SCIENTIFIC PAPERS

Series E

LAND RECLAMATION, EARTH OBSERVATION & SURVEYING, ENVIRONMENTAL ENGINEERING

Volume V

University of Agronomic Sciences
and Veterinary Medicine of Bucharest
Faculty of Land Reclamation
and Environmental Engineering

SCIENTIFIC PAPERS

Series E

LAND RECLAMATION, EARTH OBSERVATION & SURVEYING, ENVIRONMENTAL ENGINEERING

Volume V

2016
BucharesT

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

CERES Publishing House
Address: 1 Piața Presei Libere, District l, Zip code 013701, Bucharest, Romania
Phone: + 40 21 317 90 23, E-mail: edituraceres@yahoo.com, Webpage: www.editura-ceres.ro

To be cited: Scientific Papers. Series E. LAND RECLAMATION, EARTH OBSERVATION & SURVEYING, ENVIRONMENTAL ENGINEERING, Vol. V, 2016

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

International Database Indexing:
Index Copernicus; Ulrich's Periodical Directory (ProQuest); PNB (Polish Scholarly Bibliography);
Scientific Indexing Service; Cite Factor (Academic Scientific Journals) Scipio; OCLC; Research Bible

SCIENTIFIC & REVIEW COMMITTEE

SCIENTIFIC CHAIRMAN
Prof. univ. dr. Sorin Mihai CIMPEANU

Members*

- Alexandru BADEA - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Ioan BICA - Technical University of Civil Engineering Bucharest, Romania
- Daniel BUCUR – "Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine Iasi, Romania
- Stefano CASADEI - University of Perugia, Italy
- Fulvio CELICO - University of Molise, Italy
- Carmen CIMPEANU - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Delia DIMITRIU - Manchester Metropolitan University, United Kingdom
- Marcel DIRJA - University of Agricultural Sciences and Veterinary Medicine, Cluj, Romania
- Claudiu DRAGOMIR - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Eric DUCLOS-GENDREU - Spot Image, GEO-Information Services, France
- Ion GIURMA - Technical University "Gh. Asachi", Iasi, Romania
- Pietro GRIMALDI - University of Bari, Italy
- Jean-Luc HORNICK - Faculté de Médecine Vétérinaire, Université de Liège, Belgium
- Bela KOVACS - University of Debrecen, Hungary
- Ilias KYRIAZAKIS - Newcastle University - United Kingdom
- Raluca MANEA - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Florin MARACINEANU - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Sevastel MIRCEA - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Nelson PÉREZ-GUERRA - University of Vigo, Spain
- John OLDHAM - Scottish Agricultural College, UK
- Andreea OLTEANU - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Maria J. ORUNA-CONCHA - University of Reading, United Kingdom
- Marius Ioan PISO - Romanian Space Agency, Romania
- Maria POPA – "1 Decembrie 1918" University of Alba Iulia, Romania
- Dorin Dumitru PRUNARIU - Romanian Space Agency, Romania
- Gabriel POPESCU - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Dan RADUCANU - Technical Military Academy of Bucharest, Romania
- Jesus SIMAL-GANDARA - University of Vigo, Spain
- Ramiro SOFRONIE - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Marisanna SPERONI - Centro di ricerca per le produzioni foraggere e lattiero-casearie Sede distaccata di Cremona, Italy
- Razvan Ionut TEODORESCU - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Ana TORRADO-AGRASAR - University of Vigo, Spain
- Augustina TRONAC - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania
- Ana VIRSTA - University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania

**alphabetically ordered by family name*

CONTENTS

ENVIRONMENTAL SCIENCE AND ENGINEERING

SUSTAINABLE DEVELOPMENT OF RURAL AREA

DISASTER MANAGEMENT

WATER RESOURCES MANAGEMENT

POLLUTION CONTROL, LAND PLANNING

TOPOGRAPHY AND CADASTRE

EARTH OBSERVATION AND GEOGRAPHIC INFORMATION SYSTEMS

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

QUESTIONNAIRE ABOUT GREEN ROOFS AND THEIR RETENTION QUALITIES FEATURES

Zuzana POÓROVÁ, Zuzana VRANAYOVÁ

Technical University of Košice, Faculty of Civil Engineering, Vysokoškolská 4 Košice 042 00, Slovakia

Corresponding author email: zuzana.poorova@tuke.sk

Abstract

Current worldwide agenda about climatic changes is very serious. Situation about changing climate, ecological issues like heavy rains, flooding areas, impervious surfaces are highly debated issues. There are many ongoing researches focusing on these problems. The aim of this article is showing the results of the questionnaire focusing its questions on climatic changes, ecology and microurbanism in bigger detail and problematic of green roofs, their retention and some other qualities, ecological and economical features. The questionnaire is a part of ongoing research and the results will be used in the dissertation.

Key words*: changing climate, ecology, nature in city, green roof qualities.*

INTRODUCTION

A learner is by nature a questioner. If there is a drive in an individual to increase knowledge, skills or understanding it is driven by doubt, curiosity, wonderment, incomprehension, puzzlement, uncertainty, recognition of a need, or curiosity. This drive is then focused through questions that the learner formulates and actively seeks to find answers to. They may be simple questions that seek clear facts, or complex questions that probe deep into concepts, beliefs and understandings.
The question may provide an answer that solves the learning need or may lead to further questions as knowledge and understanding grows. It is obvious though, that however simple or complex an issue is, a good clear relevant question will be of far greater use to the learner than a question that is vague, poorly defined or irrelevant (Bond, 2011).

MATERIALS AND METHODS

Questionnaires provide a relatively cheap, quick and efficient way of obtaining large amounts of information from a large sample of people. Data can be collected relatively quickly because the researcher would not need to be present when the questionnaires were completed. This is useful for large populations when interviews would be impractical (Mc Leod, 2014).
The dissertation work Conception of green roofs in sustainability of water retention in Slovakia is focusing on the topic of green roofs and their retention qualities.
The questionnaire will be a part of the dissertation. Asked questions may provide answers that should be helpful to prove or disprove hypotheses asked in the questions.

Gender:
☐ male
☐ female

Age:
☐ 21-30
☐ 31-40
☐ 41-50
☐ >61

Education:
☐ secondary education
☐ higher education (1´st., 2´nd., 3´rd. degree)

☐ natural sciences
☐ technical sciences
☐ medical sciences
☐ agricultural sciences
☐ social sciences
☐ human sciences

Country where you currently live/work/study in?

Where do you live in?
☐family house
☐block of flats
☐other (specify) ...

1 Do you consider the question of the climate change as current issue?
☐yes
☐partially yes
☐don´t know
☐partially no
☐no

2 Do you think human migration (f. e. in North Africa) is related to the climate change?
☐yes
☐partially yes
☐don´t know
☐partially no
☐no

3 Are agreements like the Kyoto protocol (Framework convention on climate change) necessary?
☐yes
☐partially yes
☐don´t know
☐partially no
☐no

4 Are the questions of ecology important for you?
☐yes
☐partially
☐no

5 Would you like to be informed about possibilities how to protect the environment?
☐yes
☐don´t care
☐no

6 Is the lack of green areas in town affecting you?
☐yes
☐partially yes
☐don´t know
☐partially no
☐no

7 Are you familiar with building systems like: „Nature-Based Solutions“, „Re-Naturing Cities“?
☐yes
☐maybe yes, but I am not familiar with these terms
☐no

8 Do you think hard surfaces cause change in a microclimate in the local areas?
☐yes
☐partially yes
☐don´t know
☐partially no
☐no

9 Do you think building green roofs may affect change in a microclimate in the local areas?
☐yes
☐partially yes
☐don´t know
☐partially no
☐no

10 Is the legislation of green roofs secured in the country you currently live/work/study in?
☐yes
☐don´t know
☐no

11 Do you think building green roofs on new buildings and reconstructions should be mandatory?
☐yes
☐don´t know
☐no

12 Is there enough information about the green roofs in the country you live/work/study in?
☐yes
☐don´t know
☐no

13 Do you have any objections about the green roofs?
☐yes (specify)
☐no

14 Would you like to have a green roof on a building you currently live/work/study in?
☐yes
☐don´t care

☐no (specify)

15 What would be your reason to build a green roof?
☐saving money
☐technical specifications
☐ecology and sustainability
☐no reason
☐something else (specify) .

16 Which name of the roof in more common?
☐green roof
☐vegetative roof
☐don´t know

17 Do you know that green roof has retention features (ability to keep the water)?
☐yes
☐no

18 Can you imagine yourself using retained water, after filtration, for f. e. watering the garden, cleaning the car, washing clothes?
☐yes
☐no

19 If you built a green roof, in how many years would you expect the rate of return on the money?
☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐more than 15 years
☐ I am not interested in investing in building a green roof

20 Should owners of green roofs have financial benefits of sewerage charge?
☐yes
☐don´t know
☐no

Was this questionnaire educational?
☐yes
☐partially
☐no

RESULTS AND DISCUSSIONS

Basic information about the respondents:
These questions are to provide basic information about the respondents, their gender, age, education. Last two questions focus on where the respondent live. These questions will be the first criteria to evaluate the answers. So far, the questionnaire is answered by 55% men and 45% women. 42% in the age between 21-30 years, 29% in the age between 31-40 years, 96% finished their higher education, 77% are educated in technical sciences. 51% lives in family house, 58% in block of flats.

1. Hypothesis: Changes in climate
These questions (1-3) are to provide basic information about the respondent´s opinion about climate changes. Questions ask about the topicality of issues such as climate change, human migration and Kyoto protocol. These questions should prove/disprove the hypothesis of climate change, if it is happening or not. 67% consider the question of climate change as a current issue, only 15% think the human migration is related to the climate change and 56% think the agreements like the Kyoto protocol are necessary.

2. Hypothesis: Ecological issues
These questions (4-5) focus on the topic of ecology and its importance to the respondents. These questions are directly asking the respondents their opinion, there is no extra information needed to answer these questions because they are very personal. The aim of these questions is to have information if people are truly interested in these topics, or if it is only worldwide issue known thanks to few people in higher positions / activists. These questions should prove/disprove the hypothesis of ecological issue, if it is important nowadays or not. Ecology is important to 86% and 89% would like to be informed about the possibilities how to protect the environment.

3. Hypothesis: Problematics of microurbanism
These questions (6-9) are to provide basic information about the respondent´s opinion about microurbanism. Question about lack of green areas is personal; questions about affecting microclimate and the question about building systems need some background about the topic of microclimate and microurbanism. There are always 5 answers so the respondent can truly choose what he thinks about the topic

and answer honestly. The aim of these questions is to prove the fact that, if people see problem in microurbanism, they may see problem also in bigger scale. These questions should prove/disprove the hypothesis of microurbanism which is related to the previous hypothesis of ecological issues in smaller scale. 55% is affected by the lack of green areas, 37% is partially affected. 46% know building solutions based on nature, 44% think they know it. 48% think hard surfaces cause changes in microclimate, 32% partially agree. 48% think green roofs may change that, 42% partially agree.

4. Hypothesis: Legislation
These questions (10-11) are to provide information about legislation of green roofs where the respondents live. Second question is to make the respondent think and express his/her opinion. These questions should prove/disprove the hypothesis of legislation, its problems and topicality. Only 15% agree that the legislation in their country is secured, 60% don´t know.

5. Hypothesis: Green roofs
These questions (12-16) are to provide information about green roofs. Almost all yes/no questions end with the last question, where an opinion of the respondent is very important.
These questions allow people to express what they think in their own words. These questions should prove/disprove the hypothesis of green roofs, its necessity, topicality, importance in terms of all previous four hypothesis- change in climate, ecology, microurbanism and legislation. 40% think building the green roofs should be mandatory, 32% don´t know, 29% disagree. 53% say there is not enough information about this in their country.
76% have no objections about the green roofs. 79% would like to have a green roof on the building they live /study/work in. 73% agrees that building a green roof´s main reason is sustainability and ecology.
77% agree that more common name of this roof is green, not vegetative.

6. Hypothesis: Retention features
These questions (17-18) focus on the topic of retention qualities of green roofs. Second question should provide basic information about respondent´s opinion about using water from green roof. These questions should prove/disprove the hypothesis of retention features of green roofs, related to the previous hypothesis but more focused on its special features. 84% know about the retention features of these roofs. 86% can imagine using this water after the recycling.

7. Hypothesis: Economical situation
These questions (19-20) focus on the topic of economy. These questions should prove/disprove the hypothesis of economy related on the issue of green roofs.

8. Hypothesis: Education of people
Last question of the questionnaire is about the educational character of the asked questions. Aim of this question is to obtain the knowledge, if the questionnaire informed the respondents, if they learnt something new, if it was maybe helpful for them. According to this question, there might be an idea that people would like to be informed about current topics like ecology, microclimate etc. These questions should prove/disprove the hypothesis of the importance of education people nowadays. 39% expect the rate of return after building a green roof in max 10 years, 23% in max 20 years, 36% don´t know. 69% think that owners of these roofs should be financially benefited.

CONCLUSIONS

The aim of this questionnaire in the dissertation is to obtain as many opinions as possible. It is very well known and very useful tool how to get information about some problematic. Many researches begin with questionnaires, because they provide basic information about the topic. In 20 questions, for the dissertation Conception of green roofs in sustainability of water retention in Slovakia, many topics can be debated. The main idea of the questionnaire is to get information with the intention to make a conclusion about the topic of retention qualities of green roofs.

The idea is to prove or disprove this hypothesis: 1. change in climate, 2. ecology, 3. microurbanism.
These hypothesis are related to the hypothesis of: 4. green roofs, their 5. legislation, 6. retention features, 7. economy and current 8. education. The questionnaire has been online for 3 weeks. So far, 154 respondents answered all the questions. When 200 respondents will answer, the questionnaire will be evaluated following the criteria of the respondents and following each hypothesis explained above. Statistic method will be used to evaluate the questionnaires.

ACKNOWLEDGEMENTS

This work was supported by: VEGA 1/0202/15 Bezpečné a udržateľné hospodárenie s vodou v budovách tretieho milénia/ Sustainable and Safe Water Management in Buildings of the 3rd. Millennium

REFERENCES

Bond, T., 2011. The importance of questioning. Dairy and Animal Science, http://ictnz.com/importance ofquestioning.htm
Mc Leod, S., 2014. Questionnaires. Simply Psychology, http://www.simplypsychology.org/questionnaires.html

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE EFFECT OF CHROMIUM ON THE GROWTH OF *CHLORELLA PYRENOIDOSA* ALGAL CULTURES

Sebastian PLUGARU[1], Anca SARB[2],Tibor Zsolt HORCSIK[3], Tiberiu RUSU[1]

[1]Technical University of Cluj Napoca, Faculty of Materials and Environmental Engineering, 103-105 Muncii Boulevard, Cluj-Napoca, Romania
[2]Technical University of Cluj-Napoca, Faculty of Machine Building, Department of Engineering Design and Robotics, 103-105 Muncii Boulevard, Cluj-Napoca, Romania
[3]College of Nyíregyháza, Institute of Biology, H-4400 Nyíregyháza, Sóstói Boulevard 31/B

Corresponding author email: sebastian.plugaru@yahoo.com

Abstract

Different forms of chromium can be found in soil, water and even in the air. Around 60% ofthe chromium in the air is a result of human activities, the rest occurs naturally (by way of volcanic eruptions, fires). Gaseous chromium cannot be found in the atmosphere, chromium binds to the solid particles or to the atmospheric aerosol drops.
Most of the forms of Cr (VI) occur in the environment as a result of industrial activity, having chromite as main source, also known as iron and chromium chromate. The ideal composition is FeCr2O4.
The chromium in the water originates from dust from the air and cliff erosion. The chromium in freshwater varies in the range 0.1-800 mg/l. In polluted areas the values can be even higher. In natural waters Cr(III) and Cr(VI) is stable.

Key words*: toxicity, green algae, heavy metals, phytotoxicity.*

INTRODUCTION

This paper studies the effects of a toxic heavy metal ion, Cr(VI), in addition to Cr(III), on certain growing processes of *Chlorella pyrenoidosa* green algae. *Chlorella pyrenoidosa* is commonly used in biochemical and biological stress experiments due to its photosynthetic apparatus resembling that of higher plants, and its fast reproduction. For that reason, the experiments with *Chlorella pyrenoidosa* can be carried out in large numbers and with multiple repetitions; they are easily reproducible and controlled.

Living beings assimilate from the environment the materials, implicitly various metal ions, necessary for the organism and metabolism development. When the concentration of toxic (or essential) metal ions in the environment, that can be assimilated, a certain threshold is reached leading to the inhibition of a series of metabolism processes of living beings, which in this case may cause the death of the living being. Subjected to the stress of heavy metals, these organisms try to decrease the degree of toxicity as much as possible.

Interest in chromium comes from its large scale usage, given that the metallurgical, paints, electrochemical and leather industries release chromium in high quantities in the liquid, solid and vapour form, thus causing major biological and ecological problems. Chromium can be found in countless states of oxidation, although only Cr(III) and Cr(VI) is fairly stable in nature, Cr Cr (IV) and (V) are unstable intermediaries in the redox transition of Cr(III) and Cr(VI).

The ratio of the two forms of chromium is determined by the physical and chemical parameters of the environment. In a well oxygenated, pH≥7 environment, the presence of CrO_4^{2-} ions is expected, while Cr(III) ions are expected in a poorly oxygenated, pH≤6 environment. This is greatly influenced by the oxidation and reduction agents and by molecules capable to produce complexes. Except for the aerated surface waters with a higher level of oxygen, Cr(VI) occurs in the form of H_2CrO_4 only at a low pH level. Within the normal pH values of natural waters, Cr(III) occurs in the form of hydro-complexes, organic complexes and less mobile Cr(OH)3 precipitations, but in this case the production of complexes lowers the precipitation production possibility. Depending on environmental conditions, Cr(VI) knows many forms and their

solvability and agility is significantly higher than that of Cr(III).
According to current knowledge, Cr(III) is essential to human and other living beings, it has an important role in the normal functioning of the lipids and glucose metabolism. In the case of Cr (VI), however, toxic and teratogenic effects are known to exist.
Plants, primarily due to solvability aspects, cannot assimilate Cr(III), and Cr(VI) has a toxic effect, especially in higher concentrations.

THE INTERACTION OF CHROMIUM AND MICRO-ORGANISMS

Research on the interaction between algae and metals has a significant past.
Experiments regarding Chromium began in the 70s, followed by a long pause; however, interest has grown in recent years.
Meisch and Schmitt-Beckmann researched the effect of Cr(III) and Cr(VI) compounds of various compositions on a strain of wild and laboratory *Chlorella.*
In the case of low concentrations, both a growth and a photosynthesis stimulating effect was observed, while in the case of higher concentrations the decrease of the cell reproduction and size was observed, as well as the inhibition of chlorophyll synthesis (Meisch and Schmitt-Beckmann, 1979).
In the case of *Glaucocystis nostochinearum* the EC_{50} value was observed to be 1 mg dm^{-3} and in atomic absorption research a notable Chromium accumulation was observed (Rai et al., 1992).
Metal accumulation and toxicity symptoms - the chlorophyll concentration, protein content, and the nitrate and nitrite reductase - have been shown to be dependent on concentration (Rai et al. 1992).
In the study of individual and combined effects of several toxic heavy metals (Cu, Cr, Ni) synergistic effects in growth, photosynthetic activity and the chlorophyll synthesis in the case of *Chlorella pyrenoidosa* 251 were observed.
In the case of heavy metals used individually in the study of the algal species, toxicity decreased towards Cu, Cr, Ni (Wong and Chang, 1990).

MATERIALS AND METHODS

In the preparation of the culture medium the purest compounds available on the market were used. The Bacto Agar used in the solid culture medium.
The growth medium used for incubating the algae is a standard medium containing a wide range of nutrients to ensure the natural growing conditions of the organism.
All vessels used for the test are made of glass, glass is known as an inert material.
In our studies we used the green algae *Chlorella pyrenoidosa* (IAM-128) in the collection at the Department of Microbiology at the University of Szeged, Hungary. The algal cells were kept in a solid culture medium and sterility was maintained. The algal cells were cultivated in special 500 ml algae growing vessels, in a liquid C-30 modified culture medium, in a sterile medium at 25°C. Table 1 features the composition of the culture medium. Trace elements were added to the medium substrate from the basic solution prepared beforehand. For the inoculation, I have calculated and used an amount necessary to obtain a 10^4 cells/ml initial cellular density which proved to be optimal for growing experimental cultures. During the 72 hours test period, the daily density of the algae suspensions in each test recipient was tested by using a Thoma chamber and a microscope.
The results were then subjected to statistical analysis.

Table 1. Trace elements

KNO_3	2.02 g
KH_2PO_4	0.113 g
K_2HPO_4	0.087g
$MgSO_4x7H_2O$	0.24 g
$CaCl_2x6H_2O$	0.037 g
$NaHCO_3$	1.0 g
Fe (Fe^{2+}-EDTA)	5 mg
H_3BO_3	1.43 mg
$MnCl_2x4H_2O$	0.905 mg
$ZnSO_4x7H_2O$	0.111 mg
$CuSO_4x5H_2O$	0.0395 mg
$Na_2MoO_4x2H_2O$	0.0126 mg
NH_4VO_3	0.0115 mg
Co $(NO_3)_2x6H_2O$	0.0245 mg

RESULTS AND DISCUSSIONS

As Cr (III) $Cr_2(SO_4)_3$ was used , and as the compound Cr (VI) ($Na_2Cr_2O_7$). When cultures of algae reached 10^4 cell/ml in the culture medium, the algae were treated with 1-10 mg ions of Cr(III) and Cr(VI) with the help of basic solutions prepared in advance. Untreated cultures in identical conditions were used for each experiment. After applying the treatments, the algae were cultivated for 48-72 hours.

I studied the algae cell growth using several methods:

a./by counting cells using a cytometer

b./in the case of a low cell number I performed orientation measures using photometry on 600 and 660 nm (Rodrigues and Lopez, 1964).

