70 kg/m³ on average. Through optimal fertilization in the rain-fed case, a sharp increase of average WUE to 2.62 kg/m³ can be achieved. By irrigation as a surplus to optimal fertilization, average WUE (2.12 kg/m³) slightly declines as there is no significant yield increase in the potential scenario, but higher water losses as most of the additional irrigation water is unproductively evaporated, leading to a lowering of WUE.

In contrast, actual maize WUE amounts to 1.57 kg/m³ on average. With optimal fertilization, average WUE (1.56 kg/m³) even decreases due to water stress and yield losses. Regions which already show water stress in the actual scenario are particularly affected. By irrigation as a surplus to optimal fertilization, average WUE (1.80 kg/m³) increases over the actual WUE level as crop water consumption is not restricted during dry season anymore and can properly contribute to yield formation.

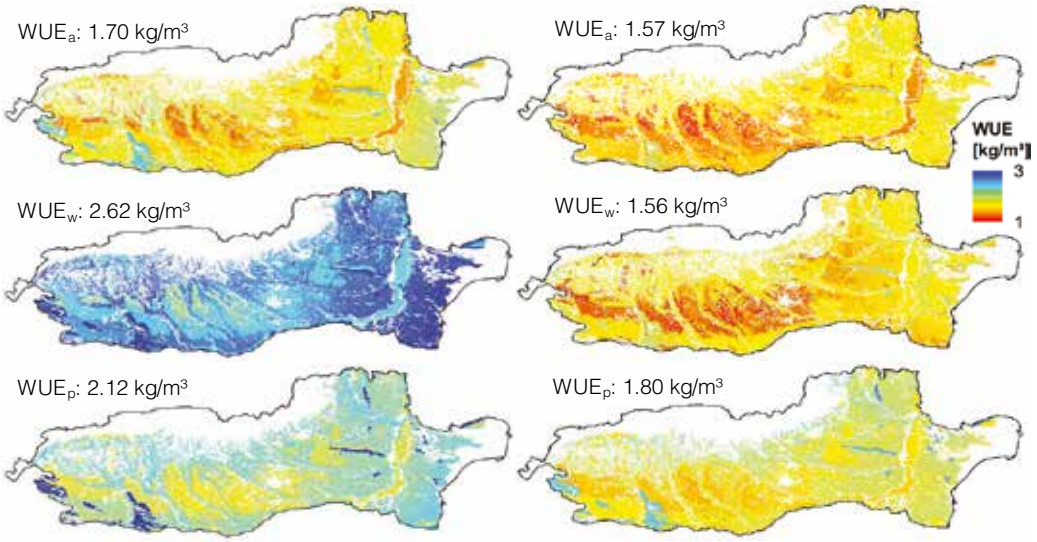

Figure 7. Spatial distribution of simulated actual (top), water-limited (center) and potential (bottom) WUE of winter wheat (left) and maize (right) in 2017 in the Romanian Plain

Again, the spatial patterns depicted in all WUE maps clearly hint at the strong relationship of WUE with the water holding capacities of the soils.

The scatterplots (Figure 8) give insights into the scenario specific yield-WUE-relationships. Here, the dependence of simulated actual (left), water-limited (center) and potential (right) WUE of winter wheat (top) and maize (bottom) on their respective yields in the period 2015-2017 in the Romanian Plain are shown. The highest yielding scenarios largely coincide with the scenarios of highest WUE. Simulations show that in the case of winter wheat, yield can be maximized under highest WUE by increasing fertilization. In the case of maize, highest yields under highest WUE can be achieved by increasing fertilization and additional irrigation.

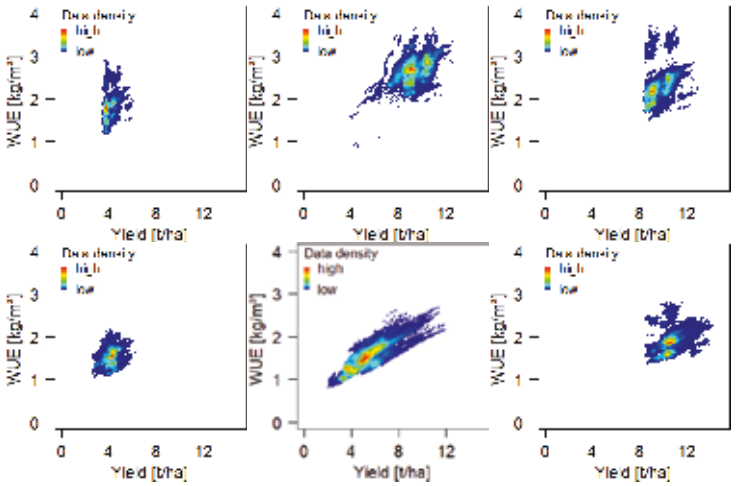

Figure 8. Scatterplots of the relationship of simulated actual (left), water-limited (center) and potential (right) WUE of winter wheat (top) and maize (bottom) and their respective yields in 2015–2017 in the Romanian Plain. Each data point represents the yield-WUE-relationship of one pixel in the study region in one year out of the period 2015–2017

Comparison of simulated and inverted sentinel-2 LAI

Sentinel-2 data is available from July 2015 onwards. Since the launch of Sentinel-2B, two identical satellites are orbiting the Earth, reducing the theoretical revisit time to between 2and 5 days in the Romanian Plain.

The sub-section ROU005 (Figure 9) of tile 34TGQ was chosen for the comparison of modeled and inverted LAI. A total of 75 completely or partly cloud-free images of 2015–2017 were processed using an inverse modeling approach to determine land-use and LAI from all Sentinel-2 spectral bands for each 10 m x 10 m pixel (Bach et al., 2016; Migdall et al., 2009).

The exemplary Sentinel-2 satellite image (subsection ROU005 on 21 April 2016) in Figure 9 shows a false color composite of the spectral bands red (R), NIR (G) and MIR (B).

It includes rural villages (e.g. on the left and right side of the image) and covers all field sizes from extremely small fields in the vicinity of the villages to large and intensively used fields in the North and South.

An inoperative irrigation canal can be identified running through the upper part of the image from the left side to the upper right corner. The different shades of green indicate different development stages of spring-active winter cereals.

Figure 9. Sub-section ROU005 of Sentinel-2 tile 34TGQ observed on 21 April 2016

In some fields, specifically in the lower part of the image, different growth conditions related to soil and geomorphological differences can

be recognized within the fields. Other fields showing no greenness do not carry vegetation at this stage of development and will most likely develop summer-active crops like maize, sunflower or sugar beet.

From the selected and processed Sentinel-2 images, the temporal development of LAI was extracted and analyzed. Figure 10 shows the LAI development during the season of 2016 for three selected neighboring winter wheat fields together with the nutrient ensemble of simulated winter wheat LAI developments at the respective location.

Figure 10 shows commonalities as well as differences between the simulated and observed LAI developments. In general, the date of peak LAI roughly coincides between simulation and observations. The simulated LAI development as well as the observed LAI development at EO2 already starts in early spring whereas the observed LAI at EO1 and EO3 starts to increase as late as mid to end of March. Harvest date in the simulated winter wheat development occurs at the beginning of July, which is in accordance with EO observations. Winter wheat vegetation period as simulated by PROMET coincides with the observed vegetation period at the EO2 field.

The EO1 field shows no sign of green leaves during winter, which is most likely due to frost damage during the cold season. This may also explain the retarded and poor development and consequently low LAI peak values on that field.

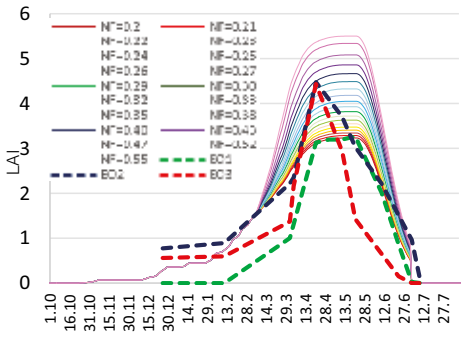

Figure 10. Comparison of the simulated nutrition ensemble of LAI development (solid lines) and the LAI development of three selected winter wheat fields in the Romanian Plain derived from a time series of Sentinel-2 images for the season of 2015/2016 (dashed lines)

However, absolute peak LAI values of the selected fields satisfactorily cover the range of LAI simulated for 2016 by varying the nutrition factor in PROMET. Comparing peak LAI of the three fields may suggest a low yield of approx. 3 t/ha at EO1, whereas the yields at EO2 and EO3 could be of the order of 7 t/ha.

These findingshintat pronounced spatial heterogeneities on an even small scale between neighboring fields, which pose great challenges to crop model studies in the Romanian Plain. Further studies should focus on a refinement of crop parameterization accounting for the special sub-regional and local realities in the Plain, markedly the favoring climatic conditions and very fertile soils in combination with most variable nutrient management and water shortages during mid-summer. Thus, a major perception of the study is that Sentinel-2 satellite time series are an important source of information to understand the agricultural realities in the Romanian Plain.

CONCLUSIONS

Simulations were carried out with the crop growth model PROMET to investigate the relation between yield and WUE for three different scenarios: i) actual yield, ii) water-limited yield and iii) potential yield of winter wheat and maize in the Romanian Plain. The simulation period covered the years 2015 (dry), 2016 (wet) and 2017 (normal to slightly dry).

Winter wheat and maize show a distinctly different behavior in the study region in 2015–2017. Winter wheat is hardly affected by water stress; its yield is therefore mainly determined by the fertilization level, which is generally low in the Romanian Plain. Even with optimal fertilizer application, water stress is not a limiting factor for winter wheat. Maize does not show severe water stress under the actual level of fertilization. By raising fertilization in contrast, water stress intensity increases drastically and can in some regions even lead to yield reductions compared to yields levels achieved by current management practice. This suggests that farmers who do not introduce irrigation do not waste fertilizer unproductively likewise.

An assessment of the efficiency of water used to achieve a certain amount of yield is vital in regions prone to water stress such as the Ro-

manian Plain. The WUE of winter wheat tends to increase to high levels with increasing yields and fertilizer application. This does not hold for maize where WUE stagnates at medium levels and even decreases with high nutrition factors. Only by introducing irrigation on top of fertilization, maize WUE can be increased significantly. Our simulations show that irrigation does not affect winter wheat yield much, whereas it can more than double current maize yield.

The preliminary results of the comparison of simulated and Sentinel-2 derived LAI development are promising. They show that the satellite observations point at improvements in the region dependent parameterization of the crop models. Further steps in the analysis of the Sentinel-2 time series will further clarify and stabilize the results and will lead into the direction of field specific model parameter derivation from satellite time series.

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NOWADAYS SITUATION OF DRAINAGE SYSTEMS IN THE MOLDOVA RIVER WATERSHED

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Abstract

The surface and subsurface drainage systems developed in the Moldova River watershed in the County of Suceava have been designed to be used on drainage sectors, and, in order to enhance excessive water capture and discharge, several complementary works have been planned from time to time, namely: land levelling, shaping, deep loosening etc. Due to the extension of the private ownership of the land with drainage systems starting with 1991 and due to the carrying out of soil works on individual plots of land, the land was shaped in the bedding with ridges and furrows, of variable widths, level differences and transverse slopes. Land shaping that does not match the routing of the plastic drain lines and of the drainage network allows the water to stagnate in the furrows and extend the excessive humidity period. The use of the developed areas on drainage sectors facilitates the levelling of small depressions and supports the even removal of excessive water. As maintenance works have not been performed from time to time, this has gradually led to the erosion of slopes and to the slitting of the canal network and of the discharge holes in the drains, which caused excessive humidity to reoccur.

Key words*: humidity excess, surface and subsurface drainage systems, individual land parcels, land shaping*

INTRODUCTION

The reasonable use, protection, improvement and preservation of soil have been a constant preoccupation lately, as the success of development depends on it. Soil resources, together with the other environmental components, are directly or indirectly involved in all the aspects of the development process, and play an important role in the economic power of any country, at all levels of development (Rauta C. et al., 1998).

Soil quality is more or less affected by one or more conditions, such as drought, periodic excess water, soil erosion, landslides etc (Hornbuckle J.W. et al., 2007; Burja C. et al., 2013).

These conditions are determined either by natural factors or by agricultural and industrial activities that might have a negative synergic action (Lukianas A. et al., 2006).

Excessive humidity is one of the major soil fertility limiting factors, as it is able to diminish considerably and sometimes evencompletely destroy the productive capacity of the land.

After the development of surface and subsurface drainage systems it is very important to use and maintain them properly, in order to preserve the physical, chemical and biological characteristics of the soil (Radu O. 2016).

MATERIALS AND METHODS

Excessive natural rain and/or underground water, together with the constant flooding of the river system in the Moldova River watershed area, have materialized under various formsand intensities, both on horizontal and on sloping land.

The natural conditions of the Baia piedmont plain favor the occurrence and maintenance of excessive humidity both on the surface and underground. The flood plain of Moldova River and the strip-shaped 1.5 km wideterraces, which are almost parallel to the Moldova riverbed, running from NW to SE, with mild 1-5% slopes, with flat areas and many small depressions, allow the water to stagnate.

The wet climate specific to the Moldova River watershed area, the heavy rainfalls of 1-5 consecutive days and the low evaporation and perspiration rates are the main cause of excessive humidity in hardly permeable soils (Nitu T. et al., 1985).

In order to remove the excessive water in the flood plain and terraces of Moldova River in the County of Suceava, three surface and subsurface drainage systems (Rotopanesti-Radaseni-Fantana Mare, Dragoiesti-Berchisesti, Bogdanesti-Baia) and the Baisesti-Dumbrava irrigation and drainage system were developed between 1978 and 1980, which covered 8761 ha of drained land, of which 3059 ha comprised underground drainage works (Figure 1).

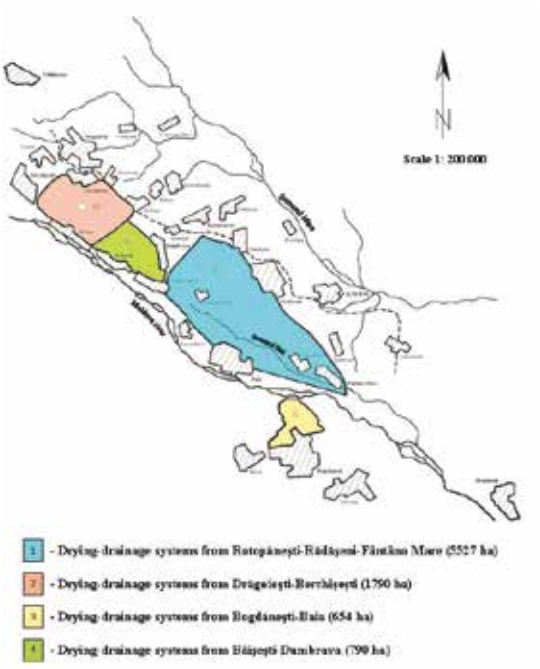


Figure 1. Surface and subsurface drainage systems of the Moldova River flood plain in the County of Suceava

The network of drainage ditches with a total length of 126.85 km comprises main collecting drains, secondary collecting drains, sector collecting drains and belt canals.

In order to discharge the excessive water from the soil, an underground drainage network was developed, depending on the nature and intensity of excessive humidity, made up of plastic drains and collecting drains, with a total length of 1575.12 km.

In order to determine the current state of the surface and subsurface drainage systems, field observations and topographic measurements were carried out and transverse profiles were developed.

RESULTS AND DISCUSSIONS

In principle, effective excessive water discharge from land with surface and subsurface drainage systems is provided by a well maintained drainage network and by adequate land use.

Starting with 1991, the land with surface and subsurface drainage systems has gradually become private property and it has been worked on individual plots, which has led to land shaping in the bedding with ridges and furrows, of variable widths, level differences and transverse slopes, depending on widths of the plots, on the manner in which they were used and on the agricultural machinery used (Radu O. et al., 2008).