The effect of Chromium on the growth of *Chlorella pyrenoidosa.*

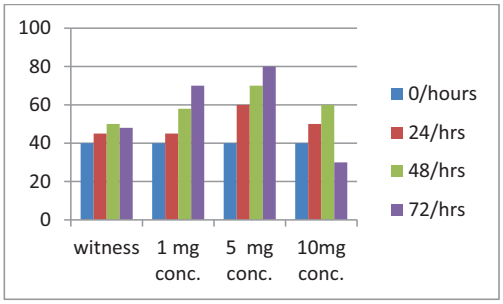


Figure 1. The evolution of cell growth in the presence of Cr III

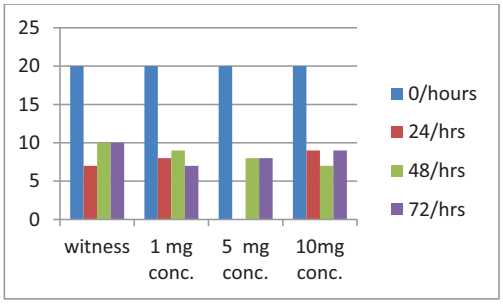


Figure 2. The evolution of cell growth in the presence of Cr VI

I studied the effect of Cr(III) and Cr(VI) with increasing concentration on various growth parameters of *Chlorella pyrenoidosa.* Although the published literature points out that Cr(VI) is significantly more toxic than Cr(III), I performed measurements with $Cr_2(SO_4)_3$ besides $K_2Cr_2O_7$.

The results show that not even in a 1-5 mg concentration did Cr(III) significantly affect the green algae growth parameters; it did not produce any significant differences in relation to the control medium. At a 5 mg concentration a slight increase in the algae cells can be observed. This happens due to the chemical properties of Cr(III) because it is found in nature in the form of various precipitations depending on the pH conditions. Depending on the soil conditions and the medium of the roots, in the case of land plants, the electrochemical features and the pH of the soil allow for the Cr(III) → Cr(VI) transformation, if the Cr(VI) form is possible (Kotás and Stasicka, 2000).

The measurement data are similar to data from the published literature, where, except a few cases, Cr(III) is not considered toxic for plants (Samantaray et al. 1998).

In the case of treatment with 1 mg concentration Chromium, there are no significant differences between the control and the treated samples. As for the content of solid material, the cell and chlorophyll number, there was no difference observed at this concentration.

However, the increase in the concentration of Cr(VI), has produced a significant decline both in terms of the density of cells and cell number. At a concentration of 5 mg, significant modifications in relation to the control sample took place.

Crops treated with 1-5 mg concentration Cr(VI) showed chlorotic symptoms.

The algae cells removed from the culture recipient containing 5 mg concentration Cr(VI) did not reproduce anymore when they were placed in a fresh, Cr(VI)free culture medium. The data suggest that the lethal concentration of Cr(VI) in the case of *Chlorella pyrenoidosa* is 10 mg.

CONCLUSIONS

The ratio of the two forms of chromium is determined by the physical and chemical parameters of the environment.

In a well oxygenated medium with a pH≥7 the presence of CrI_4^{2-} ions is expected and in a medium poor in oxygen and with a pH≤6 the

presence of Cr(III) ions is expected, this being influenced greatly by the potential oxidation and reduction agents and the molecules capable of producing complexes.

According to current knowledge Cr(III) is essential to humans and other living things and plays an important role in the normal functioning of the metabolism of lipids and glucose.

However, in the case of Cr(VI) we do know that it has toxic and teratogenic effects.

Plants - primarily because of solvency issues - cannot assimilate Cr(III), and - especially in larger concentrations -Cr(VI) has toxic effects. The study of plant tolerance to Chromium is just the beginning, physiological and biochemical aspects are mostly unexplored.

REFERENCES

Kotás, J., Stasicka, Z., 2000- Chromium occurence in the environment and methods of its speciation. Environ. Poll. 107: 263-283.

Meisch, H.U. and Schmitt-Beckmann, I., 1979- Influence of tri- and hexavalent chromium on two Chlorella strians. Zeitschrift für Pflanzenphysiologie, 94:231-239.

Rodrigues, M., Lopez, M., 1964- Influence of the inoculum and the medium on the growth of Chlorella pyrenoidosa. Nature, 203: 66-67.

Rai,D., Eary, L.E., Zachara, J.M., 1989-Environmental chemistry of chromium. Sci. Tot. Environ., 86: 15-23.

Samantaray, S., Das, P., 1991- Effect of chromite minewaste on seed germination, growth, biomass yield of Oryza sativa L. cv. Panthara. Orissa J. Agric. Res. 1991, 4: 1-6.

Wong, P.K. and Chang, L.,1991-Effects of copper, chromium and nickel on growth,photosynthesis and chlorophyll a synthesis of Chlorella pyrenoidosa. Env. Poll., 72: 127-139.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

STUDY ON MONITORING OF *CANIS LUPUS* L. POPULATIONS WITHIN THE NATURAL PROTECTED AREA FROM THE NORTH-WESTERN GORJ COUNTY

Irina-Ramona PECINGINA[1], Roxana-Gabriela POPA[1], Bogdan-Andrei GATEJ[2]

[1]"Constantin Brancusi" University of Targu Jiu, Eroilor Street No. 30, Targu Jiu, Gorj, Romania
[2]Administration of the Protected Natural Area the North of Western Gorj, Targu Jiu, Romania

Corresponding author email: irinacornescu@yahoo.com

Abstract

The Gorj County is located in the south-western part of the country, in northern Oltenia, on the Middle Jiu river. The physical-geographical framework reflects the richness and the diversity of the flora and the fauna of the county, too. The wolf (Canis lupus L.), together with the brown bear (Ursus arctos L.) and the lynx (Lynx lynx L.),is a priority species of European interest whose conservation requires the designation of the special conservation areas. To monitor the wolf populations (Canis lupus L.), it used both passive and active methods of study in the field. The monitoring period was between May 2014 and June 2015. During the researches done in the field, the Canis lupus species was identified within the ROSCI0129 site the North of the Western Gorj in the following areas: Bumbesti –Jiu area, forest habitat 1100 m altitude; Runcu area, forest habitat 1120 m altitude, Pestisani area, forest habitat 1633 m altitude,Tismana area, forest habitat 1140 m, altitude Motru area, forest habitat 1130 m altitude, Stanesti area 1280m altitude.The habitat area of Canis lupus was evaluated according to the field analyses at 40039.73 ha, related to the ROSCI0129 Site the North of the Western Gorj. The repartition area is stable, with a habitat enough extended to ensure the long-term surviving of the species.After the analyse of the gathered datas, it is considered that the increase of the wolf herd whose territory overlaps with the study area is of 75 specimens.76

Key words: *Natural Protected Area*, *Canis lupus monitoring.*

INTRODUCTION

The Gorj County is located in the south-western part of the country, in northern Oltenia, on the Middle Jiu river. The Parallel 45 crosses through the middle of the county and at the south of the Targu-Jiu city, its neighborhoods being at north Hunedoara County, at north-west Caras-Severin County, at east south-east and south-west Valcea, Dolj and Mehedinti counties, having a total area of 5.602 km^2, 2.3% of Romania territory.

The Relief of the county is various, including three major stages: mountains, Sub-Carpathian hills and the northern extremity of the Getic Plateau. The mountains cover 30% of the county area. The Sub-Carpathians hills (400 – 800 m altitude) go from Oltet as far as Motru, where they link with the mountains. At south of the Sub-Carpathians area, the relief is still high, the hills of the Getic Plateau are like ridges which go down to the south.

The climates temperate-continental with mild mediterranean influences, with a annual average temperature of 10.3^{0}C. The hydrographic basin of the Gorj county covers the Jiu river (the middle course) which run through Lainici Pass, to the confluence with the Gilort river, gathering the waters on an area of 10469 km^2, The river Jiu increases its flow gathering the waters of the Tismana, Orlea, Bistrita, Jales, Susita, Sadu, Amaradia, Cioiana rivers. Others important rivers of the county are: Gilort, Oltet and Motru.

The Carpathian region of the Romania, though represents less than 2% of the Europe area, supports viable and stable populations of large carnivores: 30% of european effectives of wolves, 35% of effectives of brown bears and 25% of effectives of linxes. These large carnivores represent symbol species for the preservation of the biodiversity in Europe. They have an important role in the ecosystem exercising the "top-down" control on large

territories over the prey populations. Thus, the presence of these species indicates natural habitats with a high ecological value and functional ecosystems, which can be a model for the ecological reconstruction in other regions of Europe.

The physical-geographical framework reflects the richness and the diversity of the flora and the fauna of the county, too.

The large carnivors (the bear, the wolf, the linx) are top species of the trophic pyramide and are considered to be the key species in the operation of the ecosystem, implicitly in the maintaining balance in the ecological communities.

The Protected Natural Area the North of Western Gorj ROSCI0129 occupies an area of 86.958 hectars in 9 townships of the Gorj County - Bumbesti-Jiu (7%), Godinesti (8%), Pades (23%), Pestisani (69%), Runcu (86%), Schela (84%), Stanesti (67%), Tismana (82%) and Turcinesti (2%), and in 3 localities of Hunedoara County: Lupeni (<1%), Uricani (3%) and Vulcan (<1%) and the Baia de Arama locality (<1%) of Mehedinti County, too.. The geographic coordinates: 23˚4'44″ east longitude, and 45˚9'5″ north latitude. Altitude: maximum -1940m, medium - 835m, minimum -192m. (Figure 1)
(http://www.rezervatiagorjului.ro)

From the point of view of the use of the land in the area, with refferences specially at the major habitat types, the Protected Natural Area the North of Western Gorj is mainly coverd by mixed forests and broadleaf forests (Figure 2)(http://www.rezervatiagorjului.ro)

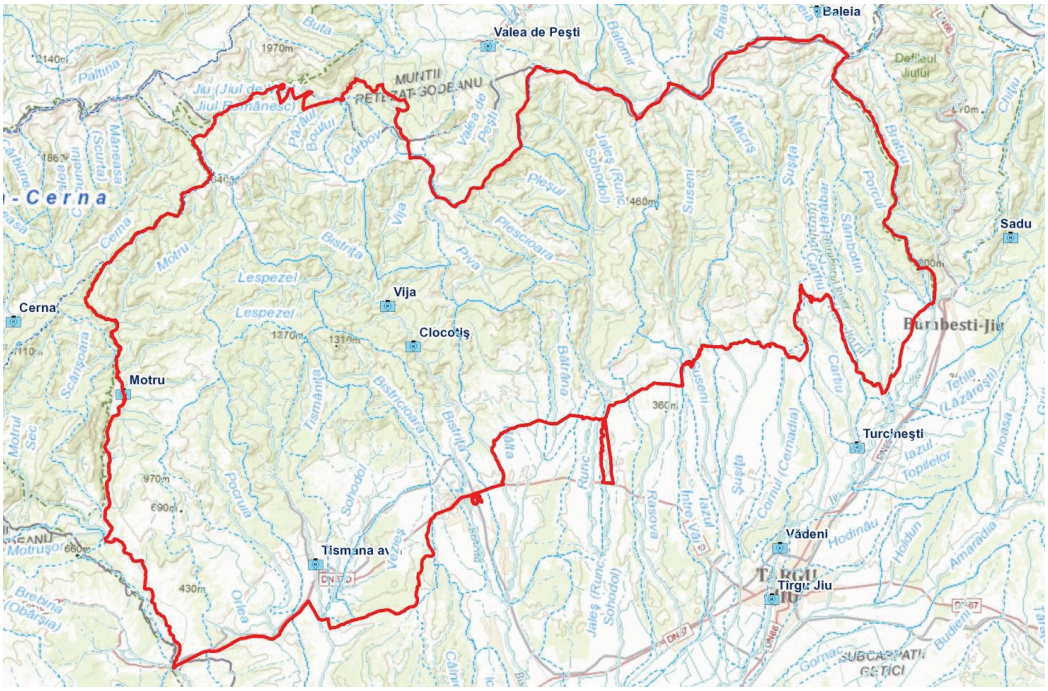


Figure 1. The limit of the Protected Natural Area the North of Western Gorj

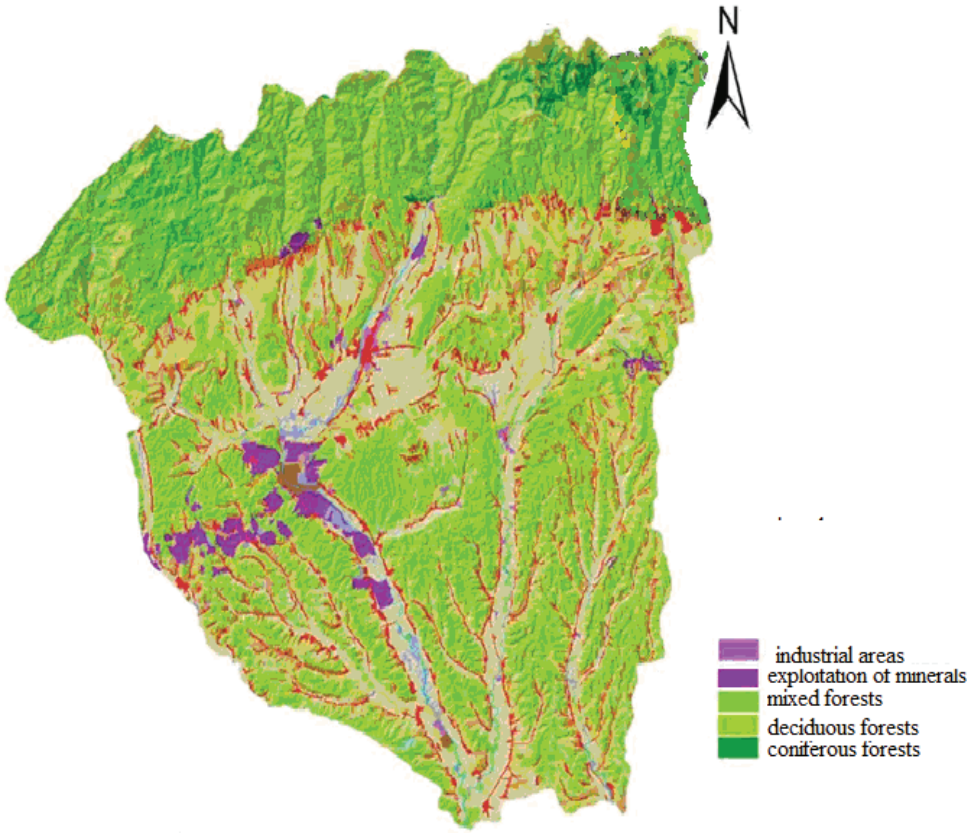


Figure 2. The location of the Protected Natural Area the North of Western Gorj in the Gorj County, with refferences of the using way of the land

MATERIALS AND METHODS

The wolf (*Canis lupus* L.), together with the brown bear (*Ursus arctos* L.) and the lynx (*Lynx lynx* L.), is a priority species of European interest whose conservation requires the designation of the special conservation areas.
The increasing of the accuracy of estimating populations of the wolves is a fundamental requirement for an efficient management of the wild mammals populations according to the sustainable management principles of the natural patrimony and it is an European Union requirement.
To assess the presence of this species and to count his number within the project area, within the adjacent areas, too, it uses various methods, for some periods of time, opting for concurrent application of two or more evaluation techniques, to gather a larger quantity of data.
To monitor the wolf populations (*Canis lupus* L.), it used both passive and active methods of study in the field (Linnell, J.and al.1998).
The monitoring period was between May 2014 and June 2015.

- **Passive study methods in the field**

- The evaluation of the species presence by continuous monitoring method

The continuous monitoring method of some interest locations using photo cameras/ cameras with infrared motion sensor implied the placing of 20 photo- and cameras equiped with motion sensors.
To offer an increased visibility, the cameras were placed at 3-5m on the tree trunks, being oriented with IR sensor downward. One

exception has been made in the case of CAM 5 from area 1, which it was placed at the base of a tree, at the height of 0.5 m, being later camouflaged with branches and dried leaves. It opted for this decision to increase the sensibility of the sensor by reducing the distance from the subject. (Figure 3).

The type of the camera choosed for this study took into account of these aspects, linked to the parameters of the study and of the land from the interest location.

All the 20 cameras equiped with shutter system with IR sensor.

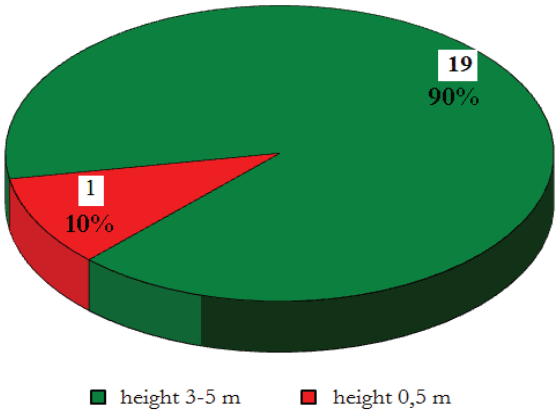


Figure 3. The placing of cameras depending on the height location

Figure 4. The location of the cameras with automatic shutter systems with IR sensor

Figure 5.Camera PNI type Hunting Camo 2.6 C with IR sensor and automatic shutter

It opted for shutter system cameras (with IR sensor) because the only impediment raised by this type of cameras is the false shooting (determination of objects which, from various reasons or actions, cross the shutter ray and initiate the photo recording), but this aspect can be surpassed equiping the monitoring cameras with high capacity data storage medium and ensuring the frequency of the maintenance visits thus the time between two such consecutive visits is no more than half of life span of the batteries (for a charging cycle) and than the necessary time to charge with records of maximum half of storage medium. In this respect, at the initial placing of the cameras did higher frequency maintenance visits to observe the records accumulation rate and the energy consumption rate of the

batteries, the final decision being to set time between two consecutive visits at maximum 3 weeks.

The monitoring cameras with IR active sensor shutter set to record data and time of each photo and, at the same time, opted to achieve three succesive shots, at 1 second time one from each other, to ensure the data redundancy and to not leave out important elements to be catalogued.

The collected imagines were grouped in files pointing the location area and the record period (from the last maintenance visit to that were downloaded those images) to allow the evaluation of the time parameter of the records.

The aim of cameras mounting was representated by the evaluation of the interest species occurence in the field, and of the wild prey species, too.

Initially there were selected 6 monitoring areas, chosen according to the preliminary map of the species occurence in the interest area, made based on the data analyse offered by the Hunting Funds, to identify the frequented areas by the wolf, bear and linx within the Protected Natural Area the North of Western Gorj perimeter.

Intercurrent, the 6 monitoring areas were kept, but the monitoring cameras were relocated in other locations from these areas. (Figure 6.)

According as the land structure (relief and vegetation) allowed, the monitoring areas were placed at relatively equal distances from each other.

Covering the period dedicated to continuous monitoring, the cameras were installed in the interests locations.

In table 2 are shown the data regarding the number of camera placed in each location, the data regarding the type and the definition, and the data regarding the lifetime for each of them.

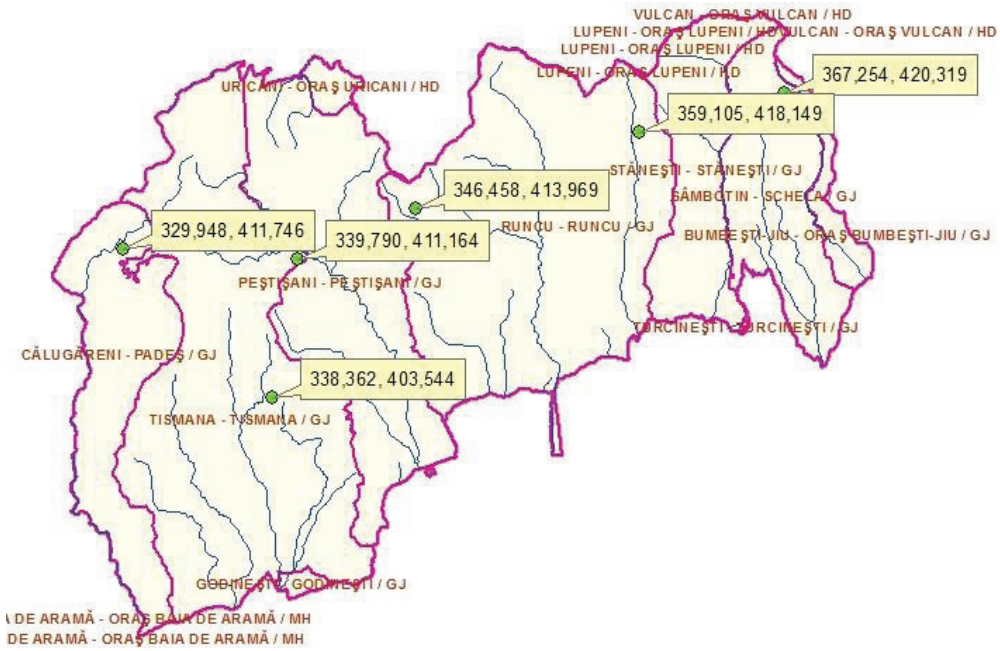


Figure 6. The preliminary map of the interest area with placing of the continuos monitoring areas

Table 1. The camera locations, their type and the lifetime

Camera detection	Exemplary chamber	Resolution (megapixel)	Location(area)	Surveillance time(interval)	Monitoring time(interval)
CAM 1, 2, 4	PNI Hunting Camo 2.6 C	12	1. Pades (Alunu)	20.06.2014-30.06.2015	405
CAM 13, 14, 15	PNI Hunting Camo 2.6 C	12	2. Tismana (Silea and Pietricica)	20.06.2014-30.06.2015	405
CAM 10, 11, 12	PNI Hunting Camo 2.6 C	12	3. Bistrita (Leordile)	20.06.2014-30.06.2015	405
CAM 7, 8, 9, 20	PNI Hunting Camo 2.6 C	12	4. Runcu (Gropu Sec)	20.06.2014-30.06.2015	405
CAM 3, 5,6	PNI Hunting Camo 2.6 C	12	5. Susita (Valea Rea)	20.06.2014-30.06.2015	405
CAM 16, 17,18, 19	PNI Hunting Camo 2.6 C	12	6. Schela (Valea Porcului, Haraboru andComanda)	20.06.2014-30.06.2015	405
Cumulative time monitoring (all camera, all locations)					**2430**

- **Active study methods in the field**

Specific density evaluation methodbased on collection and interpretation of „transect" data type, consisting of counting the traces of path and pattern types which cross a preset study route, eventually a study route periodically verified and with historical (annual) reply.The technique consists in the counting by an observer of the incidence of the path type traces with a longitudinal transect parallel with the longest side of the interest perimeter for the study.

For a better space correlation of data, it makes a variable number of such parallel transects, with various distances between them, at random chosen and depending on the structure of the land (relief, accessibility level in the cold season, etc.).

For each location (representing the intercross of a path trace, that means of a pattern type trace row, with the study transect) it is noted the GPS position and the sample size (the specimen number, the number of the parallel paths which cross the transect in that location).

The Wolf Abundance Index interprets this data reporting the number of the individual records (the sample size) to a meter variable, generally represented by the length of the transect made by the observator and conventionally expressed in kilometers. Though the dimension of the interest area of the project is reduced, suggesting in this respect the use of a low measure scale for the metric variable (in meters), we preferred the conventional use (in kilometers), though this aspect offered sub-unitary values for this variable. It opted for this pattern because we aimed to obtain some values conventionally expressed, to allow the comparison with the values of the Wolf Abundance Index resulted of other similar studies, in other locations. (Crete, M., and F. Messier, 1987).

The formula for Wolf Abu used in this study, according to Stolyarov, V.P, Vorobei, N.N., Ivanova, N.V., Jedrzejewska, B., Litter size, sex ratio and age strucure of gray wolf, *Canis lupus*, *Ursus arctos, Lynx lynx* in relation to population fluctuations in northern Belarus is the following:

$$WAI = \frac{n}{L * z}$$

Where:

- WAI= Wolf Abundance Index;
- n= the number of individual traces of path type which cross the transect;
- L= the transect length made by the observer
- z= the correction factor of trace time accumulation, representing the number of days from the last snowfall, which could covered the last traces.

WAI does not represent a dimension of the numerical herds, but rather an image of the intensity of the interest species activity within an area or a measure of the abundance index in that location.

The criteria used in the recognition of the wolf traces summarize various aspects related to the geometry and the size of the traces, but various particular aspects which can indicate the membership of the paw print:

- the presence of all 4 claw print or of their traces in the snow/humid soil (always);
- the positioning of fingers 2 and 5 behind the fingers 3 and 4 (the line which unify the fingertips 2 and 5 crosses the print of the fingers 3 and 4 below of their half);
- the traces of the finger claws 3 and 4 converge, different of dog traces which are divergent
- the angle previously created by the back „pad" is sharp for the wolf trace, compared to the dog;
- the aspect of path type trace is rectilinear (wolf0, not meander (dog).

Figure 7. Trace of pattern type from one lone adult wolf (*Canis lupus*)

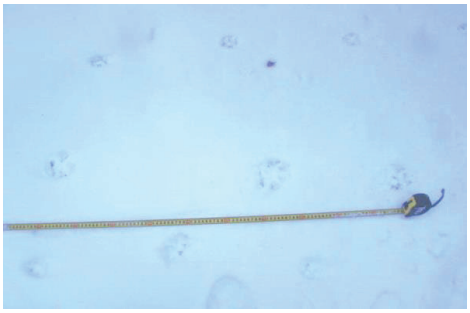


Figure 8. The measuring of a path type trace

RESULTS AND DISCUSSIONS

Because the *Canis lupus* species (the wolf) is particularly elusive, avoiding mainly the contact with the man or the proximity to the human settlements (with the exception of the moments in which they attack the domestic animal stocks, in the years with diminished food resources), presented low densities compared to other species, on the hand, due to the fact that the average of the territory dimension for this species is very big (the central area of the pack covers, average, 35 km^2,average for the populations in the whole world, for Romania, this value being bigger, between 50 km^2- 150 km^2) – the pack spends in this area over 50% of time), but the territorial shifting phenomenon is frequently in the cases when the prey species (domestic or wild) do seasonal migrations, it recoursed to the inventory of the wolf population in the adiacent areas of the perimeter, in the cases when it was found the presence of the species in these locations.

The wolf species distribution (*Canis lupus* L.*)*within the Protected Natural Area the North of the Western Gorj (ROSCI 0129) was evaluated by addition of the used methods. (Figure 9).

During the researches done in the field, the *Canis lupus* species was identified within the ROSCI0129 site the North of the Western Gorj in the following areas:

- Bumbesti –Jiu area, forest habitat 1100 m altitude;
- Runcu area, forest habitat 1120 m altitude,
- Pestisani area, forest habitat 1633 m altitude,
- Tismana area, forest habitat 1140 m, altitude,
- Motru area, forest habitat 1130 m altitude,
- Stanesti area 1280m altitude.

The habitat area of *Canis lupus* was evaluated according to the field analyses at 40039.73 ha, related to the ROSCI0129 Site the North of the Western Gorj. The repartition area is stable, with a habitat enough extended to ensure the long-term surviving of the species.

After the analyse of the gathered datas, it is considered that the increase of the wolf herd whose territory overlaps with the study area is of 75 specimens(13 specimens at Bumbeşti, at Pestisani 14 specimens, at Tismana 14 specimens,at Runcu 10 specimens, at Motru 10, and at Stanesti 14 specimens (two packs). (Figure 10)

It is possible that, some specimens belonging to the same group, to dwell in various areas of the Hunting Funds which do not cover the interest area (the perimeter of the Natural

Area from North-Western Gorj County) or some specimens belonging to other packs to adventure occasionally searching for food within the dwelling pack territory, though the probability of that fact is quite low, because to the aggressive character shown by the species to defend the territory borders. If this fact is possible, then the occurrence areas of the intruders must be found, most probably, in the minimum occurrence area of the dwelling herd).

From the point of view of the time presence of the species within area, it is noted that the species occurence within the interest area covers only the cold season (all the pack specimens) and it is extended (for the male – datas obtained using the continuous monitoring method by photo cameras with IR) and in the spring period (in may), when probably, this frequens this area searching for food, because of the increased needed of the pack and of the lower available pack members for the hunting (only the male and eventually the last year sub-adults can hunt, the female being occupied with the pups care) (Table 2).

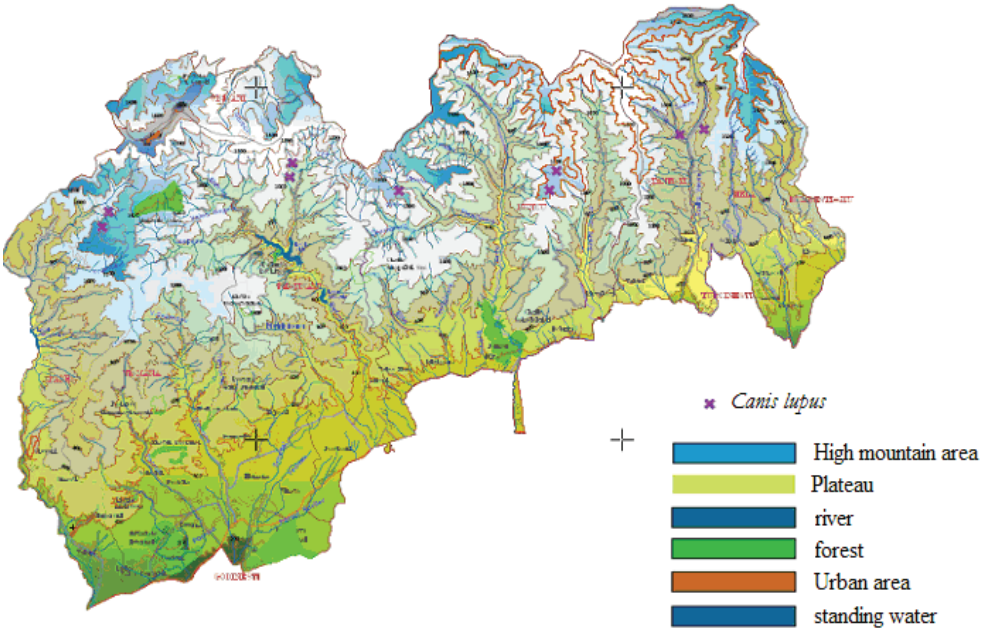


Figure 9. The distribution map of the *Canis lupus* species within the study perimeter

Figure 10. Specimens of wolf surprised by the photo- / cameras with infrared sensor

Table 2. The calendar of the species presence in the natural area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
The presence of the species												

It is possible that, some specimens belonging to the same group, to dwell in various areas of the Hunting Funds which do not cover the interest area (the perimeter of the Natural Area from the North- Western part of the Gorj County) or some specimens belonging to other packs to adventure occasionally searching for food within the dwelling pack territory, though the probability of that fact is quite low, because to the aggressive character shown by the species to defend the territory borders. If this fact is possible, then the occurrence areas of the intruders must be found, most probably, in the minimum occurrence area of the dwelling herd).

From the point of view of the time presence of the species within area, it is noted that the species occurence within the interest area covers only the cold season (all the pack specimens) and it is extended (for the male – datas obtained using the continuous monitoring method by photo cameras with IR) and in the spring period (in may), when probably, this frequens this area searching for food, because of the increased needed of the pack and of the lower available pack members for the hunting (only the male and eventually the last year sub-adults can hunt, the female being occupied with the pups care) (Table 2). (Cirtina D., Gamaneci Ghe, 2015).

CONCLUSIONS

To monitor the wolf populations (*Canis lupus* L.), it used both passive and active methods of study in the field.

The monitoring period was between May 2014 and June 2015.

The wolf species distribution (*Canis lupus* L.)within the Protected Natural Area the North of the Western Gorj (ROSCI 0129) was evaluated by addition of the used methods.

During the researches done in the field, the *Canis lupus* species was identified within the ROSCI0129 site the North of the Western Gorj in the following areas:

- Bumbesti –Jiu area, forest habitat 1100 m altitude;
- Runcu area, forest habitat 1120 m altitude,
- Pestisani area, forest habitat 1633 m altitude,
- Tismana area, forest habitat 1140 m, altitude
- Motru area, forest habitat 1130 m altitude,
- Stanesti area 1280m altitude.

After the analyses of the gathered datas, it is considered that the increase of the wolf herd whose territory overlaps with the study area is of 75 specimens.

ACKNOWLEDGEMENTS

The datas were collected from the monitoring activity of the large mammals species of wolf, bear, linx, of european interest from the Protected Natural Area the North of the Western Gorj within „.The monitoring of the species the Nature 2000 – large carnivors, respectively the creation of a visiting center of the protected natural area ROSCI0129 the North of the Western Gorj” project141076/17.06.2013

REFERENCES

Cirtina D., Gamaneci Ghe, 2015, Study *Regarding the Elaboration of Certain Management Measures of the Protected Area Oltet Gorges, Gorj County – a Premise of the Sustainable Development,* Journal

of Environmental Protection and Ecology, Book 2, Vol.16/2015, pag. 667-675, ISSN 1311-5065**.**

Crete, M., and F. Messier, 1987,*Evaluation of indices of gray wolf, Canis Lupus, density in hardwood-conifer forests of southwestern forests of southwestern* Quebec, Canadian Field-Naturalist 101:147-152.

Linnell, J., J. Swenson, A. Landa, and T. Kvam. 1998. *Methods for monitoring Europeanlarge carnivores - a worldwide review of relevant experience*. Norwegian Institute forNature Research, Oppdragsmelding 549, Norway.

http://www.rezervatiagorjului.ro/web/Arhiva-Stiri-/Situl-de-importanta-comunitara-ROSCI0129-NORDUL-GORJULUI-DE-VEST-419.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

RESEARCH OF MORPHOLOGICAL PROCESSES INTO THE MOLDOVA RIVERBED USING PERIODIC TOPOGRAPHIC MEASUREMENTS

Anca BALAN, Mihail LUCA, Daniel TOMA

"Gheorghe Asachi" Technical University of Iasi,
63 Dimitrie Mangeron Blvd., 700050, Iasi, Romania

Corresponding author email: anca_balan2003@yahoo.com

Abstract

The floods occurred on Moldova River, during 2004-2015 changed the minor bed in Soci area. In this area it is embedded the undergoing Timișești-Iași adduction pipe. The undergoing section morphological changes have influenced the vertical and horizontal minor bed stability. Morphological changes were monitored by topographical surveys. The leveling surveys of research area were updated after each flood. There were made cross section and longitudinal section of the riverbed in the research area. By processing the topographical series of surveys it result the riverbed changes under the action floods. The longitudinal and cross sections indicated the riverbed hydrodynamic erosion parameters. The data collected and processed allowed the design of the breastwork in the area where the headrace ducts under-cross the river.

Key words*: river, flood, morphological process, topographical surveys, hydrodynamic erosion.*

INTRODUCTION

Floods are natural events being part of the natural course of normal events into a drainage area. Spatial distribution and floods amplitude are caused flash by natural and anthropogenic factors. Most high floods are caused by meteorological factors. Floods action is different depending on the environment where they take place. Triggering floods in the warm season is especially given by the downpour. Characteristic of these floods is the sudden increase in flow and level in the river bed in a very short time.

The floods period from summer beginning has an annual frequency. But the beginning and magnitude of floods are varying widely during the year.

Flood wave is moving through the riverbed and then through streambed. The flood wave can have one crest (monounda) or several crests, based on the sequence of occurrence of precipitation. Flash floods cause significant morphological changes in rivers with eroded riverbeds.

The construction works located in erodible riverbeds are highly degraded by flood actions. The breastworks are partially or totally destroyed by disaster nature floods. After such a flood is likely that the breastworks could lose the role for witch this was made.

Morphological changes of the river bed can be studied by various methods. Topographic measurements at intervals allow analysis of the evolution of the riverbed in the longitudinal and cross sections.

MATERIALS AND METHODS

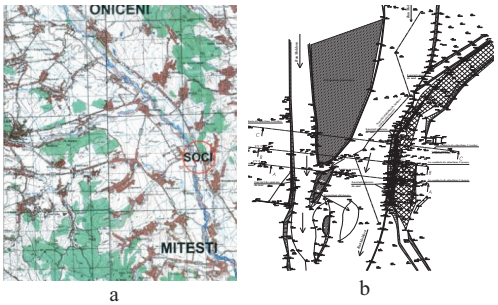
The research was performed on a section of Moldova River within the city of Soci, Iasi County (Fig. 1a).

In this section are riverbed regularization and bank protection works. The work was carried out to protect the under-crossing construction of the three adduction ducts with 1000 mm diameter.

Moldova River Basin has an area of 4299 km^2. River water supply is achieved through collected on the western side of the Eastern Carpathians.

The Moldova River basin presents a moderate continental hydroclimatic regime.

The flow in the river is characterized by frequent discontinuities of temporal and spatial hydrological parameters. Rainfall in some periods of time presents a character strongly randomly



a b

Figure 1. Map of studied area:
a – research area on the Moldova River;
b – Land survey on investigated river section in 2005

Conditions of leakages into the Moldova River basin vary with in a large particularity in time and space, with an obvious torrential type. The high degree of torrential character is highlighted by extreme values multiannual leak. The ratio of maximum flow rate at low historically and is about 1.000 higher coefficient values are present torrential average monthly debits (170 - 175) and even the annual (5 - 6).The extreme values of rainfall were recorded at different times of the year: 1969 July and August, 1972 May, June and July - 1991, September - 2001 April - 2005 July - 2008 etc.

a b

Figure 2. Pictures of the Moldova River area:
a – Google earth view (2012);
b – Downstream view of the studied area

Moldova River presents in the studied area a ballast thalweg with thickness of 15 - 20 m. The ballast layer is extending in major riverbed in range of 100 200 m. Cohesionless material from riverbed allows formation of active hydrodynamic erosion processes.
In the research area the Moldova River has two branches. The second branch was made in 1970 from technological reasons for undercrossing execution.

The research method has the following steps:

- Processing the hydrological and hydraulic data specific to the considerate research river section;
- Topographical land survey in the research riverbed area to obtain the base plan;
- Surveying at timed intervals to assess morphological changes of the riverbed;
- Surveying for achieving the bed cross sections profiles of specific research sections;
- Surveying for achieving the riverbed longitudinal profile;
- Surveying the bank to determine the hydrodynamic erosion parameters;
- Acquisition of photographic images and video;
- Processing and interpretation of measurements by highlighting qualitative and analytical morphological changes of the riverbed;

Using topographic measurements are made the cross section and longitudinal profiles in specific sections through major and minor riverbed. Hydrodynamic erosion of the riverbed value is measured on the longitudinal and cross sections. The measured values are compared with those calculated. The deep of the riverbed caused by hydrodynamic erosion determines with equation (Mitoiu C., 1999):

$$h_{er} = 2.4 \cdot q \cdot \left(\frac{\eta}{w} - \frac{2,5}{v_{av}}\right) \cdot \frac{sin\alpha_{av}}{1-0,175 \cdot ctg\alpha_{av}} + 0,25 \cdot h_{av} \quad (1)$$

where: q is the specific flow; v_{av} – is the water speed downstream; η = 1,5…2 – coefficient depending on the uniformity of the velocity distribution; w - falling speed; d - the diameter d_{90} of the material from the riverbed; γ_s - grain specific weight of riverbed.

RESULTS AND DISCUSSIONS

Moldova River in the studied area shows a strong degree of instability (where the adduction pipes undercross the river Figure 2). Following transit floods were was recorded constantly morphological changes in the spatial configuration of the river. The most significant changes were:

- Changing geometry of the minor riverbed in plan and longitudinal and cross sections;

- 2D displacements to the riverbed upstream and downstream of the undercrossing;
- Hydrodynamic erosion of the thawing, with its descent below the calculated design;
- To follow the process of morphological change of the riverbed were made after floods topographic measurements at determined intervals. Topographical surveys have been executed in next periods;
- In 1968 the design and construction of hydraulic structures undercrossing pipes and the regularization of the river Moldova;
- In 2005 to check morphological changes of the riverbed after a period of operation of 30 years (total area plan and longitudinal and cross sections, Figure 1b);
- In 2008 to check morphological changes of the riverbed after the passage of floods that produced changes (topographic survey of banks);
- In 2010 to verify morphological changes of the riverbed after several floods that produced changes (topographical surveys of the banks);
- In 2012 to verify morphological changes of the riverbed after several floods that produced changes (area general plan and longitudinal and cross section);
- In 2015 to verify morphological changes of the riverbed that caused degradation of bank protection works and the undercrossing adduction pipes (local plans, cross sections and longitudinal sections).

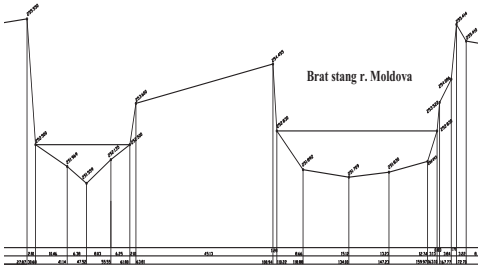


Figure 3. Cross section profile in adduction ducts undercrossing area (year 2006)

From the theoretical analysis and research in the field there were obtained the following results on morphological changes of the riverbed in the undercrossing area:

Figure 4. Downstream overview of the studied river section (left and right branches stands island and ballast foundation of the riverbed, year 2006)

The study area located in the minor riverbed of Moldova River suffered significant morphological changes between execution (year 1970-1975) and present. Factors behind the changes were:

a – The frequency of floods in the last years (2005…2015);

b – Exceeding the exploitation period of the regularization of the river;

c – The absence of regularization works related to the new hydrological regime of the river;

d – The absence of regularization works plan related to the progression of riverbed;

e – Ballast exploitation located upstream undercrossing; they have increased transportation of sediments in the riverbed;

f – The geotechnical riverbed structure (thick massive ballast).

The riverbed geometry was amended by executing the undercrossing works:

a – In 1970 the riverbed had a single flow section;

b – The riverbed currently presents two branches separated by an island; the left branch (initially) represent 70% of the flow section of the river;

Longitudinal profile through its two branches of the river was changed by lowering the thalweg level in the last 15 years.

- Longitudinal profile highlights the significant slope variation in the length of the studied riverbed. In the area where the adduction ducts is produce super elevation of the bottom of the bed due to the presence of the shoulder made by the pipe. Achieving further thresholds made of rough stone on pipeline routes modify the longitudinal profile parameters;

- Moldova minor riverbed near the site presents relative stability in the plan and the characteristics of an evolving riverbed, with the formation of bends, areas of erosion and deposition areas;

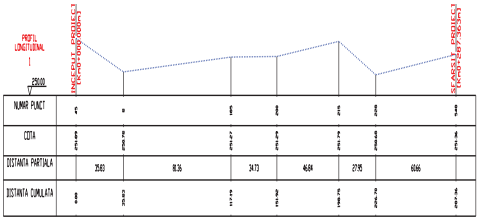


Figure 5. Longitudinal profile through Moldova riverbed in the research area

- In 1970-1972, the bed was calibrated and constrained in bank protection works and works provided with for directing currents. In 2005 ... 2015 has been a degradation of bank protection works. The area located in the right bank;
- In the river shows a relative stability in the plan and is less affected by phenomena of collapse or erosion (Figure 7).

Figure 6. Degradation of left shore protection works of Moldova River after floods in 2010

The comparative analysis made on the topographical plans and photograph mapping highlighted morphological changes in the area where the three adduction pipes undercross the river.
Alluvial processes have developed to the right side of the riverbed and especially around the island. Erosion processes were developed left bank. Left bank erosion intensified in 2005 and was manifested by washing alluvium, degradation and total destruction of bank protection etc. Excavating ballast upstream undercrossing influenced the intensification of hydrodynamic erosion.
Calculation deepening minor bed after erosive action of the water showed values of 0.55...0.81 m on the section studied. Comparison of longitudinal profiles of the Moldova riverbed at different intervals confirmed calculations.
The data were used to design the rehabilitation of existing constructions in the riverbed.

Figure 7. Downstream overview downstream of the left arm of river in the study area (year 2015)

CONCLUSIONS

The comparative analysis of initial and after floods topographical plans indicates a number of significant morphological changes in the riverbed, with particular impact on the dynamics of solid and liquid flows.
The undercrossing area through minor riverbed the river has two branches generated by the presence of alluvial formations (an island) that modifies the configuration of solid and liquid flows and levels in flood value.
Longitudinal sections have revealed the deepening of the riverbed as determined by hydrodynamic erosion. Values increased in the last 15 years and influenced the stability of the construction of transmission pipes undercrossing.
Lack of flow control works in the riverbed led to the formation of currents that influence and generate hydrodynamic erosion, with significant effects on bank protection works.
The floods from 2006 and 2008 intensified a series of morphological changes in the river channel, particularly in the left bank, a situation that resulted in partial and total degradation protection works.
Transport capacity of the Moldova's minor riverbed in the undercrossing area need to be restored by recalculating and updating the topographic geometrical parameters as planned.