The transverse profile analysis (Figure 2) reveals land shaping in the bedding with ridges and furrows with values of the furrow-ridge level differences ranging between 0.211 m and 0.760 m and transverse slopes of 4.3% to 25.3%, due to the individual soil works on the various plots of land.

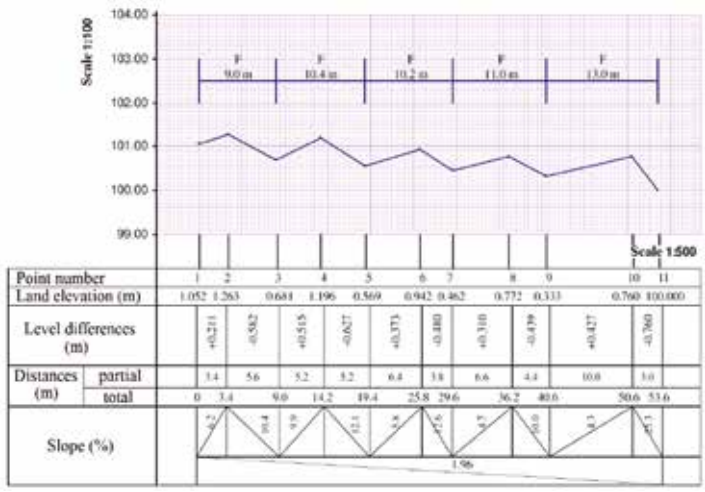


Figure 2. Land shaping by individual soil works

Land shaping due to individual soil works on various plots of land, which does not match the routing of the plastic drain lines and of the drainage network, allows the water to stagnate in the furrows and extend the excessive humidity period. Thus, this land has gradually turned from arable land into grass land (Figure 3).

Figure 3. Land shaping and stagnating water in the furrows

Whereas before 2014-2015, in the Rotopanesti-Radaseni-Fantana Mare surface and subsurface drainage system, the land was used as individual plots (Figure 4), now, due to the lack of workforce caused by an ageing population and due to the occurrence of private entrepreneurs, the land has been taken over and used uniformly on large compact areas or on drainage sectors.

On the left side of the Dumbrava main collecting drain, where the land has been used compactly for several years, the furrows and ridges were generally abolished, which allows for the excessive water from heavy rainfall of 1-5 consecutive days and from snow melting tobe easily discharged (Figure 5).

Figure 4. Use of agricultural land on individual plots

Figure 5. Use of land on drainage sectors

On the right side of the Dumbrava main collecting drain, where the land is used both on individual plots and on larger areas, we found that water stagnates and excessive humidity lingers in furrows and small depressions. Water stagnation on this side of the drain is due to the fact that the land has been used on larger areas for a little while, the areas are smaller and alternate with individual plots, which hinder the performance of soil works in optimal conditions, as the furrows and small depressions have not been completely removed yet (Figure 6).

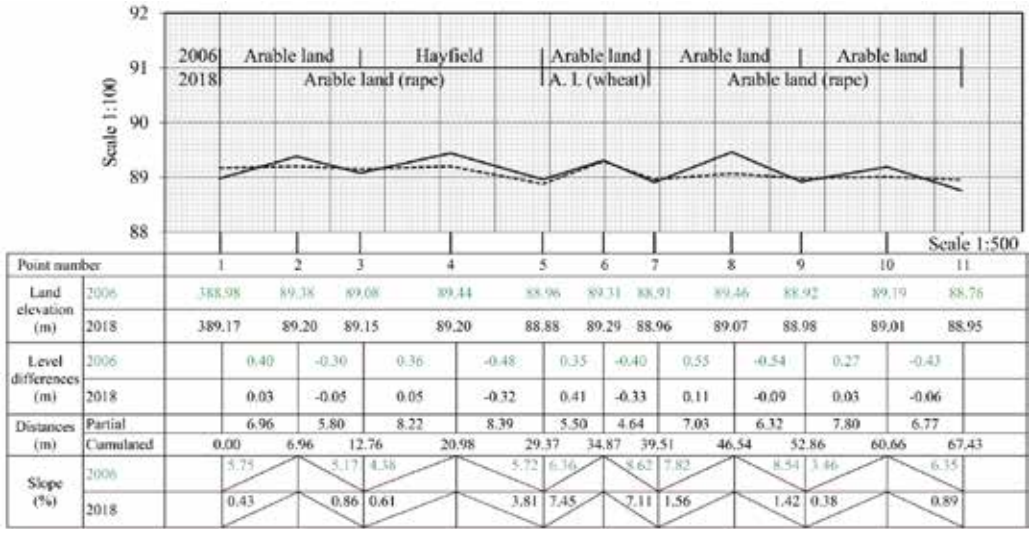
In the cross profile (Figure 7) it is found that in 2006 the surfaces resulted after modeling processes have slopes between 3.5% and 8.6%. The level differences between the highest and lowest altitudes of sloped surfaces were range between 0.27 m and 0.55 m. In 2018, the amplitude values of level differences ranged between 0.33 m and 0.41 m. The slope of the surfaces varied between 7.1% and 7.5% for the small individually parcel. In large plots, values of level differences were only by 0.03 m and 0.32 m and transverse slopes ranging from 0.4% to 3.8%.

The analysis of the section of the Dumbrava main collecting drain (Figure 5), which serviced mainly arable pieces of land for about 40 years, reveals its natural slitting. Drain slitting is due to the non-performance on time of maintenance works, to the fact that the grass was not cut and the wooden vegetation was not removed, which increases roughness, reduces the water flowing rate and supports the deposition of alluvial sediments in the drain section.

At the time of our field observations, the Dumbrava drain section was cleared of the wooden vegetation, but the surface and subsurface drainage systems, which include a network of drains of various sizes, were generally invaded by well-developed wooden vegetation (Figure 8). The discharge holes in the surface plastic drains were less clogged that the collecting drains located deep into the

ground. The discharge holes in the plastic drains of inferior rank and in the drains located on grass land were more clogged than the others (Figure 9).

Figure 6. Land use on larger areas and individual plots



Point number		1	2	3	4	5	6	7	8	9	10	11
Land elevation (m)	2006	388.98	89.38	89.08	89.44	88.96	89.31	88.91	89.46	88.92	89.19	88.76
	2018	389.17	89.20	89.15	89.20	88.88	89.29	88.96	89.07	88.98	89.01	88.95
Level differences (m)	2006		0.40	-0.30	0.36	-0.48	0.35	-0.40	0.55	-0.54	0.27	-0.43
	2018		0.03	-0.05	0.05	-0.32	0.41	-0.33	0.11	-0.09	0.03	-0.06
Distances (m)	Partial		6.96	5.80	8.22	8.39	5.50	4.64	7.03	6.32	7.80	6.77
	Cumulated	0.00	6.96	12.76	20.98	29.37	34.87	39.51	46.54	52.86	60.66	67.43
Slope (%)	2006		5.75	5.17	4.38	5.72	6.36	8.62	7.82	8.54	3.46	6.35
	2018		0.43	0.86	0.61	3.81	7.45	7.11	1.56	1.42	0.38	0.89

Figure 7. Land shaping in 2006 and 2018

Figure 8. Shrub vegetation in the canals

Figure 9. Discharge holes in clogged plastic drains

CONCLUSIONS

Individual soil works on plots of land have led to land shaping in the bedding with ridges and furrows, which does not match the routing of the plastic drain lines and of the drainage network, allow the water to stagnate in the furrows and extend the excessive humidity period, and implicitly unevenly discharge the excessive water in the land with draining systems.

Land use on drainage sectors has allowed the abolishment of furrows, ridges and small depressions and hence the discharge of excessive water.

As maintenance works have not been performed from time to time, this has gradually led to the erosion of slopes and to the slitting of the canal network and of the discharge holes in the drains, which caused excessive humidity to reoccur.

The discharge holes in the plastic drains of inferior rank and in the drains located on grass land were more clogged than the others.

The discharge holes in the collecting drains, which are deeper into the ground than plastic drains, were clogged both in the grass land and in the arable land.

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ASPECTS OF DIGIZATION IN AGRICULTURAL LOGISTICS IN GERMANY

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Abstract

Digitization is one way to fulfil the demands on agricultural logistics. The growth in farm size and new branches mean that logistics is becoming ever more complex. A simple takeover of systems from the general logistics is not possible because of the special conditions of agriculture. First offers for digital logistics in agriculture are on the market. These are usually only for small areas and not complete chains. Often there are still difficulties with data availability and interfaces. There are first solutions for digitization in logistics across several levels of trade. These work if the partners are well organized and agree. If this confidence does not exist, digital collaboration is also difficult. A big problem that still has to be solved is data ownership and privacy.

Key words: *Logistic, Digitalization, Data Management, Data Privacy Protection*

INTRODUCTION

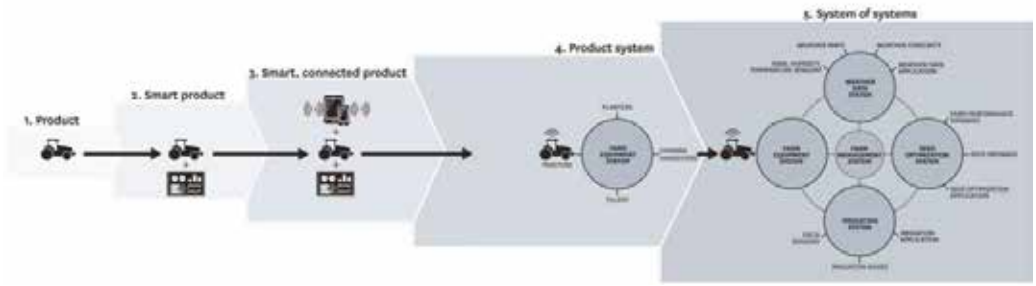
Logistics plays a crucial role in agriculture. Between field, stable and trade many different goods have to be transported. In recent years, the importance of logistics in agriculture in Germany has increased. The quantities and distances per farm have increased. This has different causes: the growth of the farms, the reduction of the locations of trade and the biogas boom (Bernhardt, 2002; Götz, 2015).

At the same time, the demands on logistics have increased. As the consumer in Germany is very critical about food safety all goods flows from the field or stable to trade must be traceable. Logistics is no longer just about the transport and handling of the goods but also on the data belonging to the transported goods (Seufert, 2006; Folinas, 2015).

The aim of the farms is also to optimize the processes in agricultural logistics. Especially in large logistics chains e.g. the transport of 500 ha of silage maize for a biogas plant cost reduction plays a decisive role. The resource manpower must also be used optimally as it is important for logistics processes and there are always less well-trained drivers available (Heizinger, 2011; Sonnen 2007).

All of this means that digitization in agricultural logistics is increasingly being used to solve the problems that arise. The effects can be subdivided into several areas. These are:

- the comparison with industrial logistics;
- the hardware and software used;
- the impact on marketing.



Figures 1. Data management in agriculture (Proter and Heppelmann, 2014)

Comparison of general logistics and agricultural logistics

Digitization is currently playing a crucial role in all sectors of the economy. In Germany, all these efforts are summarized under the term "Industry 4.0" which describes the complete digital networking of all production processes. It could be assumed that agriculture can directly take over the developments in the field of general logistics but it shows that agricultural logistics has considerable structural differences compared to general logistics. A key difference in agricultural logistics is that here the sources and sinks in logistics move during the process. In general logistics the starting point and target are always specified and therefore long term planning is possible. In agriculture the start point and target can move in space during the logistics process. The combine harvester, for example, moves on the field during harvesting. The precise location on the field on which it has to overload the grain onto the transport vehicle is difficult to determine previously because factors such as yield, driving patterns on the field, soil properties, the driver's operation etc. are difficult to simulate. This considerably complicates the preliminary planning as both vehicles continue to move during the reloading (Sonnen, 2006; Heizinger, 2014; Rusch, 2012; Wörz, 2017; Lamsal, 2016).

The agricultural logistics are also different in that the transport is generally carried out with tractors. Transport from the field to the road happens with the same technology. The transport vehicles must therefore be able to drive both in the field and on the public road. Therefore, it is difficult to use technology from the general logistics, optimized for the road, in agriculture. This structure of agricultural transport technology in Germany has grown historically and can only be changed with a complete change of organization and technology (Götz, 2014; Götz, 2011).

Hardware in agricultural logistics

Agricultural logistics has been marked by digitization in recent years. A good example of this is the use of navigation systems in agriculture (Kluge, 2015). For large logistics chains, such as the harvest of silo maize it is important for the transport vehicles that they are on time with the forage harvester. For this purpose, navigation systems have been used for several years. These differ from the usual systems for street navigation. For agriculture, dirt roads, bridge loads and other agricultural aspects must be marked on the maps. In addition, one-way street rules must be able to be deposited so that no two transport vehicles meet on a dirt road. Agricultural navigation systems must also be able to plan very dynamically on the basis of the harvest data since crop quantity, ground conditions or machine condition can change the distances. The variety of influencing factors make the development of special systems for agriculture difficult, which is why paper cards are often still to be found as a safety system in practice (Steckel, 2015).

Another digital system which promises advantages in logistics is yield recording in the combine harvester or forage harvester. However, both systems show that they record the data too late for direct logistics. There is no time left to plan the logistics accordingly, as the transport vehicles almost have to be at the harvester when they are collected. With the forage harvester, the yield data are sometimes used to divide the costs of transport from different farmers. More interesting for logistics is currently the development of drones or satellites for yield estimation. This data could be available early and precisely enough to even reschedule the logistics in the technology and organization used (Pauli, 2012).

Overloading makes great demands on the drivers of the harvesting vehicle or the transport vehicle, especially at night or after many hours of work. Here digitization also offers opportunities to relieve the driver. From several manufacturers systems are offered in which the track signal of the harvester is charged and transmitted by radio to the transport vehicle. The steering of the transport vehicle is thereby taken over by the harvesting vehicle and the vehicle is always kept at the same distance and speed. This is particularly advantageous for sudden evasive maneuvers of the harvesting vehicle because this information engages directly in the steering of

the transport vehicle and thus can prevent accidents caused by the reaction delay of the driver of the transport vehicle.

During the filling process camera systems detect the filling of the transport vehicle and control the forage harvester to optimally load the transport vehicle.

Another important aspect for the digitization of large logistics chains in one area is that all vehicles are clearly identified. For newer harvesters, this can be done via the telematics system.

Many transport vehicles and older tractors do not have this. Here is now the possibility to mark these vehicles with Bluetooth chips.

This chip can be clearly recognized by the other vehicles and thus each vehicle of the chain can be identified. In order to be able to document all data of the transport of a commodity these must be collected digitally.

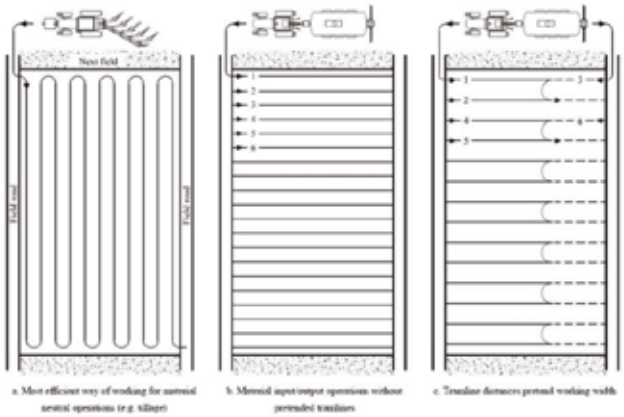
Two systems are currently used for this purpose. In one method all data of the goods are stored separately from the individual machines in a central cloud.

In the other system, the data remain with the goods and are transferred from the harvester to the transport vehicle and then goods and data are transported together to the warehouse (Rusch, 2012).

In the first system, the data is stored very quickly in the cloud, but you have to put data and goods back together properly. In the second method, the data always remain with the goods, but several transmission processes are necessary for this.