REFERENCES

Dapporto S., Rinaldi M., Casaglia N., Vannocci P., 2003, Mechanisms of bank failure along the Arno River, central Italy, vol., Earth Surface Processes and Landforms, nr., 28, 1303-1323 pp.

Hâncu S., 1976, Regularizarea albiilor raurilor, Ed. Ceres, Bucuresti,.

Luca M., 2006, Expertiza tehnica privind starea de siguranta în exploatare a subtraversarii raului Moldova –zona Soci, jud. Iasi a conductelor din captarea Timisesti.

Luca M.,2012, Technical expertise on rehabilitation in the undercrossing the river Moldova to the adduction pipes water Timisesti, village Soci, county of Iasi. SC POLIAS-INSTAL Iasi.

Luca M., 2000, Hobjila V. Complemente privind proiectarea şi expertizarea unor tipuri de constructii hidrotehnice, Ed. CERMI, Iasi.

Manoliu I., 1973, A., Regularizari de rauri si cai de comunicatie pe apa, Ed. Ed. Did. si Pedag., Bucuresti.

Mitoiu C., 1999, Marin G., Regularizarea albiilor de rauri, Indrumar de proiectare, Edit. Bren., Bucuresti.

Ratiu M., Constantinescu C., 1989, Comportarea constructiilor si amenajarilor hidrotehnice. Editura Tehnica, Bucuresti.

SingV.P.,2003, On the theories o hydraulic geometry. International Journal of Sediment Research, Vol 18, No.3, 196-218 pp.

Thorne C., 1982, Bank erosion processes and mechanisms, Ed., John Wiley & Sons, Ltd., Chichester, 227-271 pp.UK.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

AERATION LAGOON AS ADVANCED SOLUTION FOR LEACHATE EPURATION - A STUDY CASE IN GLINA PURGE UNIT

Zamfir PANTER[1], Mugur BOBE[2], Gabriela ROSU[3], Florentina MATEI[1]

[1] University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Biotechnologies, 59 Marasti Blvd, District 1, Bucharest, Romania
[2] SC ECOREC SA Bucharest
[3] University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Land Reclamation& Environmental Engineering, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: zamfirpanter@yahoo.com

Abstract

Leachate is a liquid waste product of the processes in solid waste landfills with meteoric waters seeping. A number of substances are dissolved by washing with meteoric water and other substances resulting from the processes of fermentation of organic waste components. Leachate treatment is essential to reduce mainly the organic and nitrogen content in the leachate. The initial solution applied to the purge unit-Glina was a biologic reverse osmosis in two steps (osmosis layout). An aeration lagoon has been designed and proposed to be installed as pilot in Glina. The leachate provides the food for the bacteria and the aeration system provides the oxygen. The results are suggesting that this lagoon technology can be economic to install and simple to run.

Key words*: aeration lagoon, leachate landfill.*

INTRODUCTION

In correlation with environmental protection requirements, characteristics of the deposit and weather conditions are necessary measures regarding: control of water in the body of the deposit, leachate collection through a proper drainage system, as well as its appropriate treatment.
Constraints in terms of management are specific to each site and refer to: the conditions of discharge in the receiver natural system leachate treatment, availability of space for the installation of leachate treatment in the warehouse, as those relating to performance of the treatment plant (Cretu, 2015).
The main objective of the step is the removal of biological treatment of organic solid substances undeposited (dissolved or colloidal) and the stabilization of organic materials in the sludge. At the same time it is proposed to reduce nutrients based on nitrogen and phosphorus. It is a flexible process that can easily adapt to the variability characteristics leachate concentrations and composition. (Jascau, 2015).
Factors influencing biological processes are time of contact, or during the crossing of the target technology in which the biological process takes place, temperature, pH level, and oxygen level, loading the technological object with waste waters (dilution) with the slurry nutrients, the presence of the inhibitors process hydrodynamic conditions of the process - mixing and blending.

MATERIALS AND METHODS

Leachate is nothing more but a waste liquid, a waste, highly polluted water coming from the humidity ceded garbage, and water ceded the fermentation process and most of the precipitation falling on the surface of the deposit.
Levigates' composition will vary over time depending on

- composition of the waste deposited and the degree of their decomposition;
- humidity mass of waste from storage;
- evolutionary age of the deposit defined by the phase in which the (acid metanogenic);
- storage system and technological solutions: compacting, laminating, coating, time (period) execution;
- environmental temperature.

In experimental determinations there were used samples of leachate coming from the evacuation outlet of Cell 2 from Glina waste landfill.

Samples were collected during October 2014 - December 2015 on beginning of each month. The determinations were performed according to specific standards of each component.

Detention facilities discharge pollutants into water and consist of:

1. The drainage pipes made of HDPE with Dn = 200 mm, total length of 758 m and 0.05% longitudinal slope to drain
2. leachate pre-treatment station consists of:

• underground basin for leachate collection, made of polyester reinforced fiberglass, having a capacity of 25 m^3;

• aboveground pool for collecting leachate mounted on metallic supports, made of fiberglass reinforced polyester, with capacity 25 m^3 ensuring gravitational leachate flow to the treatment plant through a pipeline from PHED Pn 4 Dn = 325 mm;

• settling tank, concrete, above ground, two-compartment with a volume of 140 m^3

3. Aeration Lagoon is approximately = 500 m^3 volume, dimensions: B x W x H = 15 x 10 x 3.3 m. The role of the lagoon system for treatment and purification of leachate is to ensure oxidation of organic matter. Demand for oxygen is provided through a battery of aeration, which includes a submersible pump mounted on a frame aeration float with a variable power as needed between 3.5 - 30 kW. Oxygen transfer rate is as Sotra (ANSI/ASCE 2-91) 1.2 kg O_2/ kWh. Suction maximum depth 21 m.
4. The metal Eurocontainer equipped with specific modules for the method of reverse osmosis treatment in two stages: pre-filtration segment, segment leaching stage E I, E II segment phase permeate system wells;
5. Outdoor storage and disposal of the resulting permeate treatment module constructed of concrete, with a volume of 35m^3.

Treated (permeated) leachate together with wastewater from the toilets at the entrance of the administrative building inside the objective and processed water from the municipal results are taken from the wash basin and clarified with three compartments 32 m^3 and discharged in the Dambovita River's cased collector.

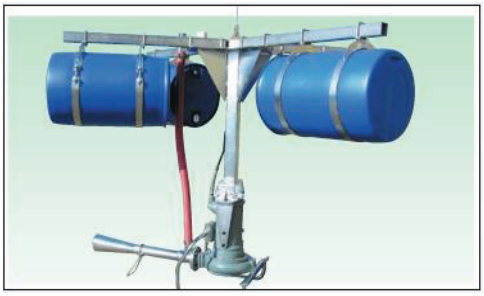


Figure 1 Aeration battery
(pumps aeration, float frame, supply air)

In their research, Schiopu et all showed that the method of treating leachate from the landfill through the process of reverse osmosis is increasingly used due to the economic, technical and environmental advantages of the removal efficiency of organic contaminants which were nearly 90% for the COD, $NH4^+$, and the electrical conductivity (Schiopu, 2012).

But this method has also got some disadvantages, such as poor retention passage of small molecules through small molecules that pass through the membrane and deposition of unwanted solutes on the outer surface of the membrane (Smith, 2012).

At the beginning of 2015 on economic and especially environmental technology leachate treatment of urban waste landfill Glina was introduced an aeration lagoon for biological treatment of leachate.

The goal is the elimination of biological treatment of colloidal and dissolved organic matter undeposited and stabilization. Microorganisms convert organic materials into cellular tissue, liquids and gases.

Determination of quality parameters (pH, nitrates and nitrites suspended matter, ammonia, phosphates, BOD, COD) of leachate was done in the laboratory using standard methods whose measurement principle is given in Table 1.

Table 1. Analytical methods used in the laboratory to determine the pollutant content of the leachate from the landfill Glina

Nr crt	Quality Indicator	U/M	The method of determination	The method principle	Standard
0	1	2	3	4	5
1	pH, to 20.6^{0}C		Electro prosody 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.	SR EN ISO 10532-2012
2	Suspended matters	mg/l	Filtration and drying	The separation of suspended particles by filtration and drying in a vacuum oven at 1050C and then weighing	STAS 6953-81
3	Nitrate NO_3^-	mg/l	Sulfosalicylic acid spectrometric method	t is based on determining the intensity of yellow coloration complex, sodium nitrosalicilatul 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.	SR ISO 7890-1998
4	Nitrite 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.	SR EN 26777-2002
5	Ammonium NH_4^+	mg/l	Manual spectrometric method	Spectrometric method is based on analysis of a light beam passing through a solution. The more particles are present in solution, the light will be increasingly more subdued - its intensity decreases.	SR ISO 7150-1-2001
6	Sum Phosphor	mg/l	Ammonium molybdate spectrophotom etric method	The phosphate ion is 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.	SR EN ISO 6878-2005
8	BOD5	mgO_2 /l	Dilution 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 API test immediately after 5 days after harvest	SR EN 1899-1-2003
9	COD-Cr	mgO_2 /l	The method with potassium dichromate	Oxidizable substances in the leachate are oxidized by potassium dichromate in sulfuric acid medium, hot, and the excess dichromate is titrated with the Mohr salt in the presence as an indicator fenioinei	SR ISO 6060-1996

Figure 2. Aeration lagoon of the landfill Glina

RESULTS AND DISCUSSIONS

Characteristics of leachate from municipal landfills can be best represented by several parameters of which the most important for introduced an aeration lagoon for biological treatment of leachate.

The goal is the elimination of biological treatment of colloidal and dissolved organic matter undeposited and stabilization. Microorganisms convert organic materials into cellular tissue, liquids and gases.

Biological treatment is: COD, BOD, the ratio BOD/COD, pH, suspended matter, ammonia, nitrates and nitrites, bacteria and turbidity (Foo K. Y., 2009).

Leachate composition and properties depend on environmental conditions (temperature, precipitation), the age and maturity of the landfill, waste characteristics and composition, operating warehouse technology.

In the process of aging, deposits pass through various stages of degradation of organic waste, from aerobic to anaerobic dissolution stage. Therefore, leachate properties such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), ammonia (NH_3) or pH changes depending on the stage of decomposition of waste (Amor C., 2015).

Biodegradability can be estimated by the ratio BOD/COD, environmental conditions; temperature, pH and the absence of inhibitors have major effects on the bacteria. The following links can be broken down biologically: carbon bonds, bonds nitrogen (including ammonia NH_4-N) AOX bonds. (Clarke, 2015).

Table 2. Composition of leachate from the landfill Glina from October 2014 to December 2015
Sampling point two-compartment tank leachate

No	No quality indicator	U/M	Oct 2014	Dec 2014	Febr 2015	Apr 2015	Jun 2015	Oct 2015	Dec 2015
0	1	2	3	4	5	6	7	8	9
1	pH, to 20.6^0C		9.1	9.2	8.4	7.4	7.6	7.1	7.3
2	Suspended matters	mg/l	12212	13122	11056	10836	10498	10216	10115
3	Nitrate NO_3^-	mg/l	90.12	83.16	85.25	74.9	80.01	78.25	80.30
4	Nitrite NO_2^-	mg/l	16.98	18.2	17.7	11.3	10.3	9.60	12.25
5	Ammonium NH_4^+	mg/l	902	801	862	749	605	594	660
6	Sum Phosphor	mg/l	85.12	95	78	87.2	103	116	120
7	Substances- extract with solvents	mg/l	38.61	53	48	64.7	54	57	56
8	BOD_5	mgO_2/l	22961	21630	22736	18712	20033	17864	20103
9	CODCr	mgO_2/l	45760	43206	45484	34706	37904	31672	36176
10	BOD_5/CODCr		0.508	0.50	0.511	0.542	0.541	0.560	0.564

Biological processes for treatment of leachate is based on the biochemical reactions in the metabolism of bacteria, fungi and other lower organisms - in particular protozoa which are organic load in waste water, which form biomass.

From the results shown in Table 2 and in the following graphs it can be clearly seen that since April 2015 the quantities of pollutants in the leachate decreased except for total phosphorus and substances extracted with solvents.

Biochemical activity of microorganisms present in the aeration lagoon have as first observed effect in experimental measurements, a change in pH that has achieved a

decrease of 2.5 units from 9.2 in December 2014 to 7.1 in October 2015 (Figure 3).

The final result of the biological process the treatment is reflected in the degradation of the organic substance, to the various stages of the relevant technology and equipment, and increase of biomass (estimated at 40 ... 60%) in the form of cellular material insoluble sediment, and some products of metabolism, easier to remove

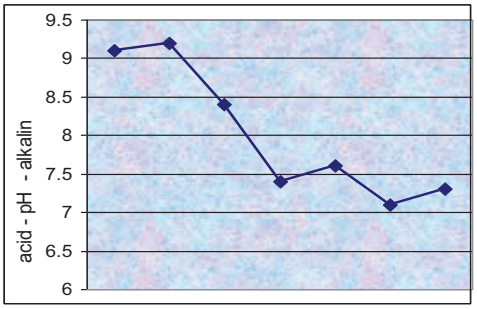


Figure 3. Changes in pH leachate from ecological landfill Glina (October 2014 to December 2015)

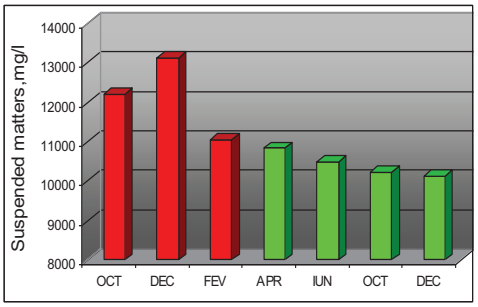


Figure 4. Suspended solids content of leachate from landfill ecological Glina (October 2014 to December 2015)

The amount of suspended solids (Figure 4) ranged from October 2014 - February 2015 between 11.06 and 13.13 g/l leachate values that are within the existing literature for deposits less than 5 years. (Jascau, 2015 Foo K.Y. 2009).

After introducing it in the lagoon aeration technology there can be observed a decrease of materials in suspension having values between 10.11 and 10.84 g/l decrease recorded an increase of 10% in the first month of operation of the lagoon and 29% after the first 8 months (Figure 4).

Biological processes for reducing the organic materials are affected by a number of specific factors such as contact time or during the crossing of the target technology in which the biological process takes place, temperature, pH, oxygen loading lagoon wastewater (dilution), the slurry nutrients, the presence of inhibitors of the process, the hydrodynamic conditions of the process - mixing and blending, as the use of the aeration system.

Considerable reductions were recorded between April-December 2015 regarding the composition of in nitrogen compounds (nitrates, nitrites and ammonia).

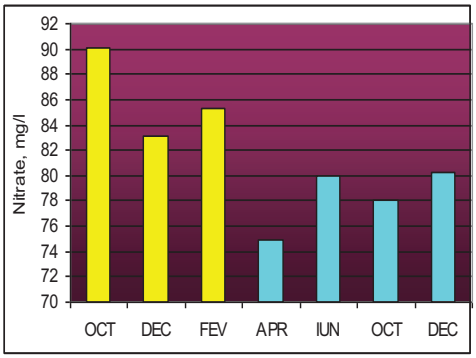


Figure 5. Content of nitrate leaching from Glina ecological deposit (October 2014 to December 2015)

The nitrate content in laboratory determinations revealed ranged between 83.16 and 90.12 mg/l before the construction of the lagoon and between 74.9 and 80.3 mg/l (Figure 5) after commissioning of the lagoon aeration.

The same effect was found in the content of nitrite, which were originally recorded values between 16.98 and 18.2 mg/l (Figure 6) and after building the lagoon have been reported very low with about 50% (9.6- 12.5 mg/l).

Renou et al. used anaerobic and aerobic lagoons situated near the landfill leachate biological treatment constructed warehouse.

Overall modifications of N, P and Fe were obtained in this system of over 70% for diluted leachate (Renoua, 2008).

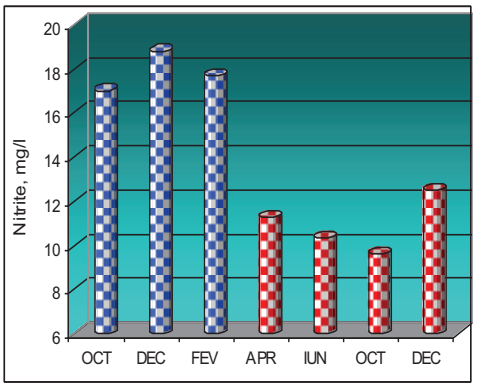


Figure 6. The nitrate content of leachate from Glina ecological deposit (October 2014 to December 2015)

Biological Cleaning lagoon aeration used to store Glina builds on the work of two groups of microorganisms: aerobic or anaerobic.

Aerobic microorganisms are commonly used in wastewater treatment with the predominant majority of organic - carbon-based compounds, nitrogen or phosphorus - and for certain categories of sludge stabilization.

Biochemical activity of microorganisms which degrade organic matter content leachate led to a decrease in Ammonium between 10% in the first month of operation of the lagoon and 30% in October (6 months of operation).

In December 2015 there can be seen an increase of the ammonium perhaps because of the reduction of biomass activity, due to the fall in temperature (Figure 7).

Some applications of biological processes in lixiviate treatment are: the removal of organic substances measured BOD, COD, BOD/COD report, nitrification, denitrification, phosphorus removal, sludge stabilization. Organic nitrogen is converted to ammonia and phosphates and phosphate. (Menyk, 2014).

From the graph shown in Figure 8 we can see an increase of the total phosphorus content of 78 mg/l up to 120 mg/l in December 2015 so to 8 months after the construction of the aeration lagoon.

Results on landfill leachate from Glina are consistent with the data presented by Zhang, G. et al (2013).

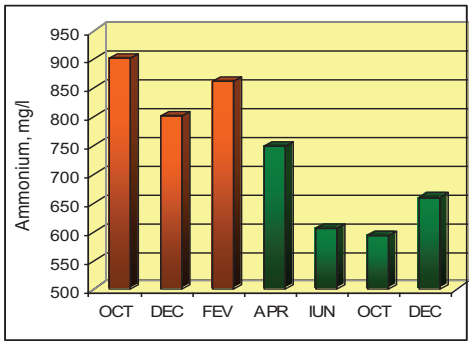


Figure 7. Ammonium content of leachate from landfill ecological Glina (October 2014 to December 2015)

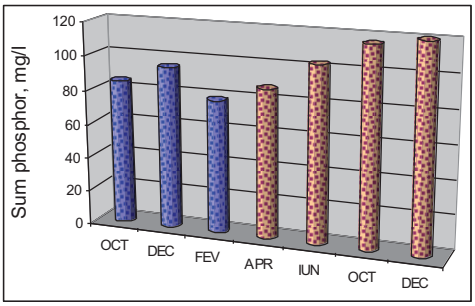


Figure 8. Change in total leachability of phosphorous the ecological deposit Glina (October 2014 to December 2015)

As shown in the graph in Figure 9 Biochemical Oxygen dropped from 22.961 mg/l (October 2014) to 17.864 mg/l (October 2015) representing a 26% reduction.

Regarding Chemical Oxygen Demand the decline is much more consistent, reaching a maximum of 38% after the start of the lagoon aeration.

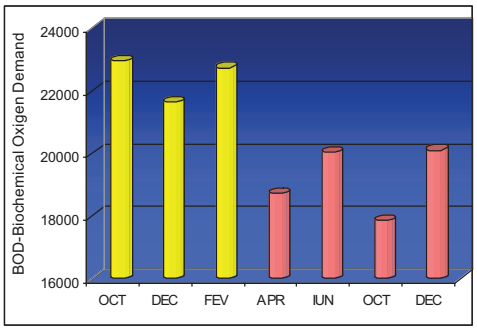


Figure 9. Changes in Biochemical Oxygen Demand BOD of leachate the ecological deposit Glina (October 2014 to December 2015)

From Figure 10 we can observe that in the months of October - Feb. 2014 COD ranged between 43 200 and 45 760 mg/l April 2015 and after that period values ranged between 31 672 and 36 900 mg/l.

During storage, waste passes through various stages of degradation of the organic constituents, from aerobic to anaerobic digestion stage. Therefore, properties such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), total oxygen consumption (TOC), pH and other characteristics change depending on the stage of decomposition of fermentable waste.

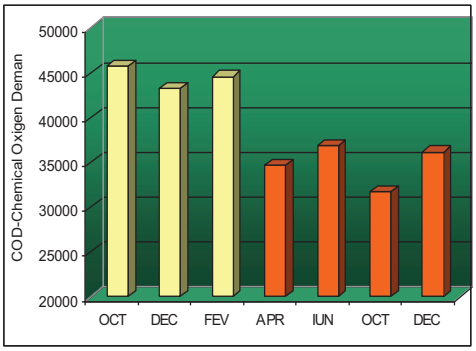


Figure 10. Changes in Chemical Oxygen Demand COD of leachate the ecological deposit Glina (October 2014 to December 2015)

Zhang and his collaborators studied the feasibility of the lagoon to treat phenolic compounds and organic matter; they have achieved a reduction of 55-64% and 80-88% of COD of phenol (Zhang, G., 2013).

When leachate from landfills presents BOD/COD report of more than 0.25, they may be subject to a standard biological treatment processes (Amor, C 2015).

Renou says that biological processes have proven to be very effective in removing organic matter and nitrogen from immature levigates when the ratio BOD/COD has a high value > 0.5 (Renoua 2008).

The analyzes presented in the graph in Figure 11 leachate from the landfill Glina the ratio BOD/COD of more than 0.5 is well suited to biological treatment.

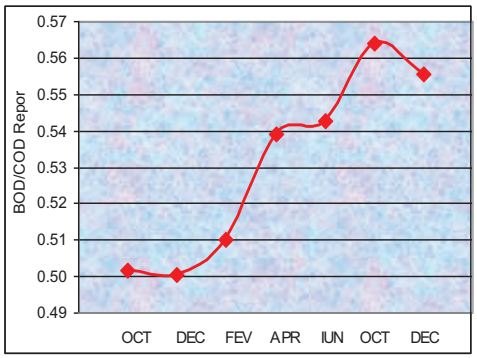


Figure 11. Variation of the BOD/COD report in leachate from Glina ecological deposit (October 2014 to December 2015)

CONCLUSIONS

Biological treatment of leachate is a simple and is particularly viable in terms of cost-effectiveness. Advantages of this method consist mainly of leachate treatment efficiency with high concentrations of organic matter, nitrogen or BOD, where a high ratio BOD/COD report, usually encountered in young leachate.

Among the advantages of the method we could mention: reducing sludge, it doesn't require oxygen, the occupied area is not large, it produces biogas and does not consume much power. In general, the biological process is one of the most successful and effective methods of treating leachate.

By entering the aeration lagoon we yielded reductions of leachate organic pollutant content in particular is reduced content of nitrates, nitrites and ammoniac. There were also recorded reductions in terms of Biochemical Oxygen Demand, Chemical Oxygen Demand and the pH decreases as confirmed by the presence of the biochemical decomposition process of organic matter in the leachate, accordingly the efficiency of the introduction of aeration lagoon.

Although there are some advantages, the implications of anaerobic processes are limited mainly because of the low growth rate of anaerobic microorganisms and weak retention of biomass.

The trial is biologically dependent on maintaining stable parameters at the entry wastewater lagoon aeration.

Because biological treatment processes are conducted under natural conditions the occurrence of temporary shocks parameters is frequent and it will reduce sedimentation sludge, sludge disintegration, increase in effluent suspended solids concentration and finally to partial or complete blocking of the process.

The approach of combining biological process of reverse osmosis is recommended as a feasible method in removing organic substances, nitrogen and other pollutants in the leachate generated by the landfill of municipal waste.

REFERENCES

Amor C., De Torres-Socias E., Peres J., Maldonado M., Oller I., Malato S., Lucas M., 2015, *Mature landfill leachate treatment by coagulation/flocculation combined with Fenton and solar photo-Fenton Processes*, Journal of Hazardous Materials, Vol 286, pp. 261-268.

Clarke, B.O., Anumol, T., Barlaz, M., Snyder A.S., 2015, *Investigating landfill leachate as a source of trace organic pollutants*, Chemosphere Journal, Vol. 127, pp. 269-275.

Cretu Ana Maria Giorgiana, Scurtu C 2015, *.Sisteme de control si gestiune a levigatului* Revista Constructiilor nr. 111 – ianuarie-februarie 2015, pp. 60 - 62

Foo K. Y., Hameed B. H., 2009, *An overview of landfill leachate treatment via activated carbon adsorption process*, Journal of Hazardous Materials, Vol. 171, pp. 54-60.

Jascau Dan-Vlad , Boroş Melania, Gabor Timea, Sur Ioana Monica, Pica Elena Maria, 2015, *Efficient Methods of trating the leachate generated from municipalwaste landfills* Ingineria Mediului şi Antreprenoriatul Dezvoltarii Durabile – Vol. 4, Nr. 1 (2015) pp 41-50

Menyk, A., Kuklinska, K., Wolska, L., Namiesnik, J., 2014, *Chemical pollution and toxicity of water samples from stream receiving leachate from controlled municipal solid waste (MSW) landfill*, Environmental Research, Vol 135, pp. 253-261

Renoua S., J.G. Givaudan a, S. Poulain a, F. Dirassouyan b, P. Moulin, 2008, *Landfill leachate treatment: Review and opportunity* Journal of Hazardous Materials Vol 150 (2008) pp. 468–493

Schiopu, A.M., Piuleacm G.C., Cojocaru, C., Apostol, I., Mamaliga, I., Gavrilescu, M., 2012, *Reducing environmental risk of landfills: Leachate treatment by reverse osmosis*, Environmental Engineering and Management Journal, Vol. 11, Nr 12, pp. 2319-2331.

Smith, A., Stadler, L., Love N.G., Skerlos, S.J., Raskin, L., 2012, *Perspectives on anaerobic membrane bioreactor treatment of domestic wastewater: A critical review,* Bioresource Technology, Vol. 122, pp. 149-159.

Zhang, G., Qin, L., Meng, Q., Fan, Z., Wu, D., 2013, *Aerobic SMBR/reverse osmosis system enhanced by Fenton oxidation for advanced treatment of old municipal landfill leachate,* Bioresource Technology, Vol. 142, pp. 261-268.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

EARTH DAM STABILITY - THE ANALYSIS OF FILTRATION PROCESS

Alexandru Lucian LUCA, Olga-Adelina POP

"Gheorghe Asachi" Technical University of Iasi
63 Dimitrie Mangeron Blvd., 700050, Iasi, Romania

Corresponding author email: pop.olga.adelina@gmail.com

Abstract

This paper presents research carried out on the earth dam stability to the combined actions of the site. The earth dam is located in Iasi, Romania. Researches were performed for several earth dam operating scenarios. First stage research considered the phenomenon of filtration through dam by Darcy's Law. Second stage of the research considered the filtration phenomenon according to post-Darcy law. Scenarios for monitoring the dam stability considered the main operating situations. The filtration and embankment behavior simulation was analyzed using a specialized soft. The studies and research results shows the differentiated behavior of dam slopes. The research results are used to design of dam rehabilitation works. Monitoring plays an essential role in evaluating the structural safety condition of dams. Monitoring activities are also useful for the collection of valuable data to enhance the understanding of the behavior of these structures.

Key words*: earth dam, Darcy filtration, post-Darcy filtration, slope stability.*

INTRODUCTION

Earth dams must be supervised at regular periods of time to analyze their operational safety. A series of values of dam structural parameters may change over time from those designed and executed.

The operational safety of the dam is affected if some parameters change. Structural parameters and functional status is verified by performing a technical expertise (Priscu R., 1976).

An important issue in earth dam evolution is uncontrolled seepage.

This directly influences the stability of structural components of the dam. The parameters of filtration phenomenon are changing over time depending on changes occurring geotechnical dam structure.

Fine material in the dam body is washed and the concentrated high speed flow through preferential paths appears. In this case there are no longer fulfilling the initial calculation assumptions (Darcy flow range).

Checking filtration phenomenon must consider the status parameters of the dam at the time of analysis. In the study should be reassessed geotechnical parameters, hydraulic parameters, hydrologic parameters, the new accumulation function etc. (Stematiu D., 1998).

The current dam operational situation requires the recalculation of the design flow and the verification of water level with various computation probability (p%) imposed by the new accumulation function.

The safe operation of the dam for the current operational status requires the development of theoretical and experimental studies. Hydraulic study carried out for the current and future state will evolve phenomenon of filtration. Analysis was carried out for various operating scenarios. The second study analyzed the stability of the dam on changed operating conditions. Results of the studies determine the measures to be taken to bring to normal the phenomenon of filtration. (Marchidanu, E., 1996).

Research conclusions determine the need of technical rehabilitation works of structural and functional components of the earth dam.

The Chirita Hydrotechnical complex is composed by an earth dam, a storage reservoir and a complex of hydraulic equipment. The Hydrotechnical complex is located in the south-east of Iași. Chirita reservoir is integrated in the water supply system of Iași city. The main purpose of the scheme design is storing and decanting water pumped from the Prut River.

The reservoir is on Chirita brook (Valea Lunga) and partially on Sapte Oameni brook.

Valea Lunga brook is last but one tributary on the left Bahlui River before its confluence with the Jijia river. The Valea Lunga land code is XII – 1.15.32.23.

The hydrographical basin characteristics are: reception area of 37 km^2 (44 km^2 total area); brook length from the source to the Valley Chirita 13.1 km (16 km total length); average slope from the source to the Valley Chirita: 7.67‰.

Chirita reservoir was designed and constructed in 1962. Chirita dam is made of earth taken from the left side of the reservoir. The main execution material was compacted loess clay.

The dam has a trapezoidal cross section with berm on downstream and upstream faces. The dam crest length is 219.00 m; the crest width is of 6.00 m. The upstream face is protected by a concrete slab riprap (1.0 x 1.0 x 0.15 m). The upstream riprap face protection is realized where is the water level variation zone.

The dam presents a filter blanket of broken stones. On 3/4 of the width, the dam is equipped with a drainage blanket of fine sand, sandy gravel + grit + gravel as a reverse filter.

At the downstream end of the mattress it was performed a gravel filter prism covering drain. The drain has a diameter of 300 mm and is made of reinforced concrete pipes. The drain collects and discharges the water filtrated through dam body.

Along the drain length are made three connections and branch manholes. At central manhole is plugged a concrete pipe (D = 300 mm) for evacuation of infiltrated water into a conduit. The conduit is connected to the Chirita brook. [Luca, M., 2002]

The characteristic level and geometrical parameters of earth dam are: 42.40 maBSL ground level; crest level 54.60 maBSL; concrete slabs level = 53.00 maBSL; upstream slope of 1:3.5 and downstream slope of 1:2.5; upstream berm level 49.60 maBSL; downstream berm level 49.00 maBSL; crest width 6.00 m; crest length = 219.00 m.

Flow rates from Table 1 characterize Chirita brook. Reservoir capacity was designed to store a volume of water pumped from the river Prut. Chirita reservoir is a pre-decantation lake for the water supply system of Iasi city from the River Prut.

a b

Figure 1. Overview of the dam Chirita: a - upstream; b - the downstream.

Table 1. Characteristic flow values with computation probability p (%)

p, (%)	50	10	1.0	0.1	0.01
Q_p, (m^3/s)	0.50	31.0	90.0	175	270

Table 2. Characteristic dam levels for flows with calculation probability p (%)

p, (%)	minimum	medium	maximum	1.0	0.1
N_p, (maBSL)	50.0	51.0	52.0	52.40	53.76

Figure 2. Overview of the earth dam and the spillway

In the dam site area are present lithological stratifications of loess clay dust composed, silty sand mixed with gravel, silty clay and marl clays (especially in foundation). Mostly, these deposit supplied materials for the dam execution. The dam of Chirita reservoir is made of local materials taken from the left side of the lake. The main execution material is compacted loess clay.

STABILITY PARAMETERS ANALYSIS FOR EARTH DAM

In the analysis of the stability of embankment dams are taken into account several assumptions. The analysis takes into account the following:
-The structural dam type (shape, slopes, number of berms, cross section and plan dimensions);
-Geo-mechanical characteristics of the materials used in execution;
-The collection and disposal methods of filtrated water;
-Exploitation conditions (water level variance upstream and downstream);
-Assumptions analysis that reflect the operational process etc.
Slope stability analysis on an earth dam is made with two assumptions:
-Hypothesis - slope design with known mechanic-physical parameters of the soil (γ, Φ c) and main functional criteria imposed by the geometrical characteristics (height, depth, width canopy).
The calculation results indicate the slope value in stable conditions;
- Hypothesis - verify the executed slope stability with well defined geometry, to estimate the stability reserve (Ratiu M., 1989).

Table 3. Safety coefficients

Actions	construction status	The working hypothesis	Check slope	$Fs_{admisible}$	
				no seism	with seism
fundamental	A the end of construction	-	upstream	1.30	1.30
			downstream		
accidental	The current exploitation	lake full to the retention maximum level	downstream	1.50	1.20
		lake partially filled	upstream	1.50	1.20
	Sudden draining	At normal retention level	upstream	1.30	not verified
		At maximum retention level	upstream	1.20	not verified

The slope stability is estimated in both analyzing hypothesis (design, verification) comparing two safety coefficients ($Fs_{effectiv}$), and restriction coefficient ($Fs_{admisible}$). The analysis equation is:

$$Fs_{effectiv} < Fs_{admissible}$$

Evaluation of stability coefficient is achieved in several assumptions:
- Construction period;
- Exploitation period (full reservoir);
- Sudden draining of reservoir.

The literature presents the safety coefficients for the construction verification for various groups of actions and conditions of the verification (Table 3).
Earth dam stability is influenced by two characteristic phenomena: the slopes sliding and the filtrate water through the dam. The two phenomena are coupled in the analysis model.
Researches were performed for various operating scenarios of earth dam. Phase I research considered the phenomenon of filtration through the dam in the area of validity of Darcy's law.

Phase II of the research considered the phenomenon of post-filtration according to Darcy law.

Study situation is imposed dams showing suffusion phenomena, sinkhole, subsidence, etc. Laws in the Post- Darcy filtration believe in a differentiated intervention force of inertia (Luca, Al., L., 2014).

Stability analysis of earth dam is done by using specialized software. The most used are: Galena, Chasm, SecuSlope, Robot-Milenium, Breach etc.

RESULTS REGARDING THE CHIRITA DAM STABILITY (FIRST STAGE)

Chirita dam stability was analyzed using Galena program. The program is applicable to earth dams. Through the program can be calculate the slope stability under various scenarios of exploitation of the reservoir.

The input data required by the program are those that define the slope geometry (Figure 3), geotechnical properties of the earth, dam filtration characteristics, forces that are applied for and appear on dam including seismic force (Figure 5).

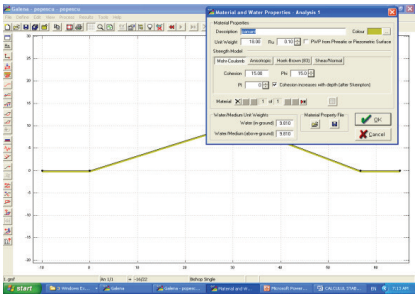


Figure 3. Defining the embankment parameters

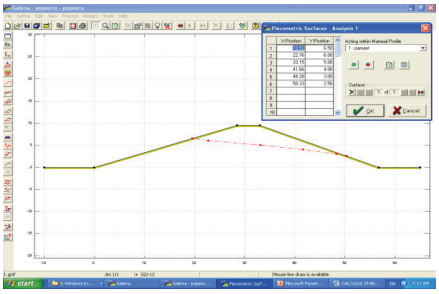


Figure 4. Defining the seepage curve

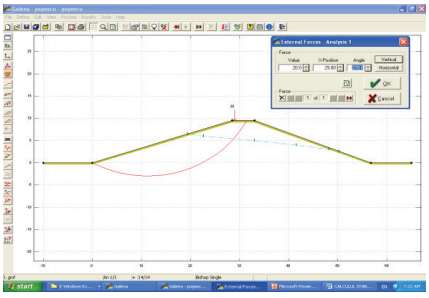


Figure 5. Defining loads

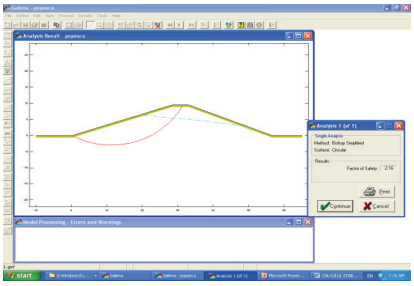


Figure 6. Display safety coefficient

The program uses three methods to analyze slope stability: Bishop, Sarma or Spencer Wright. Specifying center of the embankments critical failure circle is achieved by using Janbu nomograms (P Cercel, 2011). Janbu nomograms specify explicitly the position of subsidence circle center by geometric and geotechnical parameters of the slope. The output is the value of $Fs_{effectiv}$ stability coefficients (Figure 6).

The program allows the introduction of concentrated load or evenly distributed hydrostatic pressure, and seepage curve (Figure 4), different layers of earth or different surface discontinuities.

The plan model of analysis considers the earth dam cooperation (loess clay and silty clay) with foundation soil (sand dusty gravel and clay marl) in various risk situations (hypotheses/analysis scenarios).

Analysis scenarios were:

-Blocked spillway given by bridge collapse.

-Blocked spillway by floating objects during flood.

-Accidentally hypothesis of reaching the maximum level of retention.

The analysis shows the effect of body weight dam considering the embankment in both dry and saturated conditions, the hydrostatic pressure, the ice pressure, the wave action, the seismic response of the earth dam at maximum credible site seismic action (0.2 g peak acceleration) (Cretu I., 1980).
According to the lithological profile through the valley and performed geotechnical study of the implementation of the dam, the materials are clay loess and clay dust.
The materials used in the model for computation for "dry material" are:
A. Dry compacted clay loess. Geomechanical characteristics are: E_1 = 300 daN/cm^2, G_1 = 120 daN/cm^2, υ = 0.17 and γ_1 = 0.00184 daN/cm^3.
B. Silty clay layer (at the contact between dam body and the foundation). Geomechanical characteristics are: E_2 = 300 daN/cm^2, G_2 = 120 daN/cm^2 υ = 0.17 and γ_2 = 0.00184 daN/cm^3.
C. Dusty sand with gravel (foundation soil). Geomechanical characteristics are: E_3 = 200 daN/cm^2, G_3 = 80 daN/cm^2 υ = 0.17 and γ_3 = 0.0019 daN/cm^3.
D. Marl clay (bedrock). Geomechanical characteristics are: E_4 = 316 daN/cm^2, G_4 = 125 daN/cm$_2$, υ = 0.17 and γ_4 = 0.00184 daN/cm^3.
E. Clay dust (old dike). Geomechanical characteristics are: c = 0,18daN/cm^2, φ = 15 °, γ = 16.70 kN/m^3 and cohesion was considered increasing with depth.

The loading types/actions and their coefficients considered in the calculation model are: permanent loads, long term temporary loads, short-term temporary loads and exceptional loads, according to the norms for calculation of hydraulic structures (Luca M, 2009).
Infiltration line calculation was realized using Numerov method (Pietraru V., 1987).
Free water surface is calculated using Numerov formula:

$$x = \frac{H^2 - y^2}{2 \cdot \frac{q}{k}} - H \cdot F_1 + \frac{q}{k} \cdot F_2$$

$$\frac{q}{k} = \frac{H^2}{L + H \cdot f_1 + \sqrt{(L + H \cdot f_1)^2 + H^2 \cdot f_2}}$$

where:
x and y are coordinates of the line of free water surface (y=0...H), H is water level used in calculations, F1 and F2 are functions with 2 two arguments m1 and $s = th\left(\pi\left(H - y\right) / \frac{2q}{k}\right)$

The reservoir water level has been considered being the normal operating level, 52.50 maBSL, corresponding to a water depth of 9.50 m in the master section.

Table 4. Parameters for setting the seepage line blocked draining blanket)

X(m)	0	11.98	18.83	24.77	29.79	33.90	37.10	39.11
Y(m)	9.5	8	7	6	5	4	3	2.14

Pavlovski method was used to study the seepage through earth dam with a downstream drainage blanket. If the drainage blanket stops working, being blocked the dam will behaviour like a homogenous dam on impervious foundation.
If the drainage blanket stops working the seepage line will undergo an average lift of 0.50 m compared with the situation when the drainage blanket works. Seepage line in the two main operating cases is shown in figure 7 and figure 8.

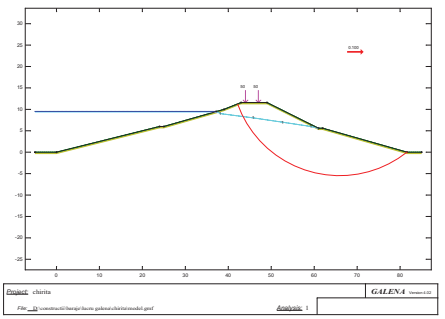


Figure 7. Seepage line when the drainage blanket is working

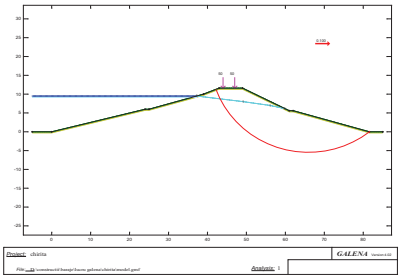


Figure 8. Seepage line when the drainage blanket is blocked

After running the analysis the results for stability coefficient computation (Phase I, where Darcy's law is valid) are presented in Table 5.

Verification of stability parameters of earth dam requires reconsideration of geometrical, geotechnical, seepage parameters etc. at the time of analysis (Carlier M., 1972). For this purpose, it must be carried out geotechnical and topographic surveys on studied objective. From initial design parameters and those existing at the moment of analysis there are differrences that may affect the value of the results.

Table 5. Stability coefficient resulted

The hypothesis taken into account	downstream slope	upstream slope
Full lake	1.488	3.47
Lake suddenly drained	1.489	1.938
Empty lake	1.674	1.917

The resulted coefficients were determined taking into account the possibility of occurring an earthquake. It was verified the downstream slope stability on the assumption of full lake, the load is a truck on the dam and the presence of an earthquake (in both cases the calculation of the infiltration line).

Results show that stability coefficient values for downstream and upstream slopes are within the recommended values (the limit values for the operating conditions) for this type of dam. In this analysis was considered the worst hypothesis for the seepage curve position (partially clogged drain).

CONCLUSIONS

Earth dams must be supervised at specific periods of time for monitoring the structural safety especially the slope stability affected by combined action occurring.

Chirita earth dam has a good functional status in terms of functional structural integrity and slope stability, given the long life (about 48 years).

The dam doesn't present uneven settlements neither in cross section nor in longitudinal section, landslides or collapse on upstream or downstream slope, sinkholes or uncontrolled infiltration. Checking the slope stability of the earth dam requires considering the geometrical and geotechnical parameters and the seepage at the time of analysis.

Determination of seepage line parameters through dam have to consider the current state of the material of the earth massive after a long period of operation.

From data analysis, the results for Chirita dam show that it is met the upstream and downstream slope stability in the considered scenarios.

REFERENCES

Carlier M., 1972 Hydraulique générale et appliquée, Edit. Eyrolles, Paris,.

Cercel, P., 2011 Research on the safety condition of hydraulic structures. PhD Thesis

CretuI., 1980, Numerical models for flow through porous medium

Hobjila V., Luca M. 2000, Complements on the design and expertise of some types of Hydrotechnical construction

Luca, M., Hobjila, V., 2002, The hydraulic expertise of the high water discharge structure in earthen dams, Ovidius University Annals of Constructions, Volume 1, number 3, 4, 419-422.

Luca M., 2009, Technical expertise concerning the safe operation of the dam Chirita. S.C. POLIAS-INSTAL S,R,L.