Software in agricultural logistics

The spread of digitization in agricultural logistics is well recognized by the use of farm management systems. Farm management systems document, process and analyses all information on location, process flow, technology, employees, costs, etc. of the farm. Farm management systems therefore provide ideal conditions for planning agricultural logistics (Pauli, 2015; Pavlou, 2016). The problem that always shows in practice is that although the appropriate tools for planning are available usually the planning goals cannot be formulated clearly. As an example, the infield logistics can serve here. The pattern of driving on a field e.g. when sowing, fertilizing or harvesting has a significant impact on the associated costs, working hours and effects on the soil structure (Shearer, 2015; Zhou, 2015; Sabelhaus, 2015). It is therefore close to the driving of the fields before a simulation to plan. For this purpose, products are also offered by various manufacturers. However, observations in practice show that these products are not as accepted by the farmers as the advertised savings potential suggests. An analysis of the objectives of the products shows that these are usually optimized for the longest route and the least turning operations. But these are not always the goals of the farmer. Here, the transport capacity of sugar beet harvester or slurry tanker or the location of possible overload points at the edge of the field may determine the route on the field (Mederle, 2015).



Figures 2. Different infield-strategies depending on various operations (Mederle, 2017)

To use digital tools to optimize the farm, the real goal of the individual operation must be precisely determined. This is often difficult.
The technical data for farm management systems are usually supplied from telematics systems of the machines. Originally designed purely as a display for IsoBus data, these systems today regulate the collection, processing, display, exchange and documentation of all machine data. Interfaces can also be used to exchange data from different machines. Telemetry systems are thus the basis of many products the previous chapters were presented. But even here, agricultural practice shows that the general use and the economic benefits usually fail due to trifles. In order to transfer the system from the demonstration phase to the general usage, it has to be stable. This is difficult because German agriculture, use different radio network, have different machines with different ages in one logistic chain or different manufacturers and data standards communicate with each other. An example is the radio data transmission. There is a lot of investment to be able to transfer even more data, but especially in rural areas, the network coverage is sometimes bad. Radio network coverage in rural areas is not optimal. Depending on the network provider, it ranges from 89% to 98% in the G4 network (LTS). The average upload rates in rural areas are between 8.41 and 19.53 Mbps, for comparison in the city between 10.65 and 29.02 Mbps on average (Mandau, 2017). Even low power wide area networks such as LoRa or Sigfox do not achieve sufficient coverage in rural areas. Navigation systems for large crop chains do not work if parts of the chain are not currently visible because they cannot transmit their position (Nordemann, 2015; Schattenberg, 2013). Another difficulty is partly the capacity of the data network in the machine. Originally the IsoBus was designed to control the machine. Today, all machine data should also be sent via this data network. To make this possible, the data is compressed. But this also loses information that would be needed in farm management systems. So it would be a new own data network for this data necessary (Weltzien, 2016). Especially on small farms in southern Germany, another problem arises for the digitization of agricultural logistics. Here the machines are used for a long time. Many of these machines do not yet have the required interfaces for data exchange.

Impact of digitization on production chain partners

Logistics also plays a decisive role in trading. Here too the transfer of digital data via the individual trading stages is considered an advantage. When implementing digitization in logistics, the individual trading chains have developed very differently.
In sugar beet production, the individual fields are recorded digitally and all important information, such as grower, rowing order or storage location documented. On the basis of this data, the planning of the shared harvesters is planned. The individual harvester then reports their operating data via GSM. These data can then be used to further fine-plan and to plan the transport. When loading the transport vehicles then all the necessary data of the sugar beets are digitally transmitted and the quality data then reported back to the farmer. All harvest, transport and billing data is recorded in a central database and can be queried online by all parties involved in the process. This system is possible because in southern Germany there is only one central processor of sugar beets with nine sugar factories and one central farming community with 18 000 farmers and 137 000 ha of sugar beet acreage, which are also economically linked. Because everything is in one hand, a functioning digital agricultural logistics system for sugar beet could be established for a long time. Difficulties in the organization can thus be easily clarified. However, the system still has technical problems as discussed in the chapter Software (Gebhard, 2016).
In the digitization of grain logistics, things look quite different. Here, neither the farmers nor the traders have central organizations that can develop a common structure. Here there are only first approaches for a digital data collection in logistics at farmer and trade. These systems are not compatible with each other. When marketing, therefore, the digital data are often given by the farmer on paper to the warehouse and re-entered by this into their digital system.

Both sides have not yet found an organizational structure with which they can digitally share logistics data.

CONCLUSIONS

Overall, the digitization of agricultural logistics in Germany is desired and also necessary. Both the condition in growing farms and the trading requirements point in this direction. The first interesting products can be found on the market. It turns out, however, that there is often still a lack of stability of the systems used. Here the agriculture which works on the area is exposed to special conditions.

An important issue that is not yet sufficiently clarified is the privacy and ownership of the data collected. Many partners have their own data as well as great interest in the data of the other partners. For fear of being cheated or exploited by others, most of them withhold their data. There is currently no structure regulating the data exchange. A shared data usage would bring economic benefits to all partners, but how these benefits have to be distributed to all just needs to be clarified.

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THE EFFECT OF DEFORESTATION IN THE SIHASTRIA WATERSHED, SUCEAVA COUNTY, ON THE TECHNICAL EFFICIENCY OF THE SMALL HYDROELECTRIC POWER PLANT

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Abstract

This paper aims to identify deforested surfaces in the studied area, fact that determines the intensification of soil erosion process and furthermore it increases the alluvial effluent witch disrupts the functioning of the hydroelectric power plant in the projected parameters. In 1990 the area covered with forest vegetation in the Sihastria watershed was about 147 ha, but due to the clear-cut on the areas that were returned to the right owners, the wooded area was reduced to 100 ha, from which, as a result of excessive cuts on 39 ha the density of the trees is very low. The Sihastria small hydroelectric power plant is located at the confluence of the Sihastria stream with Negrisoara River (25.525309^0 eastern longitude and 47.1917847^0 northern latitude). The hydropower plant constructive elements consist of: intake, desilting tank, fore bay tank, penstock pipe, and power house and tailrace channel. In order to determine the causes that led to the clogging of hydrotechnical constructions, trips were carried out in the analyzed watershed, during the vegetation seasons of the last three years (2015-2017).

Key words*: deforestation, soil erosion, alluvial, unclogging, electricity.*

INTRODUCTION

In many parts of the world the management of soil and water resources represents an important issue. The pressures exerted by the anthropic factor on the environment are reflected in its quality, but also in the quality of life in general (Bucur, 2016; Zelenakova, 2018; Pierre R, 2018).

In Romania, the surface covered with woody vegetation decreased considerably in the 20th century. If in the year of 1880 the total forest surface of the country was approximately 40%, in present the forestry fund represents only 26.39% of the total country surface (Romsilva, 2016).

In Romania, the amount of water lost due to water erosion is 2.86 t/ha, and in Suceava County this quantity is approximately 2.59 t/ha. (EUROSTAT).

Among renewable energy sources, hydropower and the potential for its exploitation by constructing hydropower plants have a very important place (Milena, 2013). The analyzed river reservoir is located in the north-western part of the Bistrita River, reservoir belonging to the Brosteni Municipality from Suceava County. From a physico-geographical point of view, the hydrographical reservoir belongs to the Bistricioarei Mountains from the Moldavian-Transylvanian Carpathian sub-region, situated between Calimanilor Massif, Binaru Massif and the Grintisul Mic Massif. Regarding geology, the analyzed reservoir is composed of crystalline dolomite and epimetamorphic shale of the sedimentogenic volcanogenic series.

In the studied area, the dominant soil classes are cambisols, spodosols and cernisoils. The identified soil types are: districambosoils - predominant throughout the entire surface of the reservoir; prepodsoils - present on the valley of the Sihastria stream, and redzinas - identified in the upper part of the hydrographic reservoir.

MATERIALS AND METHODS

In order to determine the causes that led to the clogging of the hydro technical constructions, observations were made regarding the condition of wood vegetation on the slopes and on the behavior in exploitation of the constructive elements of the hydrotechnical arrangement under study.

The observations were carried out during the vegetation seasons of the last three years (2015-2017).

For the quantitative estimation of erosion, it has been used the universal soil erosion formula, adapted for Romania by Motoc M., after Wischmeyer, 1960.

$E=K\times S\times C\times C_s\times L^{0.3}\times(1.36+0.97\times i+0.138\cdot i^2)$, $(t\cdot ha^{-1}\cdot y^{-1})$

where:
K - the rainfall erosivity index
S - soil erodibility coefficient;
C - the plant cover factor;
C_s - specific erosion control practices coefficient;
L - length of slopes;
i - slope land.

In order to determine the morphometric elements of the hydrographic reservoir, were used maps made with the help of Geographic International Systems (GIS), drawn at 1:25.000 scale.

RESULTS AND DISCUSSIONS

The Sihastria stream, one of the main tributaries of the Negrisoara River from the left side, springs from the Calimanel Massif at a height of 1565 m and it has a total length of 8.5 km.
Morphometric indicators of Sihastria hydrographic reservoir are:

- catchment length C = 33.4 km,
- watershed surface F = 22.26 km^2;
- length of watershed L = 14 km;
- average width of watershed B = 1.6 km;
- sinuosity coefficient S_t = 1.56;
- density of the hydrographical network D = 0.96 km^{-1}.

The amount of rainfall recorded in the period of 2009-2013 it was about 819.24 mm period at the nearest meteorological station and the average temperatures recorded in the same period of time were 5.76°C (Table 1).

Table 1. Monthly average of rainfall (mm) and air temperatures (°C) recorded at Poiana Stampei in period 2009-2013 (National Meteorological Administration)

Month	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*Total/Average*
Rainfall	36.37	35.32	44.5	69.74	126.68	143.75	114.96	72.68	59.28	36.16	34.9	44.9	819.24
Temp	-5.69	-5.08	-1.13	6.27	11.8	15.44	16.89	16.71	11.29	5.16	1.78	-4.15	5.76

The surface of the hydrographic reservoir is 2223 ha. In 1990 the surface of the reservoir was covered with woody vegetation in proportion of 66.39% (1,476 ha).
At present, the situation of forest land has changed considerably due to uncontrolled deforestation which happened with the issuing of law 18 of 19.02.1991, relating to the reconstitution of the property right.
The largest quantities of wood have been deforested from 2005 to 2012. In 2017 the situation of forests is presented as follows:

- 451 ha have been clear-cut deforested;
- On 442 ha have been executed deforestations (approximately 60% of the area);
- 583 ha suffered a limited intervention of the anthropic factor.

For determination of soil erosion three maps were made to highlight the slopes, depth of valleys and length of the slopes.
After analysis of the slopes map (Figure 1) was found that most significant slopes vary from 10^o to 30^o, which represents approximately 68% of the surface of the reservoir.

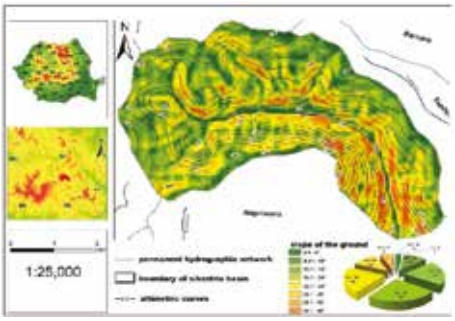

Figure 1. The slopes map

To emphasize torrential activity was developed a map to highlight the depth of the valleys (Figure 2), the highest values being recorded in the southern part of the reservoir and at the confluence of Sihastria stream with Negrisoara stream, values between 400-472 m/km^2.

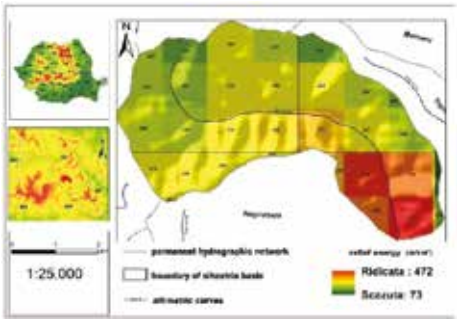

Figure 2. Depth of the valleys map

The length of the slopes varies significantly, from the lengths of 100 m to 800 m, the most significant slopes ranging from 200-300 m (Figure 3).

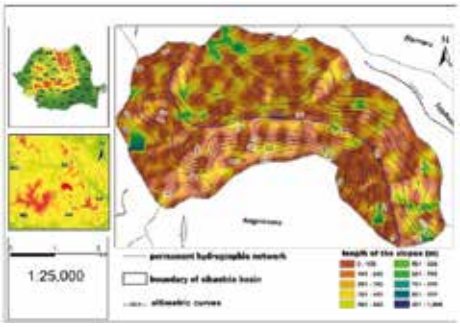

Figure 3. Length of the slopes map

After analyzing the topographic maps of geodeclivity and the average length of the slopes, quantitative estimation of soil erosion was possible, based on the universal calculation formula developed and adapted for Romania by Motoc M., after Wischmayer.

Table 2. Quantitative Estimation of Soil Erosion in the Sihastria river reservoir

Slope land I (%)	Eroded soil ($t \cdot ha^{-1} \cdot year^{-1}$) on:		
	Well-covered meadows	Moderately-covered meadows	Forest on degraded lands
< 10	0.21	1.06	0.95
10-15	0.541	2.137	1.814
15-20	0.799	5.049	4.246
20-25	1.367	8.203	6.988
25-30	2.125	12.863	10.962
> 30	3.093	18.868	16.084
18.5*	**1.06***	**6.16***	**5.24***

* - weighted average values

These data confirm that on land areas with moderately-covered meadows, but also in places where deforestation has led to soil degradation, no matter if some areas remained wooded, the average amount of soil lost was 8.203 t/ha/year on meadows and 6.988 t/ha/year on degraded lands with slope ≥ 20%, covered with woody vegetation.

The primary functionality of SHPs is the transformation of the river's water energy into electrical energy (Luka, 2015; Lehner, 2005). SPH Sihastria produces an average of 2.77 MWh per day, and the months with the highest amount of energy produced are May, June and July. The amount of electricity produced in 2017 is presented in table 3.

Table 3. Amount of energy produced at SHP Sihastria in 2017

Month	MWh	MWh/day	MWh/month
January	0.1	2.4	74.4
February	0.1	2.4	60
March	0.09	2.37	73.5
April	0.1	2.48	74.4
May	0.19	4.61	143.1
June	0.16	4.02	120.8
July	0.12	3	93.1
August	0.1	2.4	74.4
September	0.1	2.4	72
October	0.1	2.4	74.4
November	0.1	2.4	60
December	0.1	2.37	73.5
Average	**0.11**	**2.77**	**82.8**

Observations have been made during field trips regarding the state of woody vegetation and the causes of clogging of the construction elements.

Figure 4. Clogged forebay tank

Further analysis of field observations highlighted the consequences of clogging on the electricity production process, as follows:

- The forebay tank (Figure 4) must be unclogged at least once a year, the cost of this unclogging process is between 4000 - 6000 euros, during which the power plant is

decommissioned for up to 7 days, which leads to an average loss of 19.93 MWh;

- Water capture zone (Figures 5 and 6) located on the stream bed is clogged about 3 times a year, the cost of its unclogging ranging from 250 - 500 euros depending on the mass of clogging, the unclogging process takes between 8-12 hours and leads to a loss of 3.3 MWh per year.

Figure 5. Clogged intake

Figure 6. Clogged intake

- The absence of anti-erosion measures on the slopes increases the erosion process, large amounts of plant residue reaching the stream bed.
- Because of the large amount of solid suspensions in the water used to produce electricity, as well as repeated unclogging made in the compensating reservoir, respectively capture zone, the degree of wear of the hydrotechnical construction and technical equipment (lines, turbines) has increased significantly.

CONCLUSIONS

The forested area within the reservoir has decreased considerable, at present about 20% of it is totally cleared up, which determines the manifestation of soil erosion on the slopes.
The main cause of clogging is uncontrolled deforestation that favors increased soil erosion.
The forebay tank (Figure 3) must be unclogged at least once a year; the cost of this unclogging process is about 5,000 euros. For 7 days the power plant is switched off, with an energy loss of about 20 MWh.