Luca Al., L., 2014, Research on free filtrate level in the fields Darcy and post Darcy, PhD thesis, "Gheorghe Asachi" Technical University of Iaşi.

Marchidanu,E., 1996, Hydrogeology in construction engineering

Pietraru V., 1987, Seepage calculation, Edit. Ceres, Bucharest,

Prişcu R., 1976, Hydrotechnical constructions, Vol. I,

Ratiu M., Constantinescu C., 1989, Behaviour of Hydrotechnical constructions

Stematiu D., Constantinescu C., 1998, Considerations on analysis and risk assessment of dams, Hydrotechnics, 43, 5.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

USA ENVIRONMENTAL DUE DILIGENCE PRACTICE CASE STUDY ON AN INDUSTRIAL SITE LOCATED IN CARAS-SEVERIN COUNTY ROMANIA

Patricia MOCANU[1], Laurentiu MOCANU[2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, 011464, Bucharest, Romania
[2]ECOGEOMEDIA Consulting, 30 Crangasi St., Bl. 50, Ap. 63,District 6, 060339, Bucharest, Romania

Corresponding author email: laurentiu.mocanu@ecogeomedia.ro

Abstract

This paper focuses on the application of the usual approach for the environmental assessment of sites which are the subject of a real estate transaction or which are brownfields.
The existing Romanian legislation in this field must to be completed with other available regulations. In addition, the success of the approach is provided by a rich professional experience of the environmental assessors involved.
The case study presented in this paper refers to the approach taken to investigate and quantify their potential historical pollution for a former industrial land with an area of 8840 m^2. In this respect, both the international and Romanian standards were applied.

Key words*: Environmental Site Assessment, intrusive investigation, alert threshold, intervention threshold, brownfield, total petroleum hydrocarbon.*

INTRODUCTION

In the last 10–15 years began to pay increasing importance of identifying historically contaminated sites, evaluate them and solve them using the most appropriate methods.
Romanian environmental legislation has also been subject to several changes and additions in this period, but to solve the problems mentioned above there only a few titles.
For example, it was approved the GD 1408/2007 on the methods of investigation and assessment of pollution of soil and subsoil, and then would have be published the implementing rules.
After nearly nine years they have not yet been published, so that environmental consultants who usually do these kinds of investigations are forced to use other countries' legislation and standards.
This happens in a context where there is no EU legislation in this very bidder.
Identification and quantification of historical pollution of land on which industrial activities were carried out is very important especially in two specific situations: through the procedure of identification and remediation brown fields sites; in the beginning of the commercial real estate transaction process. In this second case, the buyer of a subject property is the most interested to know all the details about a possible historical pollution. Ignorance in their timely, it can cost due to the fact that it will become the owner of land for decontamination which will have to pay.
To achieve the necessary investigations to identify and quantify pollution to land, with or without ongoing activities, most environmental consultants resort to ASTM (American Society for Testing Materials) standards.
Throughout its existence, ASTM was transformed from a simple American organization into an international one. ASTM International is a globally recognized leader in the development and delivery of voluntary consensus standards. Today, over 12.000 ASTM standards are used around the world to improve product quality, enhance health and safety, strengthen market access and trade, and build consumer confidence.
According to ASTM standards and the international practice, the most usual

approach for the full environmental site assessments requires going through successive following steps:

a) Phase I Environmental Site Assessment. The purpose of this Phase I ESA is to identify the environmental conditions in connection with the property and consists of four components (ASTM E1527-13):

- Site Description
- Records Review
- Site Reconnaissance
- Interviews.

The final report shall include a conclusions section that summarizes all recognized environmental conditions connected with the property and the impact of these recognized environmental conditions on the property.

b) Phase II Environmental Site Assessment. The main objective of conducting a Phase II ESA is to evaluate the recognized environmental conditions identified in the Phase I ESA or transaction screen process for the purpose of providing sufficient information regarding the nature and extent of contamination to assist in making informed business decisions about the property (ASTM E1903-11). The components of a Phase II ESA are as follows:

- Developing the scope of work (provide the rationale for planned sampling locations and testing parameters)
- Assessment activities
- Evaluation and presentation of data
- Presentation of findings and conclusions.

c) Phase III Environmental Site Assessment. The primary objective of a Phase III ESA (also known as Site Remedial Action Plan/Remediation Strategy Phase) is to investigate the nature and extent of adverse environmental impact identified by the Phase II ESA, to develop a Remedial Action Plan (RAP). Specific investigations of this phase include the calculation of the volume of impacted soil and/or groundwater, risk assessment, presentation of possible options for remediation, and sometimes site-specific pilot studies. At the end of this stage it is mandatory to notify the competent environmental authority which must approve the proposed remediation solution.

An ASTM Standard for Phase III ESA does not exist because the type and variety of work performed under site clean-up actions is so variable. The necessary site characterization and remediation work must to use a multi-disciplinary approach to all characterization and remediation projects.

d) Phase IV Environmental Site Assessment. This phase (Remediation/clean-up or Remedial Action Plan Implementation) may involve the following components:

- Removal and disposal of existing contaminated area(s) through a variety of methods
- On site treatment of contaminated soils, groundwater, and waste streams
- Implementation of waste reduction plans, environmental management systems, and other at source remedial measures.

No international standard exists for this ESA stage.

e) Phase V Environmental Site Assessment. This phase (also known as Completion/Validation Phase) must to demonstrate that RAP was implemented, providing evidence of actions undertaken. The Completion Report may include:

- Ground level surveys to demonstrate the depth of capping layer installed
- Photographic evidence of installed features
- Reassurance/verification sampling
- Laboratory results of imported soils
- Post completion monitoring etc.

In this way it confirms that remediation targets have been achieved.

In this context, this paper presents a study case related to the environmental investigations developed on a Romanian brownfield in order to identify and quantify the existing historical pollution, required by a potential investor interested in land acquisition.

MATERIALS AND METHODS

The subject property of the study case is located in the town of Moldova Noua, Caras-Severin County and occupies 8.840 m^2 of land (which consist of two plots of land – Plot 1 of 5.000 m^2 and Plot 2 of 3.840 m^2, respectively).

The site is located in an industrial area within the Moldova Noua industrial harbour, in the

westernmost part of the town, along the Danube River. The property is bordered by the Danube River (to the West), industrial area (to the South), residential area (to the East) and by a public property (to the North).

Figure 1. Site map location

For location above was made that an environmental assessment aimed at identifying and quantifying geological environment pollution.

To this end, they have been completed phases I, II and III of the environmental assessment procedure set out above.

Also they have taken into consideration the applicable Romanian legislation included in the Ministry Order no. 184/1997 on approving the Environmental Site Assessment Procedure (with subsequent additions and modifications).

To interpret the results of measurements were taken on the provisions:

- Ministry Order no. 756/1997 approving the Regulation on the environmental pollution assessment (with subsequent additions and modifications);
- Low no. 458/2002 related on the quality of drinking water (modified by L311/2004);
- Dutch Standard related to the groundwater target values and soil and groundwater intervention values.

RESULTS AND DISCUSSIONS

Phase I ESA. Based on desk study and on site visit information, the following environmental findings could where reported on the subject property:

- The presence of potential contamination sources associated with fuel pumping and loading activities.
- The existence of three aboveground storage tanks (AST) located in the close North vicinity of the subject property, at approximately 20-50 m from its boundary; no official information could be found on past incidents related to potential leaks or inappropriate operation of the tanks.
- The presence of a metallic hall with three compartments, located south of the subject property, hosting various uncontrolled solid waste.

Phase II ESA. Based on the data and information obtained during the Phase I ESA, intrusive investigations were recommended to be performed on site. These investigations were to consist of drilling works allowing sampling and analysis of soil and ground water samples, to identify some potential historical pollution.

Potentially contaminated areas were identified in the northern part of the subject property, near the exiting ASTs located at approximately 20 and 50 m from the boundary. It is most likely that the ASTs formerly contained fuel that was pumped through the pump room to the tank trailer loading platform, both located on site.

The survey focused on a good coverage of the site surface, in order to give a relatively accurate and comprehensive view of the extent of the potential contamination, as well as of its chemical nature. Soil and ground-water sampling was performed according to the applicable Romanian regulations (Ministry Order no. 184/1997 on approving the Environmental Site Assessment Procedure).

Six boreholes were drilled to a maximum depth of 20 m bgl, one of which was equipped as monitoring well to a depth of 10 m.

The Subject Property layout and drilling locations map are enclosed in Figure 2.

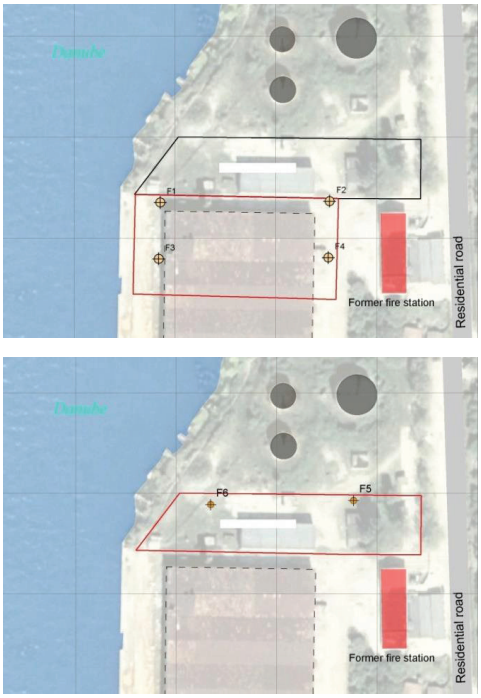


Figure 2. Phase II ESA - Drilling locations map

A total of 24 soil samples and 4 groundwater samples were recovered in order to be analysed in the analytical laboratory.
Samples were stored in pre-cleaned glass containers; the sampled quantities were decided according to the type of analysis and the laboratory requirements. The sample containers were labeled with a unique sample identification number and transported to the analytical lab (certified according ISO 17025:2001) by a consultant representative.
An example from the drilling operations is shown in Figure 3.
The analysed parameters were selected as to:

- represent all the potential pollutants for this particular site; the identification of potential sources of contamination was done by relating the nature of past activities on site to visual observations;
- provide relevant data taking into account any possible remedial actions that may be conducted as a result of significant contamination.
- Also, the selection of the parameters to be analysed for the soil samples (pH, total petroleum hydrocarbon, Cd, Cu, Total Cr, Ni, Pb, Zn and Chlorides) was made based on MO no. 184/1997 provisions.

Figure 3. Drilling of borehole F1

In order to interpreted the analytical results, the Ministry Order no. 756/1997 approving the Regulation on the environmental pollution assessment (with subsequent additions and modifications) defines the significance of and sets down the provisions on the alert threshold and the intervention threshold for air, and water pollutants and soil contaminants:

- *alert threshold* – pollutant concentrations in air, water, soil or in emissions/discharges, which have the role of warning the competent authorities on a potential environmental impact and which determine the start-up of supplementary monitoring or/and mitigation of pollutant concentrations in emissions/discharges;

- *intervention threshold* – pollutant concentrations in air, water, soil or in emissions/discharges for which the competent authorities will require risk assessment studies to be performed and pollutant concentrations to be mitigated.

The current regulations on soil contamination refer both to the sensitive and less sensitive use of land, described as follows:

- the sensitive use of land is the use of land for residential and recreational areas, for agricultural purposes, as protected or sanitary areas under a restrictive regime, as well as parcels of land foreseen to be used in the future as described above;
- the less sensitive use of land includes all the existing industrial and commercial uses, as well as parcels of land foreseen to be used in the future as described above.

The results of the analyses run on the recovered soil samples were compared to the maximum allowable levels imposed for the less-sensitive use of land, taking into account the fact that there is no known intent for a change of land use, other than industrial or commercial, relative to the subject property.
Soil analytical results for the F1-F6 boreholes are presented in Table 1 and samples with exceedances of thresholds values are highlighted in red (for intervention threshold) or blue (for alert threshold).

Table 1.Phase II ESA - Soil analytical results

Sample Identification	Depth [m]	pH	TPH (IR)	Cadmium (Cd)	Copper (Cu)	Total Chromium (Cr)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)	Chlorides
F1/1.00 m	1.0	7.93	26.2	<0.5	90.4	14.2	20.4	14.8	68.1	52.16
F1/2.00 m	2.0	8.34	**2,779.0**	<0.5	87.3	20.0	40.7	21.9	73.0	65.03
F1/3.00 m	3.0	8.41	**3,792.0**	<0.5	115.0	15.4	21.0	16.6	82.8	24.85
F1/4.00 m	4.0	8.26	41.1	<0.5	126.7	13.7	21.0	15.2	74.8	33.40
F2/1.00 m	1.0	8.39	29.7	<0.5	82.1	20.1	23.9	39.5	75.5	43.57
F2/2.00 m	2.0	8.38	28.1	<0.5	126.0	21.0	24.5	20.4	84.6	63.11
F2/3.00 m	3.0	8.49	37.1	<0.5	**452.0**	15.3	21.2	61.3	194.0	63.69
F2/4.00 m	4.0	8.36	30.7	<0.5	55.0	34.8	39.0	23.9	110.0	27.19
F3/1.00 m	1.0	8.25	<25.0	<0.5	79.5	17.2	22.2	23.2	71.5	49.71
F3/2.00 m	2.0	8.43	<25.0	<0.5	100.0	13.7	21.2	16.2	103.0	64.05
F3/3.00 m	3.0	8.42	<25.0	<0.5	96.7	16.2	21.3	16.7	76.3	20.65
F3/4.00 m	4.0	8.37	27.2	<0.5	153.0	13.9	22.3	18.5	98.9	29.37
F4/1.00 m	1.0	8.46	289.0	<0.5	165.0	15.9	18.6	26.7	89.6	75.62
F4/2.00 m	2.0	8.48	38.8	<0.5	55.9	27.6	29.7	11.0	84.5	40.28
F4/3.00 m	3.0	8.34	38.3	0.9	**854.0**	14.5	22.5	46.2	305.0	73.01
F4/4.00 m	4.0	8.30	<25.0	<0.5	31.9	31.0	35.0	13.4	70.3	31.41
F5/1.00 m	1.0	8.64	28.1	<0.5	174	20.0	24.4	96.4	103.8	60.46
F5/2.00 m	2.0	8.62	<25.0	<0.5	148	22.8	24.9	26.0	91.1	54.08
F5/3.00 m	3.0	8.69	<25.0	<0.5	209	25.8	28.7	30.4	111.0	48.35
F5/4.00 m	4.0	8.65	35.1	<0.5	132	19.2	18.8	22.5	84.0	41.38
F6/1.00 m	1.0	8.62	34.2	<0.5	174	21.5	22.3	33.2	118.0	61.88
F6/2.00 m	2.0	8.69	<25.0	<0.5	113	21.9	22.2	26.4	87.8	55.96
F6/3.00 m	3.0	8.67	**2,237.0**	<0.5	133	22.5	22.4	18.6	87.1	37.29
F6/4.00 m	4.0	8.66	79.8	<0.5	108	14.3	16.4	16.3	76.1	37.14
Measurement unit		*pH units*	*mg/kg dry matter*							
Less sensitive use of land	*Normal value*	*6.5÷7.5*	*<100*	*1*	*20*	*30*	*20*	*20*	*100*	*≤180*
	Alert threshold	**-**	***1,000***	***5***	***250***	***300***	***200***	***250***	***700***	**-**
	Intervention threshold	**-**	***2,000***	***10***	***500***	***600***	***500***	***1,000***	***1,500***	**-**

The soil analytical results revealed some significant concentrations for the chosen parameters, as follows:

- three samples, two collected from the borehole F1, at depths of 2 and 3 meters, and one collected from borehole F6, at a depth of 3 m, revealed concentrations of total petroleum hydrocarbons (TPH) above the intervention threshold;
- one sample collected from the F4 borehole, at the depth of 3 m, revealed a concentration of copper above the intervention threshold;
- one sample collected from the F2 borehole, at the depth of 3 m, revealed a concentration of copper above the alert threshold.

No exceedances of the threshold concentrations were recorded for the other samples.

According to the applicable legislation (MO no. 756/1997), the exceedance of the intervention threshold indicates a significant soil pollution, in which case it is necessary to implement soil remediation measures.

The analytical results of the groundwater chemical parameters are presented in Table 2. The measurements values were compared to the applicable Romanian standard as L no. 458/2002 regarding the quality of drinking water (modified by L no. 311/2004). Samples with exceedances of thresholds values are highlighted in red (for intervention threshold) or blue (for alert threshold).

Table 2.Phase II ESA – Groundwater analytical results

Sample id.	Depth [m]	pH [pH units]	Parameters [mg/dm^3]				
			CCO-Mn	Turbidity	Total hardness	Ammonium	TPH
F1	3.0	7.44	**5.76**	**9**	**6.3**	**1.82**	0.32
F2	3.0	6.78	3.20	**6**	**59.4**	**1.36**	<0.05
F4	3.0	6.89	2.40	**19**	**63.6**	**0.73**	<0.05
F6	3.0	6.80	**13.75**	**10**	**56.6**	**0.91**	**2.99**
Maximum allowable concentration	***L 458/2002***	***6.5÷9.5***	***5***	***≤5***	***5***	***0.50***	***-***
	Dutch Standards	***-***	***-***	***-***	***-***	***-***	***0.60***

The analytical results for groundwater revealed exceedances of the maximum allowable concentrations for the some of the chosen parameters, as follows:

- the maximum allowable concentration for chemical oxygen demand (CCO-Mn) was exceeded in 2 samples;
- the maximum allowable level for turbidity, and total hardness, and ammonium were exceeded in all samples;
- the maximum allowable concentration for TPH, as compared with the Dutch standards, was exceeded in F6.

Several conclusions can be drawn as regards the analytical results for the groundwater samples:

- the exceedances of the limits for CCO-Mn and Ammonium, which further reflect into the turbidity values, reveal high concentrations of organic matter in the first aquifer, which may be a consequence of the inappropriate waste water in the nearby residential area;
- the values for total hardness indicate the high presence of calcium and magnesium ions; however, compared to the Romanian standard for water aggressiveness, the concentrations of magnesium lower than 200 mg/l reveal the fact that water in the three monitoring wells are very low aggressive over concrete;
- the Romanian regulation for the quality of drinking water Lno. 458/2002 does not stipulate a maximum allowed concentration for petroleum hydrocarbons, therefore any presence of this chemical parameter is considered to be a contamination of the aquifer; according to the Dutch standards, the TPH concentration exceeds the maximum allowed limit of 0.6 mg/l.

However, comparing the analytical results with specific maximum allowable concentrations of drinking water is slightly forced, given that it is expected that water from aquifers is not drinking water.

Soil remediation measures are required to decrease the concentration of TPH below the intervention threshold stipulated by the Romanian legislation. There was no question of continuing soil investigations and decreasing the concentration of Copper, taking into account that in the interested area could be presented higher concentrations of Copper than normal due to prolonged use of the harbour for loading/unloading ore.

Phase III ESA. The previous step of the environmental assessment revealed a contaminated area in the north-western corner of Plot no. 1 and the south-western corner of Plot no. 2, at depths ranging from 2 to 3 m. Additional soil investigations were recommended as Phase III ESA. No additional depth for soil quality investigations were proposed because of the presence of groundwater at 3 m bgl.

A Sampling Plan was proposed and consisted of recovering additional soil samples from the surfaces already identified as contaminated (in the vicinity of F1 and F6).

In this respect, some sampling pits were conducted in order to give a more accurate view of the spatial extent and volume of contaminated soil.

Soil samples would be collected at 1 m intervals to the depth of the groundwater table, in order to perform the proposed additional analyses.

The recovered samples were analysed in order to confirm the nature and the intensity of the contamination identified during the Phase II EDD and to suggest the most suitable remediation method.

Therefore, 12 on-site sampling pits were executed by an excavator to a maximum depth of 3 m, in order to obtain the necessary material for chemical analysis (Figure 4 and Figure 5).An additional excavation (SPx) was performed in the close northern vicinity of Plot no. 2, in order help to identify more accurate the source of contamination on the subject property.

Soil samples were collected, recovery, preparation and labelling tasks were ensured by the consultant qualified personnel.

These activities were performed by observing the specific requirements of the national and international standards and by complying with the appropriate QA/QC measures.

Figure 4. Sampling pits locations map

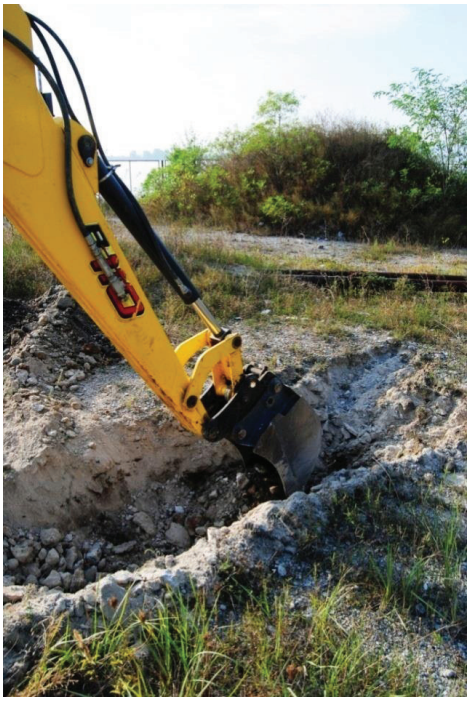


Figure 5. Digging of SP4

The bulk of the excavator was carefully cleaned after the execution of the each sampling pit.

The preservation of the samples in adequate conditions (paying more attention to cleaning

of the excavator's bucket after the execution of each sampling pit) and their transportation to the laboratory were also ensured by consultants.

The main field observations on collected samples are presented in the Table 3.It can be seen that since the time of sampling, for most samples was felt the smell of hydrocarbons. Later, it was confirmed by the results obtained in the analytical laboratory.