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OAK SPECIES – PROVIDING RENEWABLE AND SUSTAINABLE RAW MATERIALS, ENRICHING THE ECOSYSTEMS SERVICES AND FULFILLING THE SOCIAL DEMANDS. CASE-STUDY – WESTERN ROMANIA

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Abstract

Oak wood has been highly praised since the Middle Ages for its strength and durability. This is one of the densest naturally occurring materials; it has good folding qualities despite its natural durability and has a high tannin content which makes it resistant to insects and pests. It is durable, impregnates easily, resists moisture absorption and thanks to its aesthetics and resistance, it is recommended as an excellent feedstock for the furniture industry and beyond, it is often used to manufacture floors, stairs, exterior and interior joinery, interior architectural elements, natural or stained plywood, boards, tiles, ornaments turners, profiles, barrels and it should be continuously promoted because it is a renewable and sustainable raw material. The oak stands have a significant position in the Romanian forests (18% of the country's total forest area) and in the European ones; they are perhaps more appreciated now than in the past, not only for the particular structural qualities of the wood, but also because they contribute to the biological wealth of the forest ecosystems and for how they participate to the conservation of biodiversity creating an environment that helps to fulfil the social demands. Due to the present-day high market demand, the recent wood industry development and the multiple available transport options, oak wood is imported and exported at a high rate. It would be desirable to promote only those oak raw materials which originate from certified forest areas which are sustainably managed, where forest ecosystem services as well as certified wood chains of custody are promoted. That is why we need to identify, study and monitor the areas which are suitable for obtaining valuable forest stands with Quercus robur (pedunculate oak), Quercus petraea (sessile oak) or Quercus frainetto (Italian oak), and to ensure their growth by applying a sustainable forest management.

Key words: *oak species, sustainable forest management, renewable raw material, ecosystem services.*

INTRODUCTION

From ancient times, wood has been one of the most used raw materials, probably because it is one of the first natural resources that humans learned to use.

Wood and wood products are recommended because they are durable, versatile and strong; it can be transformed into all kinds of shapes and sizes, being a renewable and environmentally friendly product.

It is important to consider that the forests regulate the quality of air and water, contribute to soil formation, provide protection from erosion and mitigate climate change through carbon sequestration (wood carries the lowest carbon footprint of any comparable building material).

According to FAO 2006, around 4,000 million ha, the equivalent of around 30% of the earth's land area, is covered by forests. About 3,000 million m^3 are harvested worldwide annually, of which around 60% are used as industrial round wood and 40% as fuel wood. According to the study "Use of renewable raw materials with special emphasis on chemical industry", performed by the European Topic Centre on Sustainable Consumption and Production, it is stated that "wood is likely to be the oldest and quantitatively the biggest raw material sector from renewable sources" (Jering and Günther, 2010).

The most used wood species all over the world along history are oaks. Compared to wood provided by other tree species, oak species wood is generally light colored with a prominent grain and has a high resistance to fungal attacks. It is one of the densest naturally occurring materials and it has been praised for its strength and durability since the Middle Ages. Oak barrels were the first choice for storing and transport of liquids like water and

alcohol. The majority of the wooden boats, used for transport, were also made of oak wood, "at least 50-60% of all wooden ships were made of oak" (Agnoletti and Anderson, 2002). It was used as a building material since the beginning of human civilization, "being second only to stone in terms of its rich and storied history in the world of construction" (Agnoletti and Anderson, 2002). This exceptionally versatile material was commonly used to build shelters and houses ("the structural beams and much of the woodwork in Europe's finest and oldest remaining churches and castles are made from oak"), "throughout the whole of the medieval period, oak dominated the field of construction on the basis of both its durability and its general availability. While much of this building stock has been lost, a significant number survive today, some five hundred years or so after they were built" (Ross et al., 2007).

In the 1960s, due to the trends in the furniture market, the demand for pedunculate oak and sessile oak wood began to increase, as this wood has special qualities for as aesthetic veneer (Badea et. al., 1960). In their paper "Contribution to the Study of oak trees stands, suitable for the production of aesthetic veneers," they mention that the studies carried out in Romania showed that there are a significant number of trees from which such material could be obtained, but expressed their concern that "increased demand could be a futile tendency that would speed up the harvesting of oak trees stands".

Taking a look at the recent period we can observe that nowadays oak wood is very extensively used in the furniture and home decor industry, as it is also presented in the FAO and Forest and Timber Section of the UNECE statistics (www.unece.org).

In order to enhance the carbon sequestration it is important to promote wood as a sustainable and renewable material not only in the construction industry but also in interior design. In the paper "Environmentally sustainable interior design: A snapshot of current supply of and demand for green, sustainable or Fair Trade products for interior design practice" (Hayles, 2015), it is stated that "by integrating environmentally sustainable materials into building projects, it is possible to significantly reduce environmental impacts through lower energy consumption, lower natural resource depletion and pollution, and lower toxicity for both the occupants and the entire ecosystem. These both minimize the negative impacts on the environment and occupants while maximizing positive impacts over the lifecycle of a building." Many other authors support this view (Araji and Shakour, 2013; Kang and Guerin, 2009).

The concept of ecosystem services, meaning the benefits society obtains from ecosystems, has gained widespread acceptance among scientists, managers and politicians since its use in the Millenium Ecosystem Assessment (2005). Trees, woods and forests provide direct products (timber, fuel, food, and game), direct cultural services (recreation, aesthetic, and landscape, historic and cultural values) and indirect regulating services (air and water quality, mitigation of climate change, soil protection). All these products and services contribute to human well-being (Cranford and Mourato, 2011; Cuperus et al., 2001; Engel et al., 2008; FAO, 2010).

The European Commission stated that "today, forests cover nearly 40% of the European surface and are home to much of the continent's biodiversity. In addition to the supply of wood, to which most forested European land is dedicated, forests provide a multitude of benefits in terms of climate regulation, human health, recreation, refuges, fresh water supply and many others" (http://forest.jrc.ec.europa.eu).

"Forests play a crucial role in providing multiple benefits for citizens. They deliver forest products and many other ecosystem services (recreation, clean air and water, biodiversity, scenic and cultural values). Moreover, forests contribute to job creation and economic growth" (EUSTAFOR, 2018). Forests, especially oak ones, are a gateway for hunters and fishermen. But they are also a treasure for outdoor enthusiasts who are searching for adventures and recreation and want to improve their physical and psychological well-being.

The study "Oak trees and woodlands providing ecosystem services in Southern Spain" concludes that the "urban populations are increasing their demand for cultural services

coming from woodlands, mainly for recreation, ecotourism and for their aesthetic and spiritual values" (Marañón et. al., 2012). The abandonment of rural areas leads to a loss of cultural local knowledge but this has changed in the last decades.

"When forests are sustainably managed, their biodiversity, productivity, regeneration capacity and vitality are maintained while leaving all interconnected ecosystems intact and fulfilling relevant ecological, economic and social functions" (Thomsen, 2016).

Forests which are not well managed are often unhealthy and unproductive because of overcrowding, disease, insects, and competition for light, water and nutrients. To maintain or improve the health and productivity of a forest, foresters use a number of management techniques that include harvesting (www.ncforestry.org). Harvesting and thinning operations should be encouraged because this type of forest management mimics natural dynamics and promotes tree species that would otherwise not have a chance to thrive (like oak ones, which tend to be overwhelmed by other species when found in the same composition).

In mixed closed canopy forests, oak regeneration is often poor below the canopy (Gotmark, 2007) and the mixed species like hornbeam, acacia or lime, that normally should have a helpful role when found in the same composition with oaks, in fact they tend to replace oak seedling in absolute natural conditions the oak manages to maintain and win the competition with mixed species and, foremost because it has an extraordinary longevity (Pascovschi, 1967).

In order to provide the most adequate measures for a sustainable management of oak forests, we have started by studying the site and the forest types in the area where oak logs were harvested, trying to identify the main ecosystem driven factors which have contributed to the high quality of wood, meanwhile providing the ecosystem services. The obtained results would contribute to making further adequate forest management decisions which could influence the growth and the timber quality.

The present research main goal is to determine the site type characteristics which will favor oak stands to better grow and which will produce valuable wood as renewable and environmentally friendly material by sustainnable forest management at the end of a production cycle.

MATERIALS AND METHODS

A survey was conducted in Western Romania in the forest area managed by the State Forest Administration "Romsilva", Timis Forest Directorate, that has 77,436 hectares under management, administered through 6 Forest Districts (Forest District Ana Lugojana with an area of 11,722 ha, Forest District Cosava with an area of 18,584 ha,, Forest District Faget with an area of 13,938 ha, Forest District Lugoj with an area of 12,042 ha, Forest District Lunca Timisului with an area of 9,674 ha and Forest District Timisoara with an area of 11,476 ha) that generate an allowable cut of approximately 250,000 cubic meters per year and have a diverse species distribution. Broadleaves cover an area of 71,224 ha (beech 25,544 ha, oaks 28,806 ha, hardwood 14,390 ha and softwood 2,484 ha), the rest of 4,608 ha being covered by evergreens (spruce 2,459 ha, fir 869 ha and other evergreens 1,280 ha).

In 2000 a system of biannual public auctions (in early spring and in late autumn) was introduced in the Western part of Romania (Arad and Timis Forest Directorate).

The present study is based on the results obtained at the above mentioned public auctions organized by the Timis Directorate between 2003 and 2017. A total of 7,772 oak logs, harvested from the six forest districts, were selected from the annual harvest resulting a total volume of high quality wood logs of 8,638 m^3 to be sold in the above-mentioned auctions.

Data regarding the provenance, the origin, the site type, the forest type as well as all the characteristics provided by the informational forestry system, as they are presented in the irrespective Forest Management Plans, were analyzed for all harvested and selected wood logs using Excel programme.

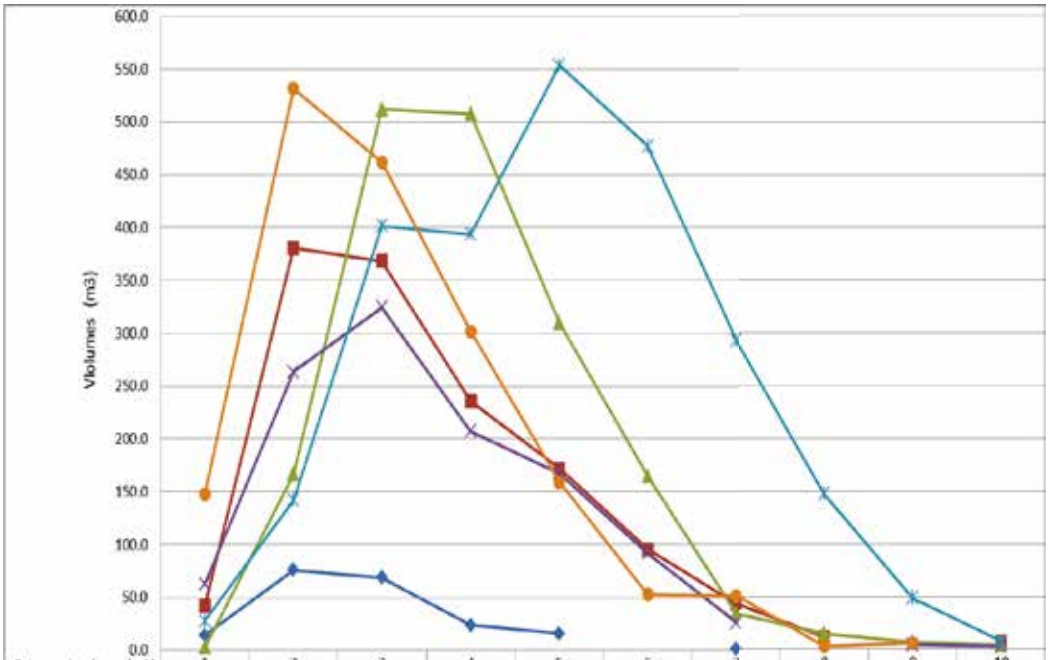
RESULTS AND DISCUSSIONS

By performing harvesting and thinning operations, which were done by the employees of the forest district or by contractors, operations that open up the forest canopy, allowing more light

to reach down through the lower levels of the forest, encouraging dormant seeds to germinate and providing light for plants to grow, that strictly followed the management plan in the period between 2003 to 2017 on the forest surface administered by Timis Forest Directorate, resulted in high quality logs of *Q. robur, Q. petraea and Q.frainetto*. The resulting wood logs have had special characteristics and after proper sorting, superior industrial quality sortiments (veneer logs, logs for barrels, sawmill logs used for furniture production or for parquet production) were sold at open public auctions at prices ranging from 100 to 1200 euro/m^3.

The State Forest Administration "Romsilva" promotes only those oak raw materials which originate from certified forest areas which are sustainably managed, where forest ecosystem services as well as certified wood chains of custody are obtained. Therefore for each log which was included in the study, the place of origin could be determined.

It was assumed that the selling price of the logs reflects the quality of the wood material obtained at the end of a production cycle. In order to be ranked according to their financial value, the logs have been classified into 10 price series from 100 euro/m^3 to 1200 euro/m^3.



Forest District / Price series (euro/m3)	1	2	3	4	5	6	7	8	9	10
Ana Lugojana	14.3	75.9	68.6	23.7	15.6		1.4			
Cosava	41.8	380.5	368.3	235.9	172.0	95.6	43.8	11.8		7.8
Faget	2.5	166.7	512.0	507.8	309.5	164.6	34.5	15.5	6.9	4.0
Lugoj	62.2	268.5	324.3	207.1	167.5	91.8	26.2		4.4	3.5
Lunca Timisului	27.5	142.1	401.5	393.7	553.3	477.0	252.9	147.4	48.7	7.7
Timisoara	147.4	531.5	461.9	302.5	158.5	52.6	51.6	3.5	6.0	

Figure 1. Price series (euro/m^3) obtained in oak wood logs auctions in 6 forest districts from the State Forest Administration "Romsilva" - Timis Forest Directorate, in the period 2003-2017

Analyzing the collected data, it can be concluded that the biggest volume of oak wood sold in the auctions are found in the third (300-399 euro/m^3) and fourth (400-499 euro/m^3) price series. It can also be observed that the biggest high quality oak wood volume comes from the Lunca Timisului Forest District, which is located in a plain area (1,534 logs of

pedunculate oak and 1 log of Italian oak, amounting a total volume of 2,491.7 m^3), closely followed by the Timisoara Forest District, which has under administration forests located in the plain and hilly area (1,357 logs of pedunculate oak, 547 logs of sessile oak and 36 logs of Italian oak with a total volume of 1,715.1 m^3); then Faget Forest District (1,109 logs of pedunculate oak, 425 logs of sessile oak and 1 log of Italian oak amounting a total volume of 1,715.1 m3) and Cosava Forest District (997 logs of pedunculate oak, 450 logs of sessile oak and 5 logs of Italian oak, with a total volume of 1,357.4 m^3), both districts (Faget and Cosava) having under administration forests located in the hilly and mountainous area; followed by Lugoj Forest District (528 logs of pedunculate oak, 547 logs of sessile oak and 33 logs of Italian oak with a total volume of 1,150.4 m^3) which has under administration forests located in the plain and hilly area and the last one - Ana Lugojana Forest District, which has under administration forests located in the mountainous area (202 logs of sessile oak amounting a volume of 199.5 m^3).

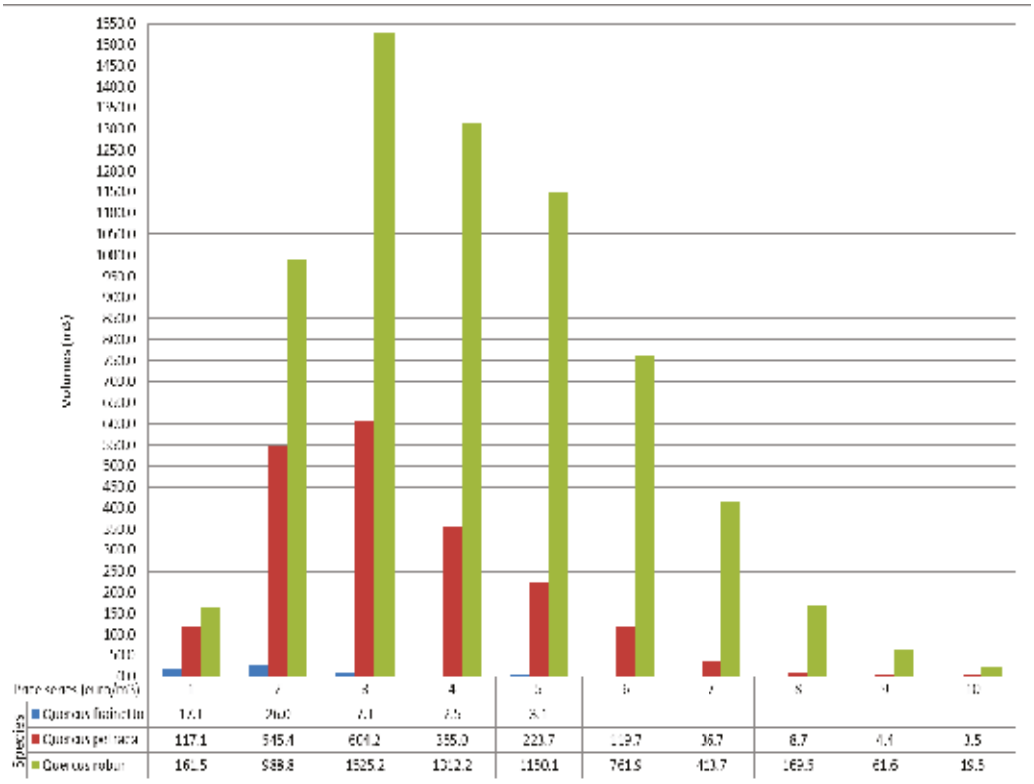


Figure 2. Price series (euro/m^3/species) obtained for *Q. robur, Q. petraea and Q. frainetto* in wood logs auctions in 6 forest districts from the State Forest Administration "Romsilva" - Timis Forest Directorate, in the period 2003-2017

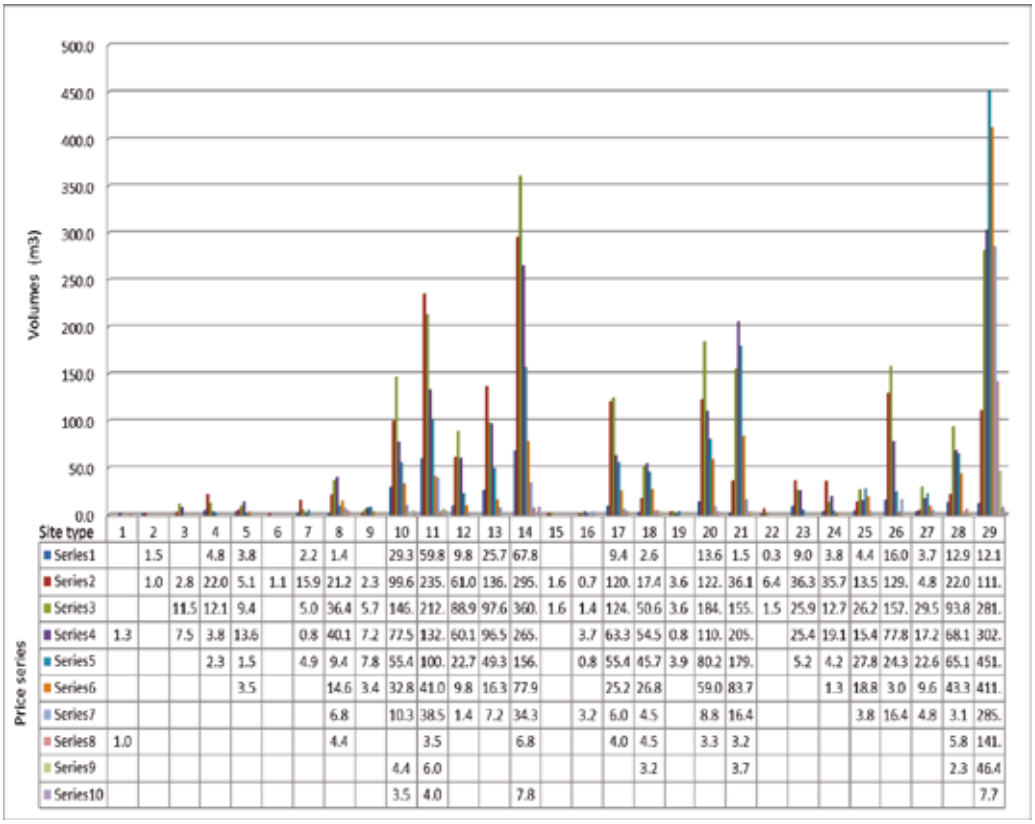
It can be observed (Figure 2) that in the upper price categories, that are generally represented by logs of superior quality, pedunculate oak logs are the main part (71% from the total number of logs and 76% of the total logs volume) followed by the sessile oak (28% from the total number of logs and 23% of the total volume.

The Italian oak represents 1% from the total number of logs and from the total volume.

Twenty nine site types have been identified where the oak logs were harvested from (the site types names are in accordance with the classification used in the informational system for forestry in Romania as it is used in the Forest management plans, Table 1).

Table 2. Site types where the high quality oak species logs were harvested between 2003-2016 in the State Forest Administration "Romsilva" - Timis Forest Directorate

Forest Types	Site Type	Site Type nr.	Site Type code	Main characteristics of the Site Type		Volume (m3)
				Soil	Flora	
Mountain F. types	Beech Forest site type	1	4430	rocky with excessive erosion		2.3
Hill and Plateau Forest types	Sessile oak Forest site type	2	5132	Argiluvisols, Eluviated brown soil, podzol	Mezofit grasses	2.5
		3	5142		Carex Pilosa	21.8
		4	5152		Asperula-Asarum	45.0
		5	5153		Asarum-Stellaria	37.0
	Beech Forests site types	6	5231		Vaccinium-Luzula	1.1
		7	5242	Cambisol, Brown eu-mesobasic soil, molic	Asperula-Asarum	28.7
		8	5243			134.3
	Sessile oak and mixed oak Forest Site Types	9	6131	Argiluvisol, Argilic iluvial brown soil, podzol	Acidofil mezoxerofit	26.4
		10	6132		mezoxerofit grasses	459.0
		11	6142	Argiluvisols, Eluviated brown soil, pseudogleyic, Argilic iluvial brown soil	Carex pilosa Carex – Poa pratensis	833.9
		12	6143			253.8
		13	6152	Argiluvisol, Argilic iluvial brown soil	Aserum Stelaria, Carex – Poa pratensis	429.5
		14	6153			1272.0
		15	6241	Argiluvisols, Eluviated brown soil, pseudogleyic,	Carex pilosa	3.2
		16	6251	Cambisol, Brown eu-mesobasic soil, tipical	Festuca altissime	9.8
		17	6252		Asperula-Asarum	408.1
		18	6253		Asperula-Asarum	209.9
		19	6264		Carex brisoides -Argostis alba	11.8
	Pedunculate oak and mixed oak species Forest site type	20	7332	Argiluvisols, Eluviated brown soil, pseudogleyic	Poa pratensis Carex caryphyllea	581.8
		21	7333		Carex – Poa pratensis Brachypodium-Geum	684.8
		22	7334	Argiluvisol, Argilic iluvial brown soil	Carex – Poa pratensis	8.2
		23	7430		Brachypodium-Geum-Pulmonaria	101.9
		24	7530			76.9
Plain Forest types	Oak and mixt Forest site types	25	8332	Argiluvisol, Eluviated brown soil, pseudogleyic	Carex brisoides -Argostis alba	109.9
		26	8333	Argiluvisols, Eluviated brown soil, molic-redzinic	Arum-Pulmonaria Rubus caesisus –Aeg.	424.3
		27	8335	Argiluvisols, Levigated reddish brown soils, pseudogleyic	Arum-Pulmonaria	92.2
	Oak river bench site types	28	8511	Argiluvisols, Redish brown forest soil, humid, gleyic or semi-gleyic,	Brachypodium-Geum-Pulmonaria	316.4
		29	8512	Argiluvisols, Redish brown forest soil, humid, gleyic or semi-gleyic, molic		2051.8



Price series / Site type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Series1		1.5		4.8	3.8		2.2	1.4		29.3	59.8	9.8	25.7	67.8			9.4	2.6		13.6	1.5	0.3	9.0	3.8	4.4	16.0	3.7	12.9	12.1
Series2		1.0	2.8	22.0	5.1	1.1	15.9	21.2	2.3	99.6	235.	61.0	136.	295.	1.6	0.7	120.	17.4	3.6	122.	36.1	6.4	36.3	35.7	13.5	129.	4.8	22.0	111.
Series3			11.5	12.1	9.4		5.0	36.4	5.7	146.	212.	88.9	97.6	360.	1.6	1.4	124.	50.6	3.6	184.	155.	1.5	25.9	12.7	26.2	157.	29.5	93.8	281.
Series4	1.3		7.5	3.8	13.6		0.8	40.1	7.2	77.5	132.	60.1	96.5	265.		3.7	63.3	54.5	0.8	110.	205.		25.4	19.1	15.4	77.8	17.2	68.1	302.
Series5				2.3	1.5		4.9	9.4	7.8	55.4	100.	22.7	49.3	156.		0.8	55.4	45.7	3.9	80.2	179.		5.2	4.2	27.8	24.3	22.6	65.1	451.
Series6					3.5			14.6	3.4	32.8	41.0	9.8	16.3	77.9			25.2	26.8		59.0	83.7			1.3	18.8	3.0	9.6	43.3	411.
Series7								6.8		10.3	38.5	1.4	7.2	34.3		3.2	6.0	4.5		8.8	16.4				3.8	16.4	4.8	3.1	285.
Series8	1.0							4.4			3.5			6.8			4.0	4.5		3.3	3.2							5.8	141.
Series9										4.4	6.0							3.2			3.7							2.3	46.4
Series10										3.5	4.0			7.8															7.7

Figure 3. The relation between volumes of harvested wood (m^3), site type and price series in euro/m^3 (results from the wood auctions in 6 forest districts from the State Forest Administration "Romsilva" - Timis Forest Directorate, in the period 2003-2017).

It can be observed that the biggest volume, 2,051.8 m3, (23.8% of the total volume taken into account in the study) can be found in the Site Type 8512 (nr. 29). At the same time we can see that the upper price series, that are generally represented by logs of superior quality, are mostly found in Site Type 8512 (33.3% of the 10th price series volume, 70.3% of the 9th price series volume, 79.5% of the 8th price series volume, 69.3% of the 7th price series volume, 46.7% of the 6th price series volume, 32.8% of the 5th price series volume, 18.1% of the 4th price series volume, 13.2% of the 3rd price series volume, 7.1% of the 2nd price series volume and 4.1% of the 1st price series volume).

The second most representative is Site Type 6153 (nr. 14) with a volume of 1,272 m3 (14.7% of the total volume taken into account in the study) in which the upper price series are found but also lower price series are well represented (34% of the 10th price series volume, 3.8% of the 8th price series volume, 7.62% of the 7th price series volume, 8.84% of the 6th price series volume, 11.4% of the 5th price series volume, 15.9% of the 4th price series volume, 16.9% of the 3rd price series volume, 18.9% of the 2nd price series volume and 22.9% of the 1st price series volume).

The third most representative is Site Type 6142 (nr. 11) with a volume of 834 m3 (9.7% of the total volume taken into account in the study) in which all the price series are found (17.6% of the 10th price series volume, 9.1% of the 9th price series volume, 2% of the 8th price series volume, 8.5% of the 7th price series volume, 4.6% of the 6th price series volume, 7.3% of the 5th price series volume, 8% of the 4th price series volume, 10% of the 3rd price series

volume, 15.1% of the 2nd price series volume and 20.1% of the 1st price series volume).

DISCUSSIONS

Forests are an important part of our life, providing ecosystems services, fulfilling social demands and contributing to the economy by providing renewable and sustainable raw materials. "The unexploited potential in terms of the wood and non-wood products and services provided by European forests is outstanding" (Borkowski and Langue, 2018).
The replacement of valuable *Quercus* sp. by low-value mixed species has negative effects both ecologically - causing major changes in forest ecosystems, and economically - reducing the value of wood produced at the end of a production cycle (pedunculate and sessile oaks, or even Italian oak, produce wood with special structural qualities which can be sold at prices 5-6 times higher than the wood of hornbeam, acacia or lime).
Taking into consideration the field conditions, appropriate silvicultural techniques must be applied in order to achieve a composition in which oaks are predominant and, once they reach the age of exploitability, they will provide timber as valuable as that originally harvested. In the study “Silviculture of Oak for High-Quality Wood Production” it is stated that silviculture based on early initiated, heavy thinning for obtaining the 'best' trees at regular intervals (Attocchi, 2015).
Identifying the areas which are favorable for valuable forest stands with of oak species; we can promote to the market only those oak raw materials which originate from certified forest areas which are sustainably managed, where forest ecosystem services as well as certified wood chains of custody are obtained.
Site types and stand factors which will favor oak stands to grow and produce valuable sustainable and renewable materials at the end of a production cycle should be identified and studied (Annighöfer et al., 2015).

CONCLUSIONS

The market demand for high quality wood logs of oak species (*Q. robur, Q. petraea* and *Q. frainetto*) in Western Romania has continuously been growing in the last decade, as well as their sale price in public auctions organized by State Forest Administration "Romsilva" - Timis Forest Directorate between the years 2003 – 2017.
The site type characteristics are an important driven factor for obtaining high quality oak wood. Analyzing the harvesting area, twenty nine site types have been identified for the above mentioned high quality oak wood logs, the results leading to the conclusion that the most suitable site types for obtaining oak species logs of superior quality are: 8512, 6153 and 6142.
The highest quality oak species logs were obtained in Western Romania in the last decade in the plain area which is characterized by rich Argiluvisols like Redish brown forest soil (humid, gleyic or semi-gleyic), Argilic iluvial brown soil and Eluviated brown soil, (pseudogleyic) with appropriate water regime.
Silvicultural measures which will combine the adequate intensive forestry measures based on recent field observations and studies to promote the most valuable oak species (pedunculate oak, sessile oak and also Italian oak) in relation with their ecological requirements, are the solution for the sustainable management of oak forests in Western Romania: big volumes of high quality logs for the wood industry and economics and services for the benefit of the society. After more than 50 years of forest management in the research area, the conclusion is that this is not a futile tendency. Oak stands are of significant importance in Romanian and all European forests. They are perhaps even more appreciated than in the past, not only for the particular structural qualities of their wood, but also more and more for the contributions that these species bring to ecosystem services.

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GIS INTEGRATION OF CLIMATE CHANGE THROUGH FAST CALCULATION OF TEMPERATURE AND PRECIPITATION MAPS FOR USE IN AGRICULTURAL LAND QUALITATIVE ASSESSMENT. CASE STUDY: ICLOD COMMUNE, CLUJ COUNTY, ROMANIA

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Abstract

Global warming in the past 30 years had serious effects on agricultural land and its crop suitability in the Iclod Commune, whose agricultural land evaluation database still uses old temperature and precipitation averages. Using WorldClim monthly temperature and precipitation distribution maps, History+ simulated archive database and SRTM's slope steepness and orientation, raster calculations were performed in GIS for a fast update of temperature and precipitation distribution maps which were then used to update the OSPA's agricultural land qualitative assessment database.
The results show that the last 30 years hot and dry tendencies substantially modify Iclod Commune's land evaluation database, suggesting that new crops are more suitable than the old ones in face of the current accelerated climate change tendencies.