Table 3. Phase III ESA – Description of recovered soil samples

Sample Identification	Sampling depth (m)	Field observations
SP1	1 – 3	Heterogeneous filling material with coarse gravel and sand; dark coloured layers with smell of hydrocarbons at 1 and 2 m bgl, noticeable smell of hydrocarbons at 3 m bgl and traces of hydrocarbons on the groundwater surface.
SP2	1 – 3	Coarse filling material with sand and gravel; thick, dark coloured layer with noticeable smell of hydrocarbons between 1 and 3 m bgl, traces of hydrocarbons on the groundwater surface.
SP3	1 – 3	Coarse filling material with sand and gravel; dark coloured layer with smell of hydrocarbons at 3 m bgl.
SP4	1 – 3	Coarse filling material with sand and gravel; dark coloured layer with noticeable smell of hydrocarbons at 3 m bgl.
SP5	1 – 3	Heterogeneous filling material with sand and gravel; dark coloured layer with smell of hydrocarbons at 3 m bgl.
SP6	1 – 3	Filling material with sand and gravel, light smell of hydrocarbons at depths below 2 m.
SP7	1 – 3	Coarse mixture of sand and gravel; thin dark coloured layer at 2 m bgl, no noticeable smell of hydrocarbons.
SP8	1 – 3	Heterogeneous filling material, no smell or traces of hydrocarbons
SP9	1 – 3	Filling material with coarse sand and gravel; thick, dark coloured layer with heavy smell of hydrocarbons and traces on the groundwater surface.
SP10	1 – 3	20 cm thick layer of concrete, coarse filling material with sand and gravel; thin, dark coloured, shallow layer with light smell of hydrocarbons at 1 m bgl.
SP11	1 – 3	20 cm thick layer of concrete, coarse filling material with sand and gravel.
SP12	1 – 3	20 cm thick layer of concrete, coarse filling material with sand and gravel.
SPx (off-site)	1 – 3	Coarse filling material with sand and gravel; dark coloured layer with noticeable smell of hydrocarbons over the 2 - 3 m depth interval.

Samples were analysed using the gas chromatography (GC) method, in order to highlight the percentages of different fractions of hydrocarbons in the recovered samples.

The analytical results are presented in the next table. Samples with exceedances of thresholds values are highlighted in red (for intervention threshold) or blue (for alert threshold).

Table 4.Phase III ESA – Analytical results

Sample Identification	Sampling depth (m)	Analysed parameter					
		TPH (mg/kg dry matter)	Fraction (%)				
			C10-C14	C14-C20	C20-C26	C26-C34	C34-C40
SP1/1 m	1	**4,562.00**	35	55	10	<5	<5
SP1/2 m	2	**5,525.00**	35	55	10	<5	<5
SP1/3 m	3	**8,066.00**	35	55	10	<5	<5
SP2/1 m	1	**7,112.00**	20	55	25	<5	<5
SP2/2 m	2	**1,379.00**	45	45	10	<5	<5
SP2/3 m	3	**2,350.00**	45	45	10	<5	<5
SP3/1 m	1	36.23	50	50	<5	<5	<5
SP3/2 m	2	471.00	25	45	30	<5	<5
SP3/3 m	3	**1,442.00**	30	55	15	<5	<5
SP4/1 m	1	37.18	<5	100	<5	<5	<5
SP4/2 m	2	75.23	<5	90	10	<5	<5
SP4/3 m	3	**3,494.00**	30	65	5	<5	<5

Sample Identification	Sampling depth (m)	Analysed parameter					
		TPH (mg/kg dry matter)	Fraction (%)				
			C10-C14	C14-C20	C20-C26	C26-C34	C34-C40
SP5/1 m	1	140.00	10	70	20	<5	<5
SP5/2 m	2	56.39	<5	90	10	<5	<5
SP5/3 m	3	**1,687.00**	25	60	15	<5	<5
SP6/1 m	1	51.24	20	75	5	<5	<5
SP6/2 m	2	**2,737.00**	15	75	10	<5	<5
SP6/3 m	3	**6,804.00**	15	75	10	<5	<5
SP7/1 m	1	59.73	<5	90	10	<5	<5
SP7/2 m	2	43.18	<5	100	<5	<5	<5
SP7/3 m	3	359.00	15	80	5	<5	<5
SP8/1 m	1	127.00	<5	100	<5	<5	<5
SP8/2 m	2	174.00	5	95	<5	<5	<5
SP8/3 m	3	129.00	5	90	5	<5	<5
SP9/1 m	1	<25.00	<5	<5	<5	<5	<5
SP9/2 m	2	30.29	<5	100	<5	<5	<5
SP9/3 m	3	**6,699.00**	45	50	5	<5	<5
SP10/1 m	1	540.00	10	80	10	<5	<5
SP10/2 m	2	161.00	10	85	5	<5	<5
SP10/3 m	3	88.73	<5	95	5	<5	<5
SP11/1 m	1	27.87	<5	95	5	<5	<5
SP11/2 m	2	99.75	<5	95	5	<5	<5
SP11/3 m	3	245.00	<5	95	5	<5	<5
SP12/1 m	1	96.41	5	90	5	<5	<5
SP12/2 m	2	<25	<5	<5	<5	<5	<5
SP12/3 m	3	<25	<5	<5	<5	<5	<5
SPx/1 m	1	133.00	25	65	10	<5	<5
SPx/2 m	2	**8,476.00**	20	55	25	<5	<5
SPx/3 m	3	**4,921.00**	20	55	25	<5	<5
Normal value		*<100*	-	-	-	-	-
Alert threshold		***1,000***	**-**	**-**	**-**	**-**	**-**
Intervention threshold		***2,000***	**-**	**-**	**-**	**-**	**-**

The analytical results for the samples recovered during Phase III ESA were graphically interpolated for a relatively accurate view of the spatial extent and volume of contaminated material (see Figures 6).

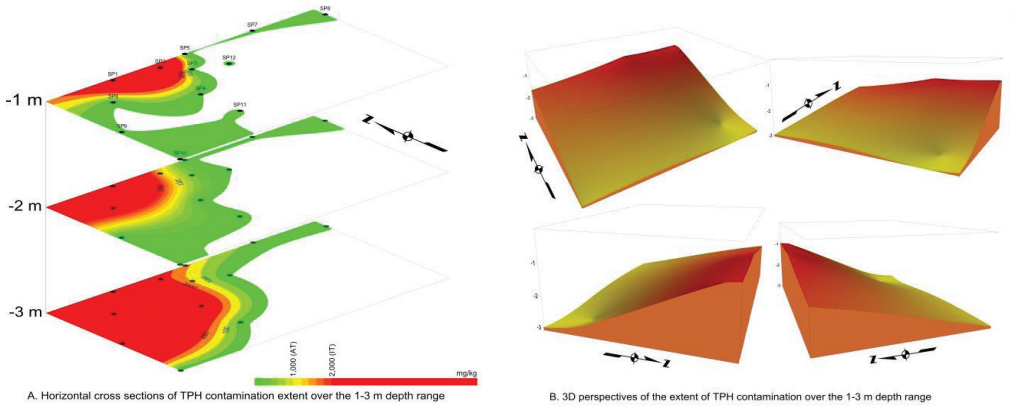


Figure 6. Horizontal cross section of TPH contamination (2D and 3D perspectives)

The analytical results based on intrusive soil investigation during Phase III ESA revealed exceedances of the legal thresholds, as follows:

- Concentrations in 11 samples, recovered from 6 of the sampling pits (SP1, SP2, SP4, SP6, SP9 and SPx) exceeded the intervention threshold for TPH, the depth of contamination being more than 3 m;
- Three 3 samples collected from 3 of the sampling pits (SP2, SP3, SP5) revealed exceedances of the AT for TPH;
- The bulk test pits (8 of 13), hydrocarbons concentration increases with depth;
- The identified fractions of hydrocarbons range from C10-C14 to C14-C20 and C20-C26, with the highest weight in the C14-C20 fraction. Given the results, it can be deduced that the contamination consists of high concentrations of diesel fuel.

CONCLUSIONS

After three successive stages, the environmental assessment for a former industrial site located in Moldova Noua town confirmed the presence of an historical pollution with petroleum hydrocarbon. The contaminated area is situated
in western side of Plot no. 2 and in the north-western corner of Plot no. 1.

As the samples collected from the off-site sampling pit, located in the close northern vicinity of Plot no. 2, revealed high exceedances of the IT for TPH, it was confirmed that the source of contamination were the 3 nearby ASTs.

Based on analytical results, the estimated volume of contaminated soil with hydrocarbons is of approximately 1,500 m^3, over a depth ranging from 1 to 3 m, on a total surface of approximately 700 m^2.

Moreover, the groundwater table was affected through progressive infiltration of the contaminant.

Soil and groundwater remediation works are required on the subject property, so the environmental assessment must be continued with Phase IV and Phase V.

REFERENCES

ASTM E1527 - 13 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process.

ASTM E1903 - 11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process.

Canadian Council of Ministers of the Environment - Environmental Guideline for Contaminated Site Remediation, 2003, pages 11-17.

Low no. 458/2002 regarding the quality of drinking water L 458/2002 (modified by L311/2004).

Ministry Order No. 184/1997 approving the environmental site assessment procedure (with subsequent additions and modifications).

Ministry Order No. 756/1997 for approval of the Regulation on the assessment of environmental pollution (with subsequent additions and modifications).

South Gloucestershire Council – Contaminated Land, 2003, pages 4-6.

US Army Corps of Engineers – Requirement for the Preparation of Sampling and Analysis Plans, 2001, pages 182-184.

US Civilian Federal Agency Task Force – Guide on Evaluating Environmental Liability for Property Transfers, 1998, pages 12-13, 24-25, 35-50

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

IRRIGATIONS: INNOVATIVE, VIRTUAL, AUGMENTED REALITY & EDUTAINMENT BASED, VET HANDBOOK AND eLEARNING FOR THE TRAINING IN ADVANCED IRRIGATIONS

Gheorghe Mincu SANDULESCU, Mariana BISTRAN, Florian UDRESCU, Laurențiu Florian ION

IPA SA, 169 Calea Floreasca, District 1, Bucharest, Romania

Corresponding author email: san@ipa.ro

Abstract

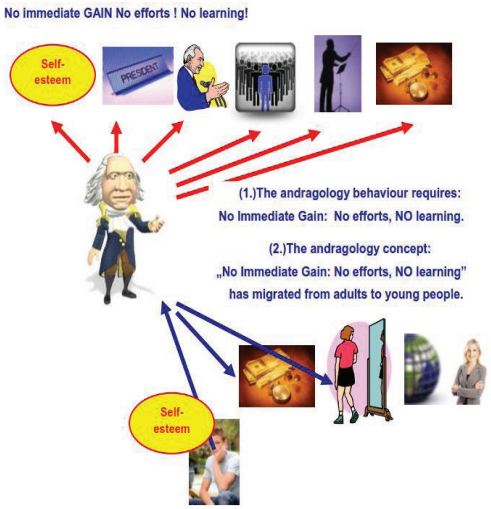
The paper presents part of the results of the EU Commission, Leonardo da Vinci Project: LDV/ToI/2013/RO/030.
The project achieved by entities from authors of the Handbook: Romania: IPA SA project proposer, writer and coordinator, Spain: University of Cordoba, Italy: 2 Partners, University of Naples and CREA/Council for Research in Agriculture and in the Agricultural Economy), USAMV Bucharest, and entities which have presented the lessons with the view of the lessons assessment: USAMV Bucharest, CCIAGR/Chamber of Industry, Agriculture and Commerce, Giurgiu), Agricultural Collegiums Sandu Aldea Calarasi, Agricultural Collegiums Viaceslav Harnaj, Bucharest, Faculty of Agronomy and Horticulture of University of Craiova, is destined for the training of farmers, technicians, people interested in the creation and development of the own irrigations.
The project has generated: (a) the printed, (b) on DVD, (c) on special digital application on DVD (d) on WEB Handbook: Innovative irrigations for All, pdf. 2200 pages.
The handbook, of 38 lessons, was converted, by IPA SA in the advanced eLearning format in HTML5. Also are elaborated 2 Occupational Standards (drafts) in irrigations.
The project has developed advanced eLearning support for the quick and efficient knowledge and skills transfer, based on over 100 Virtual Reality, 3D, Dynamic Images.
These Dynamic Images h create efficient animations, Augmented Reality products, developed by IPA SA, as SAReL system: Special Augmented Reality for eLearning and other AR tools.
Special development, such as celebrities from dedicated novel (lampoons), contributes at the Edutainment support.
The lessons have been successfully tested on the sample of over 500 interested people.
The action and developed materials add contributions at the re-launching of irrigations in Romania.

Key words*: irrigations, water, soil, irrigations agronomy, equipments, water, soil, irrigations agronomy, training, Virtual Reality, Augmented Reality, Edutainment.*

INTRODUCTION

THE ANDRAGOLOGY ASPECTS AND THE IMPERIOUS NEEDS OF THE ACCELERATING THE SPEED OF UNDERSTANDING AND OF THE KNOWLEDGE APPROACHING

The today psychology and andragology, science of the mature behaviour, indicates that the first focus in the adult training behaviour may to be achieved under the restriction of the person immediate gain.
First andragology requirement: nothing efforts without gain (respective without immediate gain)!
Therefore, taking into consideration that the audience is focused also to the disadvantaged people, slow learners, possible ESLs, the special attention is given for the quick and efficient skills and knowledge transfer.
This requirement has leaded at the intensive integration of the innovative and advanced tools, especially of the imagery, animation, Edutainment and eEdutainment procedures, based, first, on the Virtual Reality and Augmented Reality.
The following image illustrates the trend of migration of the andragology concepts towards to young people.



THE IRRIGATIONS REQUIREMENTS

On the other hand, the situation of irrigations in Romania requires the strong improvement of the knowledge and skills in irrigation, training in irrigation, the approaching of the new, efficient, environment compliant, irrigations' procedures.

We remember you, that, if in 1990 were 4 million ha irrigated and 8 million ha planed to be irrigated, now are irrigated under about 0,4 million ha, respective under 1/10 of the initial surface.

THE I4ALL PROJECT

The Project title is:

Advanced Edutainment based VET/eVET products, destined to the large amount of farmers and to disadvantaged: slow learners, poor people, and focused to innovative training content, procedures, best practice& equipment, for irrigation.

The main aims of the I4ALL Project were:

(a) To generate advanced, edutainment, IT&C based, VET / eVET products, which to assure, competencies based efficient transfer of the knowledge & skills in innovative irrigations.

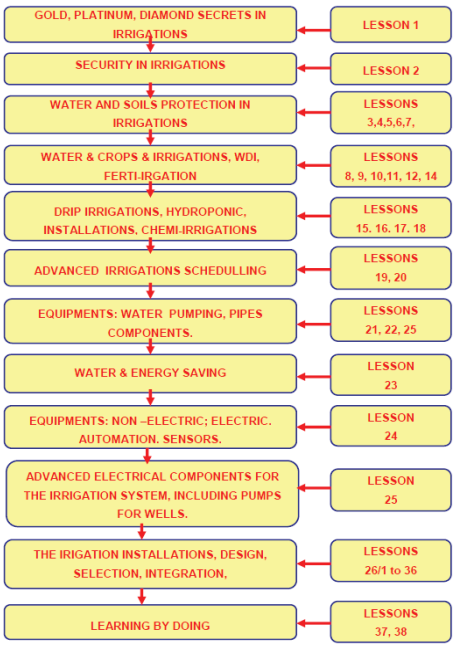
(b) To encourage cooperation between VET and the world of work.

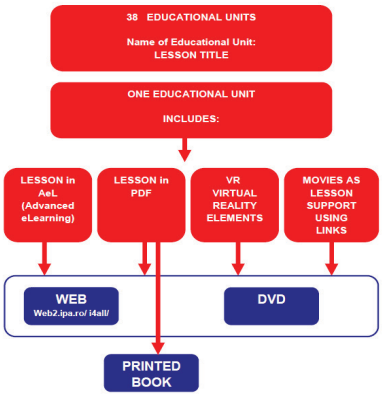
(c) To respond to the users needs education requirements of the big amount of farmers, stakeholders, inclusive of disadvantaged.

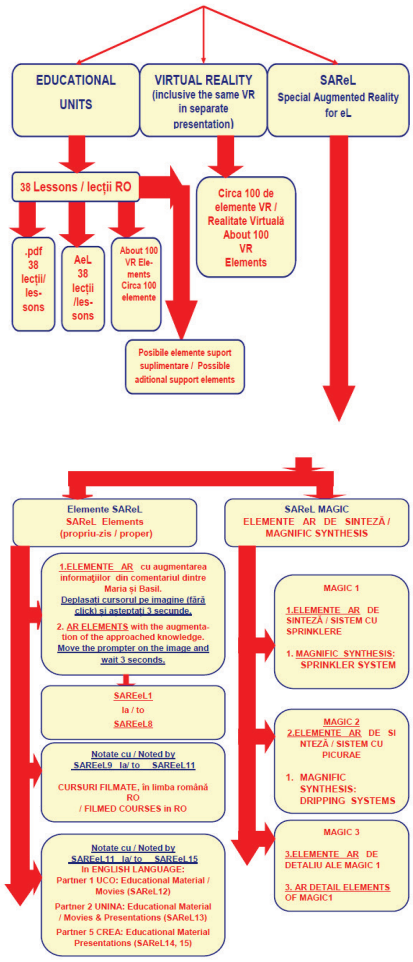
(d) To create the way for forming of the irrigations workers, technicians, masters of water. The solving of the lack of training products.

(d) To create the way for forming of the irrigations workers, technicians, masters of water. The solving of the lack of training products.

The handbook: "Advanced Irrigations for All" (2200 pages, 36 lessons) was developed, inside the project, on the basis of the achievement of (a) the EDUCATIONAL UNITS and (b) of the logic flux of knowledge as it is illustrated in the following image:







The following presentation will illustrate the mode of working of training.
Despite the handbook has 2200 pages, the basic skills may to be accomplished, using VR, AR, in some hours.
The web address is:**Web2.ipa.ro/i4all**
The 36 lessons, as you see, in this moment, are listed under the button:**EDUCATIONAL MATERIAL**.

WEB PRACTICAL PRESENTATION

Each lesson has, as you may to see at this moment, on the web:

- Own lesson, pdf. content, from which all the world bibliographic resources may to be accessed immediate, on-line.
- Own lesson, advanced eLearning pdf. content, which may to be manipulated quickly, simple and pleasant.
- Own lesson, Virtual Reality with many most important images and skills.

Also the educational material offers the possibilities, for instance on the web, of the training by the Augmented Reality as in the following, presented on the web, images.
Despite the handbook has 2200 pages, the learner has many ways to learn, the basic aspects, in time saving process.
For instance: for quick learning are intensive used the VR and AR images, and for details are used the deep presented aspects, included, for the specific topics, inside the eLearning lessons.

RESULTS AND DISCUSSIONS

The developments, through the project I4ALL, represent important steps in advance with the view of the irrigation re-implementation and for the irrigations approaching in the new advanced and very advanced mode, technologies, trends.
Some important steps in advance are constituted by the proliferation, dissemination, and, especially, application of the accomplished results.
Other steps in advance are generated by the 2 Occupational Standards developed, by the I4ALL project in the filed.
The developments through the project I4ALL represent only one of the important steps in advance.
Multiple other steps in advance are waited, and in this sense the authors look to the new cooperations with the view o the generation of new, advanced, innovative developments and applications.

CONCLUSIONS

The irrigations is necessary to be sustained by all the ways, one of these being the education.
The positive handbook organisation and content, the VR, AR, eEdutainment, Learning by Doing, have proved the power of education in the critical present field: the irrigations.

ACKNOWLEDGEMENTS

This work was carried out with the support of EU Commission, Leonardo da Vinci Programme, Project: LLP-LdV/ToI/2013/RO/030.
The content of this paper do not represents, in necessary mode, the official position of the EU Commission, or of other entity. EU Commission or other entity may not be responsible, in any mode, related to the mode in which this material is used.

REFERENCES

Web2.ipa.ro/i4all, 2015ISBN: 978-973-1704-30-2
Advanced Edutainment based VET / eVET products, destined to the large amount of farmers and to disadvantaged: slow learners, poor people, and focused to innovative training content, procedures, best practice& equipment, for irrigation. Editorial House: IPA SA, Bucharest, 2015, ISBN: 978-973-1704-30-2.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

BUILDINGS BEHAVIOUR TO SEVERE SURFACE EARTHQUAKES (CHILE 2010, NEW ZEALAND 2011, TAIWAN 2016)

Claudiu Sorin DRAGOMIR[1, 2], Daniela DOBRE[2,3], Emil-Sever GEORGESCU[2]

[1]University of Agronomic Science and Veterinary Medicine, Faculty of Land Reclamation and Environmental Engineering, Department of Environment and Land Improvement, Marasti Blvd., no. 59, 011464, District 1, Bucharest, Romania
[2]National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development "URBAN-INCERC"& European Center for Building Rehabilitation, ECBR, Pantelimon Street, no. 266, 021652 Bucharest, Romania
[3]Technical University of Civil Engineering Bucharest, Lacul Tei Blvd., no. 122 – 124 RO 020396, Bucharest, Romania

Corresponding author email: dragomirclaudiusorin@yahoo.com

Abstract

The paper presents the analysis of collapse and damage state to some special buildings during recent severe surface earthquakes, The presented irregular reinforced concrete buildings (with irregular distributions of mass, stiffness, strength, geometrical configurations), especially the setback structures and tall structures, have exhibited a poor seismic performance. Through graphical representations of response spectra obtained from records, it is revealed that most of the damage occurred to buildings due to exceeding the code requirements, the level of accelerations and to the spectral composition, unusual to the surface earthquakes, which justify the shown interest. Comparative analysis of numerical data is shown in order to put into evidence the effects of surface earthquakes on buildings. It must be accepted that an important role in the overall behaviour of the presented buildings had the higher modes of vibration and shaking time, beyond the technical aspects. What is noticeable, also, are the long periods of motions, although the earthquakes are of surface. The more accelerograms recorded are, we find that the possible values may be higher than those from design codes and sometimes the codes provisions are taken from other design rules (with other local features).