Keywords*: climate change, GIS, land evaluation, crop suitability*

INTRODUCTION

FAO (1976) defines land evaluation as „the process of assessment of land performance when used for specified purpose involving the execution and interpretation of surveys and studies of landforms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation". In Romania, agricultural land quality classification is made depending on crop production potential, which is appreciated based on rating marks in natural conditions for arable use (Zisu, 2016).
The most dynamic factors taken into account when a land evaluation is performed are climate resources, namely temperature and precipitation. Although land evaluation maps are constantly being updated, the national land evaluation methodology uses averages of temperature and precipitation over the past 30 – 50 years (OSPA Cluj, 2014). The current tendencies of climate variability are not being taken into account, thus giving a reason to run climatic scenarios for accurate land evaluation of Iclod`s Commune agricultural fields. The use of current temperature and precipitation distribution in land evaluation is a common practice in the past years (Mitrica et al., 2015; Niacsu et al., 2015; Rosca et al., 2015; Moldovan, et al., 2016; Bilasco, et. al., 2016; Oprea et al., 2016).

Figure 1. The geographical location of Iclod Commune within Cluj County and Romania

Iclod Commune is located in north western Romania, near Cluj Napoca municipality, in Cluj County (Figure 1). Most of its land is currently being occupied by field crops.

MATERIALS AND METHODS

The climate data was extracted from WorldClim monthly temperature and precipitation distribution maps (Fick & Hijmans, 2017) and Meteoblue History+ (2018) daily temperature and precipitation acquired tabular data.

For slope and aspect calculations, the SRTM's 30m maps were used

According to WorldClim version 2 for the 1970 – 2000 interval the yearly temperature for Iclod is 9.3°C and the yearly rainfall is 600 mm. In the Meteoblue History+ the yearly temperature and rainfall values vary according to the chosen intervals (Table 1).

Table 1. Temperature and precipitation averages

	1988-2017	1993-2017	1998-2017	2003-2017	2008-2017	2013-2017
Temp. (°C)	11.14	11.17	11.26	11.29	11.52	11.64
Precip. (mm)	526	518	508	503	477	441

From the 30-year interval to the last 5 year averages the temperatures increases while the precipitation decreases as shown in figure 2.

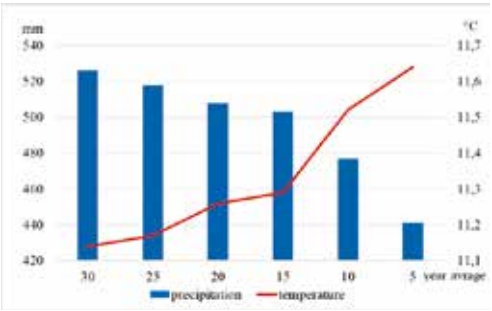

Figure 2. Precipitation and temperature evolution on a 30 years course

The highest yearly rainfall amount of 717 mm was recorded in 2004, while the lowest quantity of 308 mm was registered in 2011. The highest yearly temperature of 12.17 was recorded in 2002 and the lowest of 10.02 was recorded in 1997. For 2017 the average rainfall amount was 373 mm, and the average temperature was 11.42.

Temperature and precipitation corrections were applied on slope steepness and aspect in the case of temperature (Figure 3) and slope steepness and soil texture for rainfall (Figure 4).

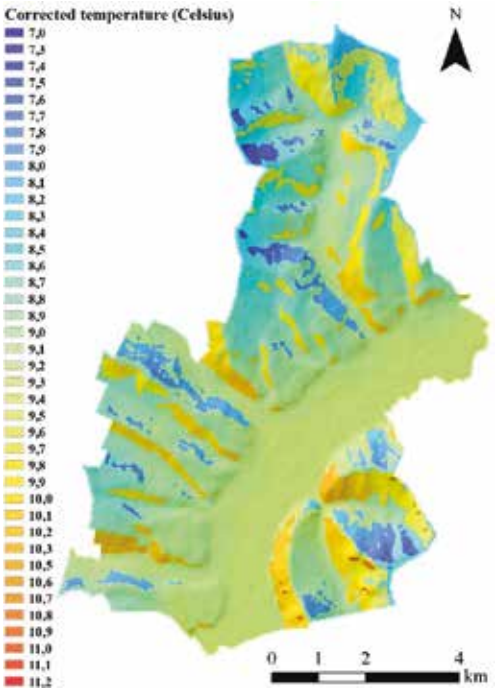

Figure 3. Average corrected temperature distribution in Iclod commune (after Worldclim version 2)

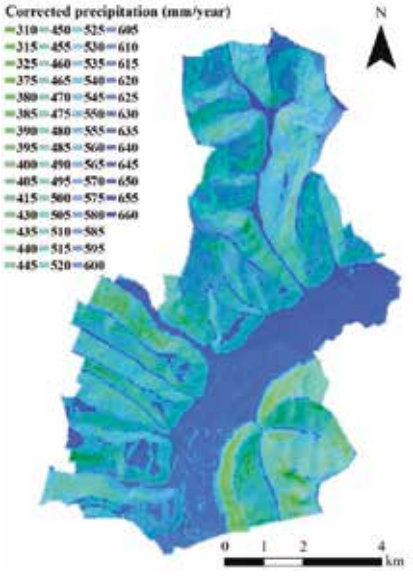

Figure 4. Average corrected precipitation distribution in Iclod commune (after Worldclim version 2)

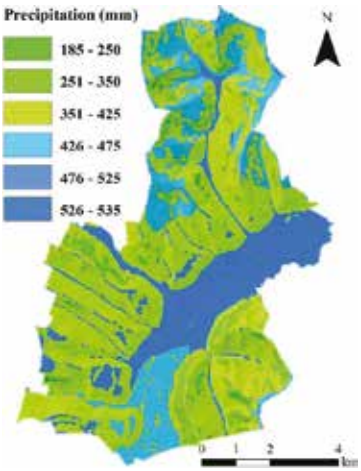

Figure 5. Precipitation distribution in the first scenario

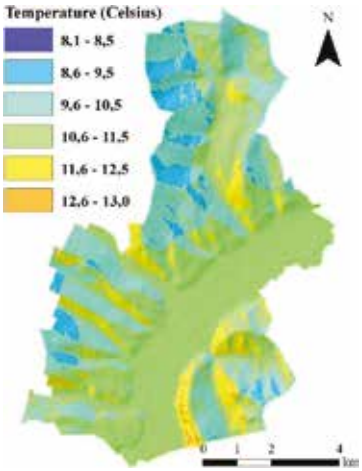

Figure 8. Temperature distribution in the first scenario

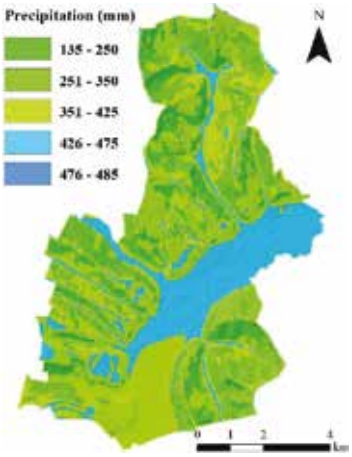

Figure 6. Precipitation distribution in the second scenario

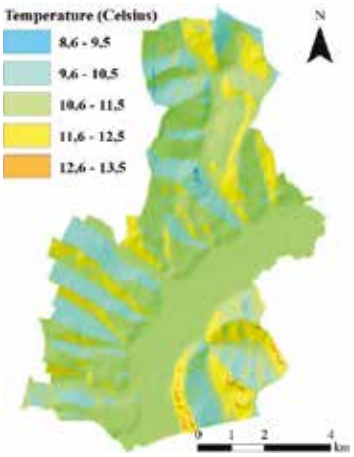

Figure 9. Temperature distribution in the second scenario

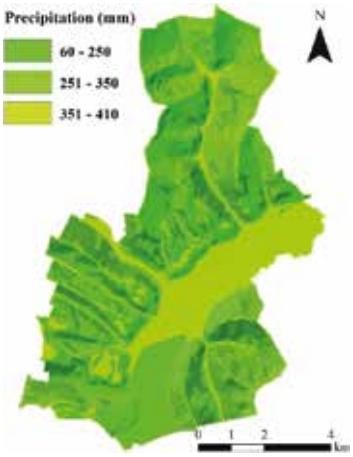

Figure 7. Precipitation distribution in the third scenario

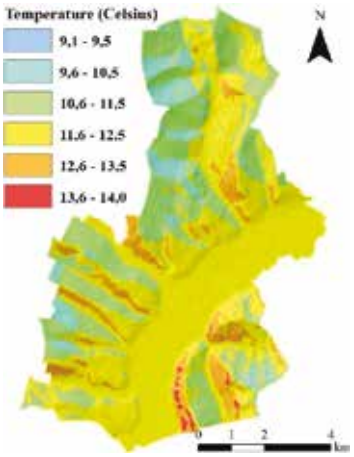

Figure 10. Temperature distribution in the third scenario

The climate data was processed in ArcGIS 10.4 software, where WorldClim's 1km^2 data was resampled to match SRTM's 30m resolution map (Pasca and Nasui, 2015; Zisu and Nasui, 2015).

RESULTS AND DISCUSSIONS

Based on temperature and precipitation trend values, three scenarios were compiled. The first scenario uses the last thirty years average temperatures: 11^{0}C and the last ten years average rainfall: 475mm. For the second scenario a temperature of 11.5^{0}C (last 10 years average) and a rainfall amount of 425mm (last 5 years average) were used. The last scenario uses the highest recorded temperature of 12^{0}C and an average of the most arid two years (in the analysed interval) of 350mm.

The first step was to correlate the Meteoblue History+ tabular data with WorldClim version 2 spatial distribution maps. In ArcGIS Raster Calculator a constant was added or subtracted to the corrected temperature and precipitation maps depending on the scenario used. For the 1st scenario 1.7^{0}C was added (Figure 8) and 125mm was subtracted (Figure 5), for the 2nd scenario 2.2^{0}C was added (Figure 9) and 175mm was subtracted (Figure 6), and for the 3rd scenario 2,7^{0}C were added (Figure 10) and 250mm were subtracted (Figure 7).

The second step was the identification of the most suitable crops for the climatic scenarios, obtained by multiplying temperature with precipitation in raster calculator. Although quite a few crops are suitable for the three scenarios (such as: peas/beans, alfalfa, sunflower, apricot tree, vineyard for wine, beetroot or soy) only four reach the highest degree of suitability: wheat (Figure 11), flax (Figure 12), vegetables (Figure 13), and barley (Figure 14). In the national land evaluation methodology the most suitable four crops are being taken into account when calculating the arable land quality rating marks, which is an average of the four.

The climate marks distribution maps for the four crops were calculated for each scenario. Their multiplication within each scenario gave the arable land climate quality rating marks distribution maps, which after reclassification gave the arable land climate favorability classes.

1st scenario is represented in Figure 15.

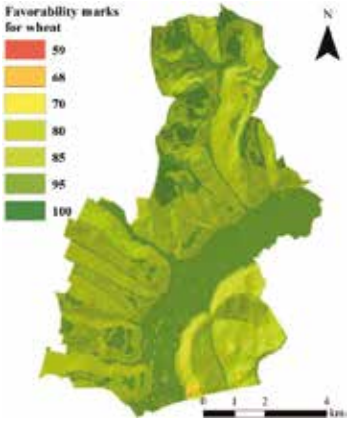

Figure 11. Wheat marks distribution in the first scenario

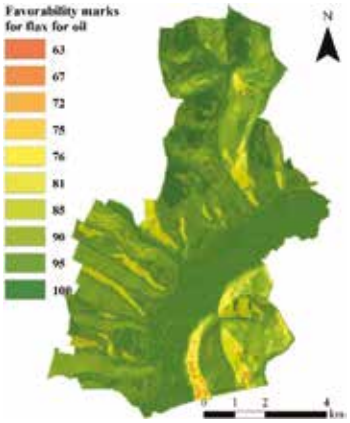

Figure 12. Flax marks distribution in the first scenario

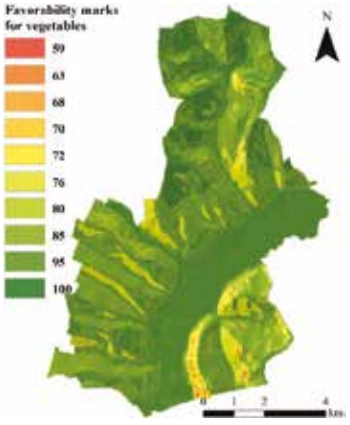

Figure 13. Vegetable marks distribution - first scenario

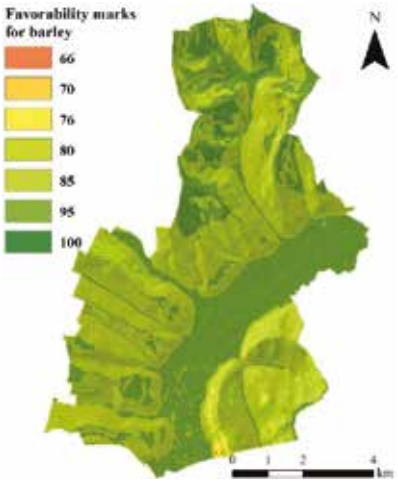

Figure 14. Wheat marks distribution in the first scenario

The 2nd scenario is represented in Figure 16 and third scenario in Figure 17.

The climate favorability in the 1st and 2nd scenarios shows a very good distribution of 1st class (in the floodplain and valleys). It encompasses the current situation (past 5 years), in which the commune's land owners cultivated mostly maize crops, with lesser yields than in previous years (due mainly to maize vulnerability to low precipitation values).

The replacement of maize with wheat or barley could prove beneficial in the long run. The 3rd scenario shows the lack of the 1st class and a domination of the 3rd class in the floodplain, while the best favorability is held by the apricot tree (if seeded in the second class slopes).

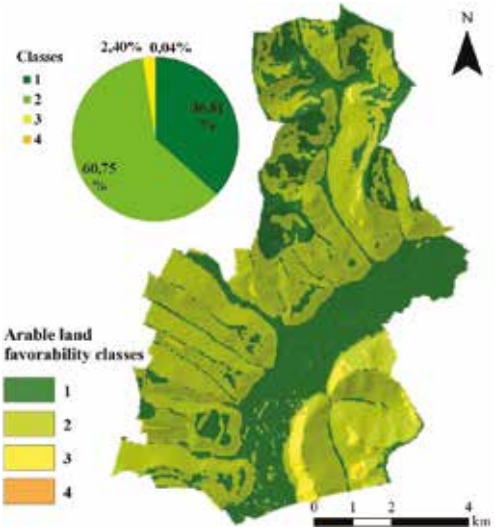

Figure 15. Arable land favorability in first scenario

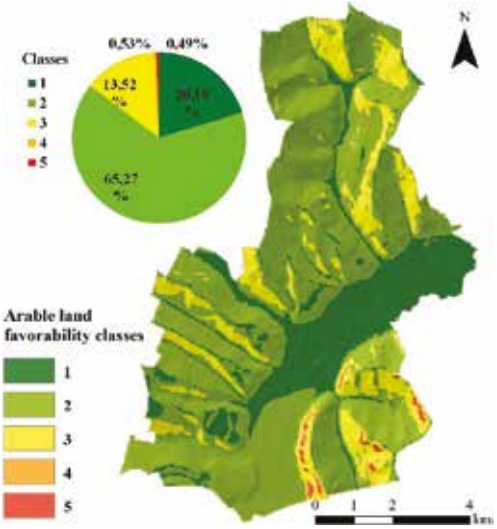

Figure 16. Arable land favorability in second scenario

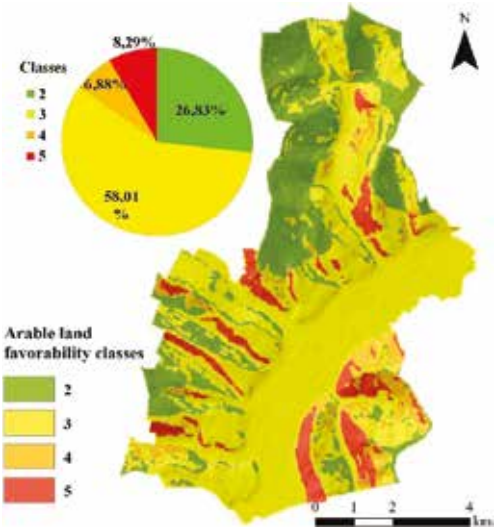

Figure 17. Arable land favorability in third scenario

CONCLUSIONS

When used in conjunction, WorldClim version 2 spatial data and Meteoblue History+ tabular data show a quick and clear distribution of temperature and precipitation trends. The current climate trends in Iclod Commune show a significant increase in temperature and an acute decrease of precipitation amounts. The scenarios used show that even if other crops are used, the overall crop yields will decrease if the existing trends continue.

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RESEARCH ON SULPHUR-BACTERIA AND PHYSICAL-CHEMICAL PARAMETERS FROM SULPHUROUS WATERS OF JIBOU AREA

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Abstract

Sulphur is the fourth major essential nutrient element, after nitrogen, phosphorus and potassium, involved in biogeochemical cycles in nature. Sulphur is essential in all organisms because it is an integral part of major metabolic compounds, such as amino acids (methionine and cysteine), and it is an active component of numerous co-factors and prosthetic groups (Fe–S clusters, sulpholipids, glucosinolates, vitamins, etc), which are involved in metabolic processes of organisms. Medical research appears to confirm the validity of the use of sulphurous spring waters as therapeutical and preventive remedies for a large variety of diseases. In order to evaluate the quality of sulphurous water, samples have been taken of the Sulphurous Springs in Jibou. The objectives of this study were to determine physical and chemical properties (pH, electrical conductivity, salinity, redox potential) of some sulphurous water samples of Jibou area, and also to determine the microbiota involved in S biogeochemical cycle. The physical analysis showed that the sulphurous water of Jibou falls within the very weakly acidic reaction class, and the salinity was 0.2% in all samples. The aerobic heterotrophic bacteria show a maximum value in the sample 4 ($2630x10^3$ bacteria/ml). The microbial sulphurous community was detected in all water samples. This information should improve our understanding on adaptation mechanisms of bacteria involved in the sulphur cycle in correlation with physical-chemical parameters.

Key words*: sulphurous water, Jibou, physical-chemical parameters, sulphate-reducing bacteria, sulphur-oxidation bacteria.*

INTRODUCTION

Jibou is an important region for occurrence of therapeutic sulphurous waters in North-Western Romania. Natural sulphurous mineral waters from Jibou have a treatment potential mostly used in balneotherapy.

Sulphur is present in all organisms and occurs in organic compounds with catalytic, structural and regulatory functions, such as amino acids, proteins, enzymes, etc. On the other hand, the biological functions of inorganic sulphur compounds are limited. These compounds are needed in assimilation (prokaryotes, plants and fungi) and synthesis of organic compounds because they provide sulphur. Sulphate, sulphide and elemental sulphur are the most abundant sulphur substances, and provide evidence for the simultaneous occurrence of dissimilatory sulphate reduction and sulphide oxidation (at *Eubacteria* and *Archaebacteria*). Hydrogen sulphide is rarely present in natural waters, with the exception of special sulphurous mineral springs. Hydrogen sulphide (H_2S) is the active component of sulphurous waters (Pokorna and Zabranska, 2015).

Balneotherapy treats many diseases, including immune-mediated skin diseases. Current medical research confirms the effect of sulphurous spring waters use, as preventive remedies and therapeutics for a large variety of diseases affecting the respiratory tract, skin, liver, intestine, gynaecological apparatus and osteoarticular system (Frosch 2007). The different studies followed the effect of sulphurous medicinal waters in a murine dermatitis and on psoriatic patients. The role of hydrogen sulphide in releasing somatostatin during bathing treatment was also studied. Some results point out the anti-inflammatory role of sulphurous medicinal waters in psoriasis (Tsoureli-Nikita et al. 2002).

According to the World Health Organization (WHO, 2013) and US Environmental Protection Agency (EPA), water for human consumption should contain less than 250 ppm

of sulphates (Balintova et al., 2015; US EPA, 2017). When the sulphate concentrations for human consumption are compromised, the human health concerns would naturally arise (Backer, 2000; Fernando et al., 2018).

Other studies on sulphurous mineral waters revealed anti-oxidant properties (Albertini et al., 2007) and, under the same oral treatment, no pathological changes on biochemical oxidative enzymatic markers and hematochrome were noticed in human healthy volunteers (Albertini et al., 2008). H_2S is known as an endogenous inter- and intracellular signaling molecule with multiple effects. Its most investigated roles are related to cardiovascular, nervous system and inflammatory diseases (Matz et al., 2003). The effect of H_2S on various clinical pathology parameters has been so far restricted to acute hematologic and enzyme alteration studies.

Sulphur bacteria are prokaryotes that use reduced or oxidized sulphur compounds in their metabolism. Reduced sulphur compounds (sulphide and elemental sulphur) are involved as electron donors in photosynthesis of anoxygenic phototrophic sulphur bacteria, or as energy and electron sources by colourless sulphur-oxidizing bacteria. In opposition, oxidized sulphur compounds (sulphate), are involved as electron acceptors for the oxidation of organic matter by sulphate-reducing bacteria. When the sulphur level in water is above the needs of plants and microbes the excess is settled down. All of it or only a part will further circulate through oxidation to sulphate or reduction to sulphide. Thus, it is important to know the bacteria involved in these reactions. Each group of sulphur bacteria needs available sulphur compounds in a specific redox status. Sulphur bacteria are a heterogeneous group with taxa belonging to different phylogenetic branches within *Bacteria* and *Archaea*.

Biological oxidation of sulphur is important in the natural sulphur cycle. The oxidation reactions are performed by sulphur-oxidizing bacteria from *Alphaproteobacteria, Betaproteobacteria, Gammaproteobacteria, Epsilonproteobacteria, Chloroflexia* and *Chlorobia* classes. The electrons resulted from sulphide oxidation are then used by aerobic chemotrophic colorless sulphur-oxidizing bacteria (*Beggiatoa, Thiobacillus,* etc) in respiration and for autotrophic CO_2 reduction. The anaerobic phototrophic sulphur-oxidizing bacteria (green sulphur bacteria - *Chlorobium,* etc; purple sulphur bacteria - *Halochromatium, Thiocapsa*, etc) transfer electrons from sulphur or other donors for autotrophic CO_2 reduction, using light energy (Zang et al., 2018).

Sulphur reducers are able to reduce elemental sulphur, and are widespread among Bacteria and Archaea (*Desulfurococcus, Clostridium, Methanococcus, Geobacter* etc). They use elemental sulphur as an electron acceptor in oxidizing organic matter (formate, acetate, lactate, pyruvate, sugars etc). The sulphide produced can further pass to autotrophic sulphide-oxidizing bacteria (*Thiobacillus, Halothiobacillus*) which oxidize it back to elemental sulphur (Ghosh and Dam, 2009; Zang et al., 2018).

This paper aims to investigate the bacteria involved in sulphur cycle (aerobic and anaerobic bacteria) in relation to physical-chemical parameters in sulphurous waters from Jibou zone (Salaj County).

MATERIALS AND METHODS

Water samples. Different sulphurous mineral water samples were collected from several local springs from Jibou town area. For the sample collection ground-glass apparatus was used. All samples were kept in the lab at 4°C, waiting processing. The waiting time before processing didn't exceed 24 hours. The water samples for physical and chemical analysis were analysed according to SR EN ISO 5667-1:2007/AC, 2007 and SR EN ISO 5667-3, 2013, and they were also microbiologically studied according to SR EN ISO 19458, 2007.

Physical and chemical analyses. A portable multiparameter was used for the physical and chemical analyses. The physical and chemical analysis consists in detection of some parameters as: pH, electrical conductivity (EC), salinity (%), redox potential (Eh) and dissolved oxygen (SR EN 27888, 1997; SR EN ISO 10523:2012).

Microbiological analyses. Bacteriological parameters for water samples were established, namely: the total number of the mesophilic heterotrophic bacteria (cfu = colony-forming

units), aerobic and anaerobic sulphur-reducing, sulphur-oxidising, sulphate-reducing bacteria. In order to determine these bacterial indicators from the water samples we used the methods according to Carpa et al., 2014 and different standards for water samples. The culture media used were: nutrient agar (for heterotophic bacteria) (SR EN ISO 6222, 2004); peptone water medium (for aerobic sulphur reducing bacteria) (Carpa et al., 2014); Oppenheimer and Gunkel culture media (for anaerobic sulphur-reducing bacteria (Atlas, 2010)); Starkey culture media (for sulphate-reducing bacteria (*Desulfovibrio*) (Cusa, 1996)); Postgate culture media (for sulphur-oxidizing bacteria (Atlas, 2010)).

Water samples were subjected to serial dilutions and the first three dilutions were used to inoculate all culture media. After inoculation, the samples were incubated for 7 days at a temperature of 25ºC.

Growth examination. In order to assess the number of heterotrophic aerobic bacteria, the number of clusters on each Petri dish was counted and then the cfu/ml was computed. Bacteria involved in sulphur cycle were determined by multiple tubes method and data were interpreted according to the Alexander statistic table – 1965 (Carpa et al., 2014).

RESULTS AND DISCUSSIONS

The physical and chemical parameters were measured in all water samples with the portable multiparameter. The number of bacteria belonging to the following ecophysiological groups was assessed: aerobic mesophilic heterotrophs, aerobic sulphur-reducing bacteria, aerobic sulphur-oxidizing bacteria, anaerobic sulphur-reducing bacteria and anaerobic sulphate-reducing bacteria. The results indicated that the number of bacteria from each group varied depending on the sampling sites.

Physical and chemical analyses. The actual acidity (pH) is very important because it influences physiological groups of bacteria. In the water samples the pH ranged between 6.73 and 6.88 (Table 1). These values belong the very weakly acidic reaction classes. The redox potential (Eh) is used in water assessments because measures the capacity of chemical elements to acquire electrons and by that be reduced. A high redox potential indicates a greater affinity of chemical species for electrons and a greater tendency to be reduced, therefore, an aerobic environment. Sulphur bacteria are critical mediators of redox transformations occurring within the biogeochemical sulphur cycle of the biosphere. The values of redox potential in our water samples were very low. Values of electrical conductivity varied between 845 and 867 µS/cm. In all water samples was measured a salinity of 0.2%, which means that the sulphurous waters from Jibou area contain salts.

Table 1. Physical and chemical parameters in water samples

Samples	pH	Eh (redox potential) (mV)	Electrical conductivity (µS/cm)	Salinity (%)	Dissolved O_2 (mg/l)
1	6.73	-3	845	0.2	0.11
2	6.81	-5	858	0.2	0.250
3	6.84	-7	862	0.2	0.30
4	6.87	-9	860	0.2	0.10
5	6.88	-10	867	0.2	0.23

Microbiological analyses. The total number of mesophilic heterotroph bacteria was measured by the growth layers method. Based on the results, colony forming units (cfu/ml) were calculated.

Viable counts of aerobic and anaerobic sulphur-reducing, sulphur-oxidising, sulphate-reducing bacteria were assessed by most probable number counts (MPN). The results are presented in Table 2, where one can observe that the predominant bacteria involved in the sulphur cycle are aerobic the sulphur-reducing bacteria, followed by sulphur-oxidizing ones. The number of anaerobic bacteria is quite low in all analysed water samples.

Table 2. Microbial communities in water samples

Samples	Bacteria					BIWQ
	Heterotrophic bacteria	Sulphur oxidizing aerobic	Sulphur reducing aerobic	Sulphur reducing anaerobic	Sulphate reducing anaerobes	
	(cfu/ml)	*(bacteria/ml)*				
1	$1146x10^3$	130	170	40	120	2.167
2	$1446x10^3$	380	440	68	91	2.835
3	$2093x10^3$	170	210	78	100	2.753
4	$2630x10^3$	170	310	82	94	2.806
5	$965x10^3$	140	260	61	82	2.649

The aerobic heterotrophs constituted the largest eco-physiological group of bacteria and it is used as a global indicator of microbiological water quality (Figure 1).
The number of aerobic heterotrophs varied in those five water samples, exhibiting values between $965x10^3$ cfu/ml and $2630x10^3$cfu/ml. One can observe that the greatest abundance of aerobic heterotrophs was in water sample 4 and the smallest value was found in water sample 5.

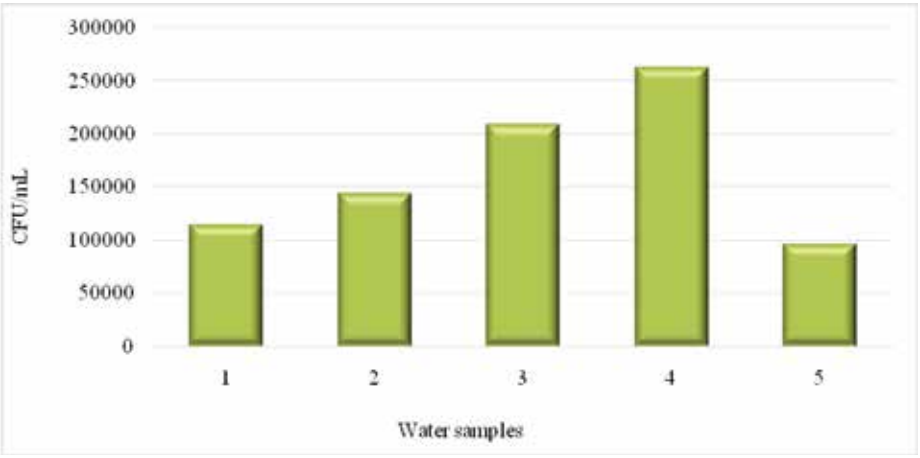

Figure 1. Aerobic heterotrophic bacteria in water samples

Bacteria in the Sulphur cycle removes the toxic effect of hydrogen sulphide and restore the sulphur to the biological use. They can be found on the bottom of standing waters and they are oxidizing the sulphur mineral compounds. Their energy source is hydrogen sulphide (H_2S), which they transform into sulphur (S), sulphurous acid (H_2SO_3) and sulphuric acid (H_2SO_4).
Sulphur-oxidizing bacteria are the main microorganisms that participate in the natural sulphur cycle. Sulphur-oxidizing bacteria are used for the continuous monitoring of toxicity and their use circumvents many of the obstacles associated with conventional assays (Luo et al., 2013). Sulphur-oxidizing bacteria, are chemoautotrophic bacteria that oxidize reduced sulphur compounds to sulphuric acid, in the presence of oxygen (O_2). Some of them, such as *Acidithiobacillus* genus, use elemental sulphur (S) particles as the electron donor (Sedky et al., 2013). Among aerobic bacteria involved in the sulphur cycle one can observe that aerobic sulphur-reducing bacteria are present in a slightly higher number compared to the number of aerobic sulphur-oxidizing bacteria (Figure 2).

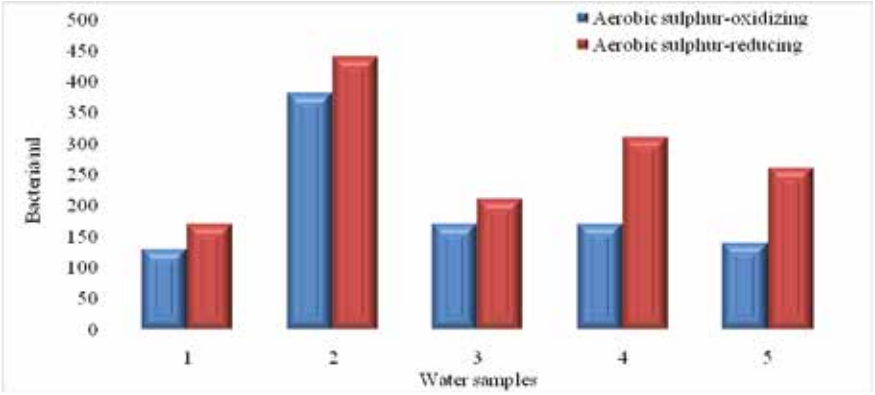

Figure 2. Aerobic sulphur bacteria (sulphur-oxidizing and sulphur-reducing) in water samples

Sulphur reducers can reduce elemental sulphur, and they can use elemental sulphur as the electron acceptor, to oxidize many organic matters (Ghosh and Dam, 2009).

Among the anaerobic bacteria, the anaerobic sulphur-reducing bacteria had the lowest count in the water samples, compared to anaerobic sulphate-reducing bacteria and aerobic bacteria (figure 3). The lowest count was discovered to be for anaerobic sulphur-reducing bacteria in sample 1 (40 bacteria/ml).

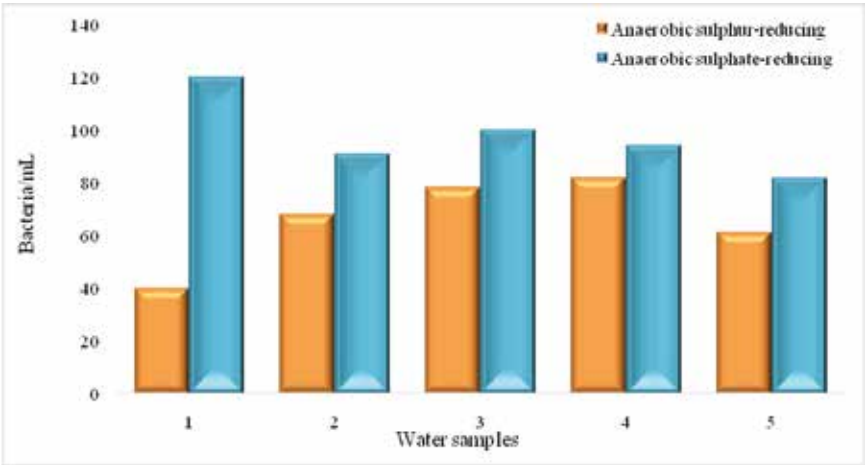

Figure 3. Anaerobic sulphur bacteria (sulphur-reducing and sulphate-reducing) in water samples

Results of the analyses indicated that the number of bacteria from each ecological group varied.

For a general characterisation of the sulphurous bacteria living in the water, we estimated the bacterial indicator of water quality (BIWQ), according to formula (Muntean, 1995-1996):

$$BIWQ = \frac{1}{n} \bullet \sum \log_{10} N$$

where:

BIWQ = the bacterial indicator of water quality;

n = the number of the physiological groups considered within the calculation;

N = the number of the bacteria belonging to each ecophysiological group.

For all samples, the BIWQ was very low and the calculated values ranged between 2.617 and 2.835. The highest BIWQ value was obtained in sample 2, collected from sulphurous waters from Jibou areas (Figure 4).

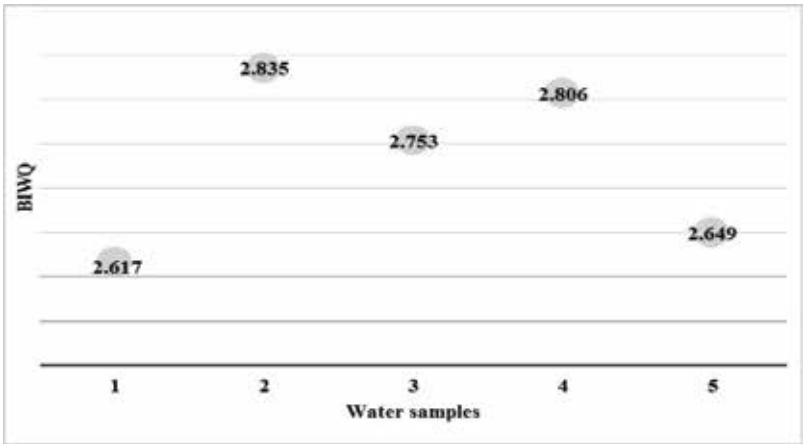

Figure 4. Bacterial indicators of water quality (BIWQ)

CONCLUSIONS

The physical analyses showed that the sulphurous water in Jibou area fits into the very weakly acidic reaction class. The values of redox potential in water samples were very low and these values affect the affinity of the nutrients and the presence of aerobic bacteria. Values of electrical conductivity varied between 845 and 867 µS/cm. In all water samples a salinity of 0.2% was detected.

Numerical distribution of aerobic heterotrophic bacteria shows higher values in the sample 4 ($2630x10^3$ cfu/ml), followed by sample 3 ($2093x10^3$cfu/ml) and the lowest value was found in sample 5 ($965x10^3$cfu/ml).

The microbial sulphur community is not very abundant but suggests that all analysed groups were present in all water samples. Even if aerobic and anaerobic sulphur bacteria were present in the water samples, the aerobic sulphur bacteria were predominant.

The presence of all the five studied bacterial ecophysiological groups studied was noticed in all the water samples. Their number decreases in the following order: aerobic mesophilic heterotrophs ($965x10^3$ - $2630x10^3$ cfu/ml) > aerobic sulphur-reducing bacteria (170 - 440 bacteria/ml) > aerobic sulphur-oxidizing bacteria (130 – 380 bacteria/ml) > anaerobic sulphate-reducing bacteria (82 - 120 bacteria/ml) > anaerobic sulphur-reducing bacteria (40 - 82 bacteria/ml). The bacterial indicator of water quality (BIWQ) had very low values, which varied between 2.617 and 2.835.

ACKNOWLEDGEMENTS

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DIGITAL MODEL OF HEATING SYSTEM FROM "GREEN ENERGY"

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Abstract

One of the ways to reduce the pollution of nature is to increase the share of "green" alternative energy and more efficient technologies in the field of its extraction and using in the household as heating. The application of the best technology, available from industry, can substantially reduce the generated waste and significantly improve its recycling or utilization.
In this article, with the creation of the digital model is shown correlations in terms of more rational use of different types of "green energy" from RES.
The main idea in the application of various types of renewable energy is the opportunity to reduce greenhouse emissions and their generation.

***Key words**: RES, green energy, digital models, process simulating.*

INTRODUCTION

The method of modelling represents by itself a complex process of research, including in observation, experiment, analysis, synthesis and etc. The essence of the method consists in the fact that the study of the object is done with the help of devices (machines, stands, appliances etc.), replicating its behaviour and, consequently, transferring the results of the model to the original.
The modern theory of similarity and modelling is the connecting link between the theoretical and experimental methods for the study of natural phenomena. In a broad sense, she provides a certain approach to planning research, processing and summarizing experiment data, and predicting the behaviour of the subject under study (Stanev, 2003; Komitov, 2003).
A basic concept in modelling is the term "model". In the modern science of modelling he is simplified system, with substantial material or abstract character, which reflects the distinct but important properties of the target object, called the "original".
From this definition it follows that with the help of the models the researchers can study specific phenomena and processes occurring in the original. The research (theoretical or experimental) itself is done on or through the model. Therefore, the value of modelling as a scientific method consists in the fact that the researchers studied the original, representing a complex system, through simpler and more accessible for research object, reflecting the most important and the most characteristic features of the original. In fact this is the reason why today modelling in all its variations is used as a primary method of scientific knowledge (Stanev, 2003; Komitov, 2003).
In order to obtain certain correspondence between the model and the original, the conditions for physical modelling should be chosen in a special way. The degree and character of similarity between the model and the original is accomplished by "criteria of similarity".
The necessary and sufficient conditions for the lines of the model and the original are based on several important principles, known as theorems of similarity (Komitov, 2003).

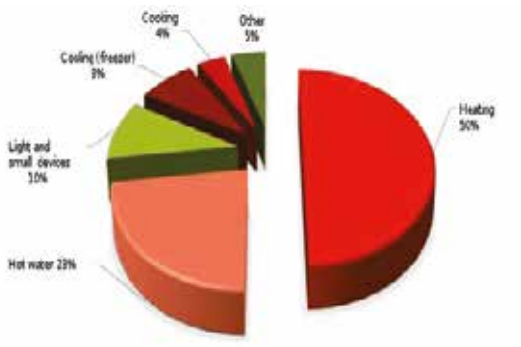

Figure 1. Household energy consumption

The analysis of energy consumption shows (Figure 1) that most of the household expenses are those for heating (50%) and hot water (23%). These costs are over 70% of all household expenses. Of utmost importance is the type of energy, equipment and efficiency of the system (Mitkov, 2017).
The research on heating systems requires a serious resource. Therefore, the idea of getting a digital model is quite attractive.
The reverse task of the theory of modelling is used.
It can influence and to set different modes, such as keep track of the status of the object in different working modes without the presence of a real original.
Subsequently, the digital model can be realized with specific real elements.

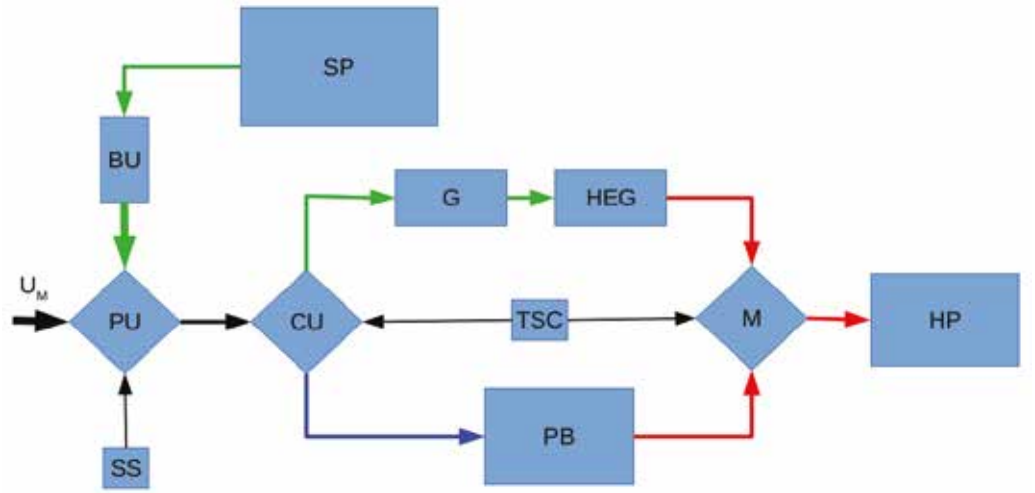

Figure 2. Principle scheme of digital model for heating system from „green energy":
SP -solar panels; BU -battery unit; PU -power unit; U_M -mains voltage; SS -solar sensor; CU -control unit; G -HHO generator; HEG -heat exchanger for HHO gas; PB -pellet boiler; M –mixer; TSC -temperature sensor of coolant; HP -heating part (radiators)

MATERIALS AND METHODS

The basis of the current digital model is the power source.
Under the Paris Agreement and the commitments of our country to protect the environment is recommended this energy source is renewable.
The model provides usage of two types of RES - waste from agricultural production and solar energy, from which produced the combustion gas.
The main elements of the current model (Figure 2) are:

- energy sources for heat generation - basic and auxiliary;
- power energy sources - solar panels with battery unit and mains voltage;
- control circuits - for the power supply and the heating source with sensors;
- consumers.

The principle of this model is as follows:
The HHO gas is the primary heat energy source in the system. It is derived from water molecules, therefore it belongs to the energy from RES. HHO gas is obtained by electrolysis in a special generator (cell), which converts the molecules of water in a convenient to use gas, according to Figure 3.
It contains two parts of gaseous hydrogen and one part of oxygen in a certain volume (modification of the physico-chemical and energetic state of water, changing the connections between the isotopes of hydrogen and oxygen (Mitkov, 2017).

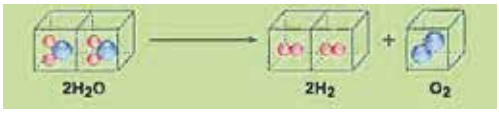

Figure 3. Structure of HHO gas

When burning, the heat is released and warmed up the coolant. The temperature in the combustion of HHO gas is high.

For receive the gas is used HHO generator (G). The generator works on the principle of electrolysis. The base for obtaining of the generator's electrolyte is KOH. The generator itself, when supplied with electric voltage, converts the water's molecules and releases flammable gas. The quantity of the gas depends on the size of the platters of the generator and the power of current. After it is mandatory should be install a water filter and the gas is fed to the burner of the gas for burning and heat generation.

The burner is mounted directly on the heat exchanger (HEG). The heat exchanger is necessary for receiving a good heat exchange between the heat from the combustible gas and the coolant. In such systems, usually the heat coolant is water with a temperature of about 60°C.

The alternate (second) version of heat source is heating boiler on pellets.

It complements the work of the primary energy source and if necessary, replaces it. The waste of agricultural productions is collected from the field and processed in the form of pellets on known technologies. Already the finished energy product shall be submitted to the pellet boiler (PB). In it, they burn and give heat to the heat exchanger built into the pellet's boiler. For the process, the pellet boiler is equipped with a pellet burner operating in the maximum efficiency mode. Thanks to it, the heating process is automated. It can work at a specific time or in accordance with a specified program to maintain the temperature of the coolant to the heating system.

One of types for system power supply is realized through the solar panels and the battery unit. The energy that results from solar radiation is captured by solar panels (SP). They are made from organic polymers or semiconductor's nanocrystals. The solar panel works on the principle of the photoelectric effect. Usually they work in the range of 24-48 V. In the specific case the operating voltage is of 24 V. With connecting of two panels is achieved a nominal current of 20 A. The energy obtained this way is a clean green energy, which, however, should be used and stored in an appropriate manner. The solar panels, sell in the market, are equipped solely with inverter for the connection.

For storage and smoothing the pulsations of obtained energy, is used the battery unit (BU). When there is sunshine, solar panels charge the battery unit. In need of power they supply electricity to the consumer.

The other type of power supply is mains voltage. It is realized through a standard voltage U_M - 220 V. If necessary, it is consumed energy from the electricity network, necessary for the maintenance of the heating system in the operating position.

One of the control circuits is the power supply unit (PU). It is aimed to determine when to use network power supply or solar panels. By priority, the main power supply is from solar panels, and in a bit of sunshine and low supply voltage from battery unit, it is switched to network power.

In order to determine the intensity of the light, to the control circuit of the power supply unit is installed the solar light sensor (SS). At low light intensity, usually in the dark of the day and in cloudy weather, the value of the sensor gives the power unit reason to switch to network power.

Another control circuit is that of the control unit (CU). It keeps track of priority of used energy sources-HHO gas or pellets and switches the operation mode. If necessary, the control unit can exclude completely one of energy sources or mutual complement them. To be able to carry out its management functions, the control unit takes the signal from the power supply unit and monitor the temperature of the coolant through the temperature sensor (TSC).

Depending from the values of temperature sensor, the different energy sources are switched and their work is managing.

The third control circuit is that of the mixer (M). It has the aims to switch the coolant to the working heat exchanger. In the mixer it is summing of heat from the two energy sources and is controlled by the temperature sensor. If

necessary or low temperature, the mixer can ensure coolant circulation in the loop of energy sources to produce a determined temperature. In this case, the system does not give up heat.

To realize the system is needed a heat consumer. The last link in this system is the heating part (HP). It consists of a pipe network and heating radiators, attached to it. The making method of heating part is irrelevant to the system. The heating part is a consumer of the produced heat energy. It can be maintained a number of other consumers, such as buffer tank and boiler for hot water.

On the basis of the proposed digital model, it has been developed a model (in "MATLAB SIMULINK" environment) to illustrate the work of the system and to simulate of different working modes.

CONCLUSIONS

The proposed digital model is an adequate one for a heating system of "green energy" type. The proposed model fully reflects the work of the system.

In the proposed model are used two types of alternative renewable energy sources. The system considers the joint use of the two types of energies.

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