Key words*: seismic records, severe irregularities, long periods, damages.*

INTRODUCTION

The analysis of collapse and damage to some special buildings is made for these severe surface earthquakes:
Chile earthquake of February 27, 2010: M_w = 8.8, a_g=0.65g, a_g=0.14g – 0.47g in Santiago de Chile (with a_g=0.40gas the minimum current design code value), *duration of shaking 3min (40-50s strong vibration),* Pacific coastline, *depth source 35 km*, 320 km south-west of the capital Santiago de Chile and approx. 100 km north of Concepcion, the second city of the country.
Christchurch-New Zealand earthquake of February 22, 2011: M_w=6.3, depth source 5km, a_g=1.68g (a_g=0.5g…0.9g in many locations in the city*), duration of shaking 10sec*, on an alluvial plain near a volcanic chain.
Taiwan earthquake of February 8, 2016: M_w=6.4, depth source 16.7 km, *duration of shaking20...44sec*, a_g=0.3g, the most damaged buildings scattered in the east area of Tainan.

MATERIALS AND METHODS

SEISMIC RECORDINGS AND OBSERVATIONS

Regarding Chile earthquake 2010 effects, collapse mechanisms, structural assessment.

a. Collapse of 15-storeys building Torre Rio Alto of Concepcion, *H= 42m* (it was completed in 2009), Figure 1.

The structural system of the building consisted of an array of reinforced concrete structural walls and pilasters, designed taking into account the earthquake (thin structural walls, which support concrete slabs without

intermediary beams, with many openings and structural discontinuities; the walls had a thickness of 200mm, L and T shapes, many of them were retired from outside of the building at the first two levels).

The period of vibration for the first mode of vibration was approx. *T=1.09s* (Kohrangi et al, 2010).

Its collapse was not the most destructive type because the structural walls have ensured a high rigidity and did not allow a "sandwich" overlapping of floors, considered most dangerous for residents.

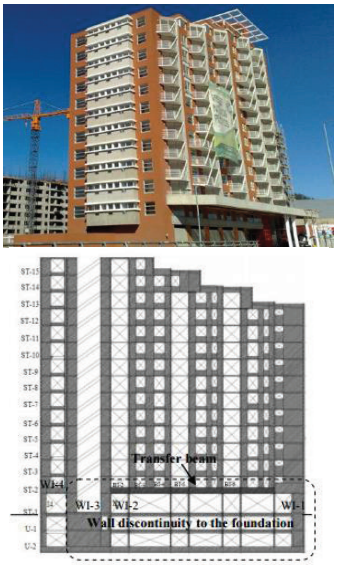


Figure 1. Some severe irregularities and discontinuity of walls at the base of the structural system (Kohrangi et al, 2012)

It has been found that, Figures 1...5:

- building was in an eccentric position respect to the whole basement;
- some severe irregularities and discontinuity of walls at the base of the structural system;
- the transverse reinforcement was not done properly with sizes of building and the wall thickness was not increased proportionately to reflect a greater height regime;
- the lack of bulbs at the ends of the structural walls;
- the relatively high levels of wall axial load (the wall axial tensile forces were probably underestimated) etc.

Also, the walls on the first floor and the basements (parking lot) are smaller than those on the second and above floors in both length and there is a difference in wall volume and layout among basement, first floor, and second floor, Figure 2, 3.

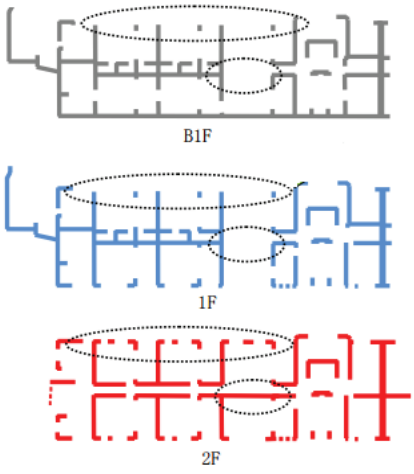


Figure 2. Difference in wall volume and layout among basement, first floor, and second floor (Saito et al, 2010)

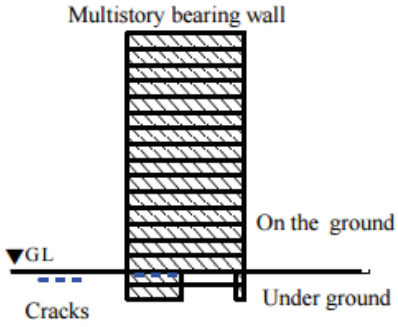


Figure 3. Schematic illustration of multi-story bearing wall with large opening at basement (http://www.kenken.go.jp)

Figure 4. Damage modelling and view of collapsed building (http://www.nehrp.gov/pdf)

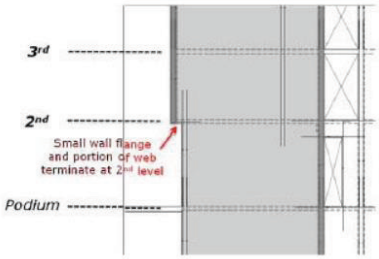


Figure 5. Details of vertical discontinuities of a shear wall (http://www.nehrp.gov/pdf/GCR%2014-917-25_RecommendationsforRCWallBuildings_std.pdf)

From this fact, the damages on the wall footing on the basements have resulted. The walls failed in the first story, causing the overturning of the entire building.

b. Partial collapse of 23-storeys modern tall building Torre O'Higgins, *H=73m* (it was completed in 2008 and demolished in 2012), Figures 6...9.

The reinforced concrete structural system of the building consists of a dual system of frames and shear walls (the shear walls positioned in the west side and on the other sides of the columns and beams), was designed to the latest Chilean seismic code and its failure was not anticipated, given the construction standards). The period of vibration for the first mode of vibration was approx. T= 0.9s (Silva et al, 2013).

Figure 6. Torre O'Higgins building before earthquake

The building experienced dramatic failures in several of its upper levels above mid-height (12, 16, 20), each coincident with a framing setback, that were likely a result of stiffness discontinuities and vertical irregularities in the structure.

The localized failures on the south and east faces were most likely due to the horizontal and vertical irregularities of the structure (irregular torsional stiffness, structural wrong torsion effects combined with structural defects). The perforated shear walls on the east face and south face showed damage to both wall piers and spandrels.

Figure 7. Torre O'Higgins building before earthquake and after, with dramatic failures in several of its upper levels (12, 16, 20) (Decanini, 2010)

Figure 8. Details of the main collapse at story 1 (Decanini, 2010)

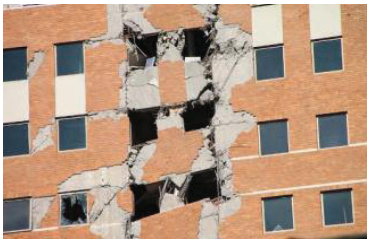


Figure 9. Details of facade failure, high axial/shear and bending forces (Decanini, 2010)

The causes that lead to shear wall failures are:

- low percentage of longitudinal and transversal reinforcement;
- rigidity variations in the elevation of the structures (wall thickness variations in the height of the building);

- due to the higher modes of vibration and large deformations of bending, inelastic shear values can develop much higher values (than those prescribed by the Eurocodes).

Regarding New Zealand earthquake 2011 effects, collapse mechanisms, structural assessment.

a. Collapse of 5-storeys Pyne Gould Building Co., *H= 15m* (it was built in 1964), Figure 10...16.

The reinforced concrete structural system of the building consists in a six-storey five-by-five bays frames (frame with a core wall offset towards the rear of the building).

Figure 10. Pyne Gould Co. building in October 2010

The lateral load resisting system consists of 200 mm thick RC core walls with two 15 m long RC walls, acting in the North-South direction, and three shorter (two 5 m and one 2.6 m long) RC walls along, acting in the East-West direction).

The period of vibration for the first mode of vibration was approx. T=0.7s ($0.09*H^{0.75}$ for RC moment-resisting frame).

Vertical stiffness irregularity, observed in construction plans, explains the collapse of type "sandwich" at the first level, with the collapse of the floors along the east-west axis of the building.

The poor performance led to the collapse, Figures 10...16:

– because it was a building built before the introduction of modern seismic design codes (1963 and 1964)
– due to the building had several critical reinforcement deficiencies (lack of shear reinforcement of nodes, inadequate anchoring beam-column/wall;
– soffit of slab showing where slab reinforcement has been ripped from slab;
– typical perimeter beam/column joint, with lack of joint ties;
– fractured slab reinforcement at wall/roof slab interface on the east side of the shear core etc.)

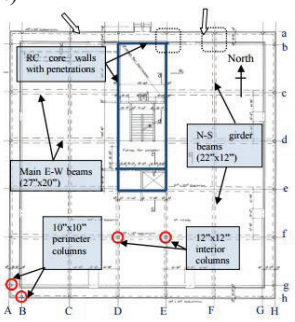


Figure 11. Plan view of the typical upper floors (2nd to4th Floors).

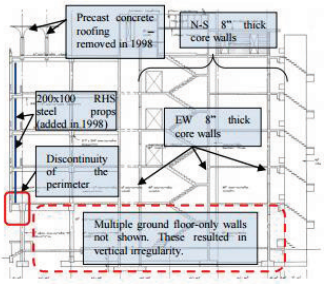


Figure 12. North-South elevation on Grid Line D.

Figure shows the East-West cross elevation view, which indicates some of the openings in the North-South 15 m long walls. The shorter RC walls have significant openings (two door openings of approximately 850 mm x 2.200 mm dimensions).

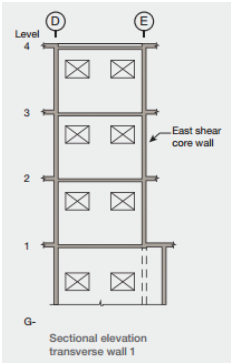


Figure 13. Sectional view (www.file:///C:/Documents%20and%20Settings/winxp/My%20Documents/Downloads/Final_Report_Volume_2_Web.pdf)

Figure 14.General Location of Main Structural Components after Collapse (http://www.building.govt.nz)

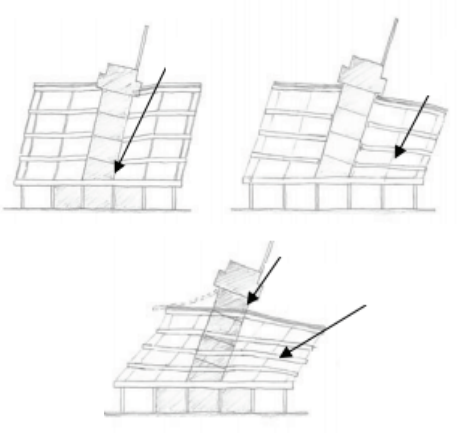


Figure 15. Time evolution of failure. Crushing of wall concrete, Failure of column/joints in compression, Failure of slab/wall connection, Failure of steel props (Beca Carter Hollings & Ferner Ltd (Beca) 26th September 2011)

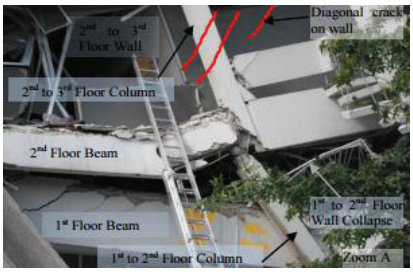


Figure 16 a. Various failure mechanisms observed on the Northern elevation of the collapsed PGC building (http://www.nzsee.org.nz)

The building collapsed when the reinforced concrete walls of the core of the structure between level 1 and level 2 failed. Subsequently, the perimeter columns and/or joints between the columns and the beams and the connections between the floor slabs and the shear-core failed, causing the floors to collapse.

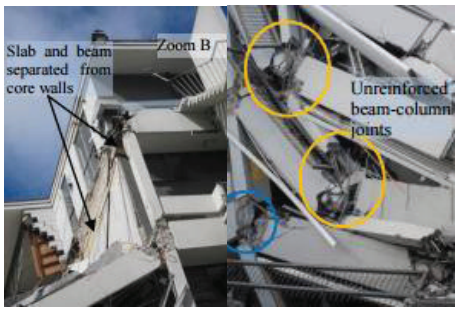


Figure 16 b. Various failure mechanisms observed on the Northern elevation of the collapsed PGC building (http://www.nzsee.org.nz)

b. Collapse of Grand Chancellor Hotel, *H= 85m* (it was built in 1986), Figures 17...25.

Grand Chancellor Hotel was the city's tallest building from Christchurch, *a reinforced concrete frame structure* (no. levels=26), with some vertical and horizontal irregularities.

The period of vibration for the first mode of vibration was approx. T=2.5 s ($0.09*H^{0.75}$ for RC moment-resisting frame).

Figure 17. View of the Grand Chancellor before 2011 earthquake (http://www.building.govt.nz)

Vertical irregularity arises from the fact that the upper tower relies on frame action (moment-resisting reinforced concrete frames) for its seismic resistance while the lower tower relies on reinforced concrete shear walls. The two structural forms inherently have different stiffnesses and, if not linked, would respond differently to seismic shaking.

The horizontal irregularity arises from the fact that the eastern bay of the building is cantilevered. Large cantilever transfer beams

extend out to the east at levels 12 to 14 above Tatters alls Lane to support the car park floors. The wall with a plate cantilever supported between 600 and 800 tons from weight higher levels. It is estimated that during the earthquake, this wall has undergone a request side 1800 to 2400tf. Two of these cantilevered transfer beams sit on top of the key supporting shear wall (wall D5-6), Figure 17. The damaged foundations lead to the visible leaning of the building to one side, Figure 18.

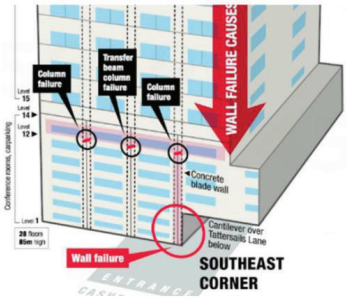


Figure 18. Failures of columns, transfer beam column, concrete wall (http://sciblogs.co.nz)

The wall failure and the south-east corner of the building dropped by approximately 800 mm and developed an accompanying horizontal lean of approximately 1300 mm at the top of the building, Figure 19.

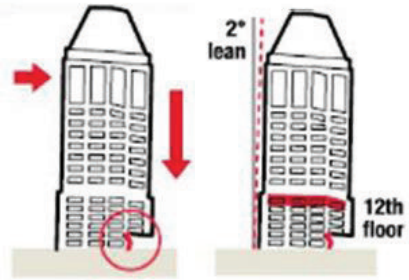


Figure 19. Wall failure and the south-east corner of the building (http://sciblogs.co.nz)

The building suffered structural damage, caused by the collapse of a key supporting shear wall "D5-6" located in the south-east corner of the building, Figures 20...23. The shear wall was responsible for roughly one-eighth of the Hotel Grand Chancellor's mass.

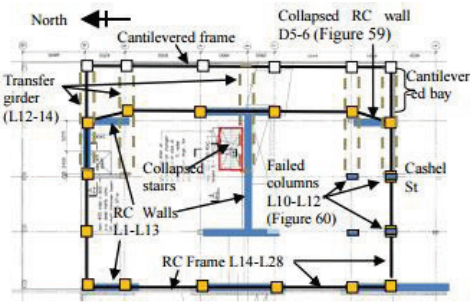


Figure 20. (http://www.nzsee.org.nz)

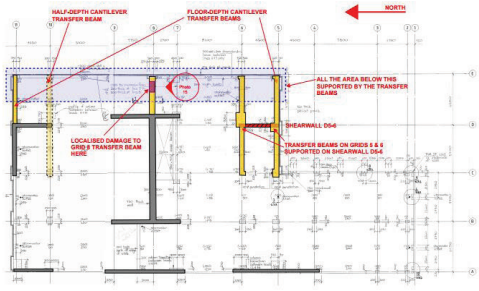


Figure 21. Level floor plan, with the shear wall D5-6 (http://www.building.govt.nz)

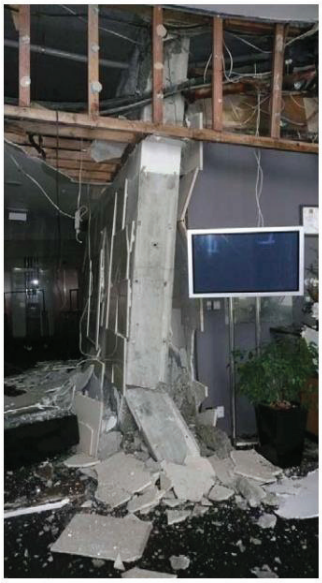


Figure 22. Shear wall D5-6 base failure. A lack of steel reinforcing in the concrete was the biggest factor in the shear wall's failure which failed in a brittle manner. This shear wall had supported vertically approximately one eighth of building's mass and was also expected to carry a portion of lateral earthquake loads

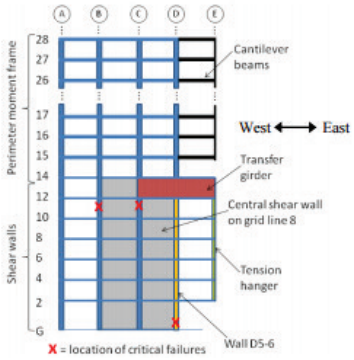


Figure 23. Schematic plan and elevation of the Grand Chancellor Hotel. The floor numbering is based on the original construction drawings – the lower 14 floors are half-height car park floors (http://www.nzsee.org.nz)

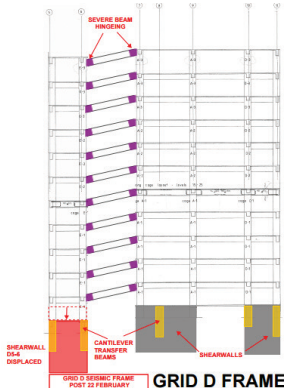


Figure 24. Details of cantilever transfer beams, with severe beam hinging (http://www.building.govt.nz)

Figure 25. Grand Chancellor Hotel: The shear-axial failure of the RC columns below the transfer girders at Level 10 and 11.

Regarding Taiwan earthquake 2016 effects, collapse mechanisms, structural assessment.

a. Collapse of 17-storeys Weiguan Jinlong residential building in Yongkang District, *H=52m*, Tainan (Weiguan Golden Dragon high-rise Tower was completed in 1994), Taiwan, Figures 26...29.

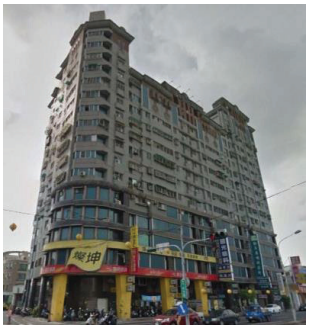


Figure 26. Weiguan Jinlong residential building before earthquake

This high-rise residential building is a mixed-use reinforced concrete structure, an U-shaped residential complex without walls on the ground floor.

The period of vibration for the first mode of vibration was approx. T=1.5s ($0.07*H^{0.75}$ for RC moment-resisting frame)

Figure 27. Collapse scheme (H. Stone, 2016)

There are some reasons for its collapse (H. Stone, 2016, nonsolidground.blogspot.com):

- the design of the construction did not match calculations made in its structural and steel blueprints;
- the difference in stiffness between the apartments above and the soft storey below causing failure at the junction between the two (at second floor level);
- at the bottom of the building, a possible soft storey which has caused the overturning of the entire structure;
- the possibility of structural problems related to poor-quality reinforced steel and cement;
- only half the designated amount of reinforced steel beams were used in the construction of the complex, which explains its weak structural integrity;

– there is a high likelihood that the basement acted as a soft storey and caused the building to collapse;
– some residents in the building broke and cleared many in fills and columns of a storey so that more rooms could be arranged for rent.

Figure 28. Some 90-degree bend hooks (http://www.businessinsider.com)

Figure 29. (http://www.eqclearinghouse.org/2016-02-taiwan/files/2016/02/2WeiguanBuilding-3.pdf)

COMPARATIVE PROCESSING DATA

➢ The recorded accelerograms for Chile *surface earthquake 2010*, at San Pedro Colegio Conception (CCSP), 2 horizontal components, and INCERC accelerogram, NS component, registered at Vrancea *intermediate earthquake 1977* (using the same scale) are shown in Fig. 28 [Dragomir et al, 2010].

The recording time of Vrancea seismic motion was approx. half from the recording time of Chile earthquake and the maximum amplitude of the acceleration recorded in Chile is about 3 times higher than the maximum of 1977 recording.

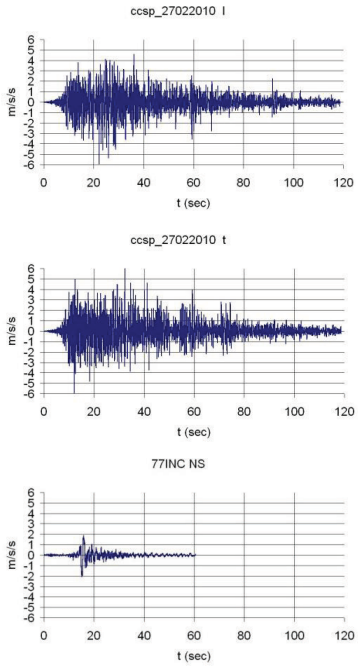


Figure 30. Recorded accelerograms for Chile earthquake 2010, at San Pedro Colegio Conception (CCSP)-2 horizontal components, and INCERC accelerogram- NS component, registered in Vrancea earthquake 1977 (Dragomir et al, 2010)

Response spectra in absolute acceleration (5% fraction of critical damping) for the horizontal components of recording from Colegio San Pedro Conception and NS component recording from INCERC Bucharest, with the spectrum of Chilean Code NCh433/96 and spectrum from Code P100-1/2006 (corresponding to an earthquake with a mean recurrence interval reference TNCR = 100 years) and for TNCR = 475 years are shown in Figure 29.

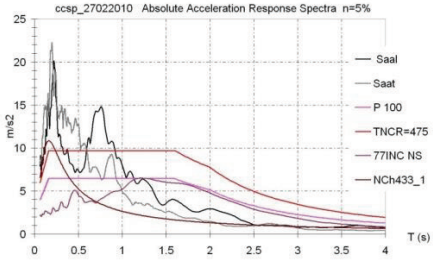


Figure 31. Comparative analysis of response spectra in absolute accelerations (Dragomir et al, 2010)

- The recorded accelerograms for Taiwan 2016

The response spectra have the followings characteristics:

- maximum acceleration 0.22 g EW
- spectrum E-W was approached to the spectrum code with return period of 475 yrs. and it was shifted to the period of 1 s
- the spectrum of the N-S remained in the spectrum code area for return period of 475 years but showed some major peaks between 0.6 s and 0.9 s

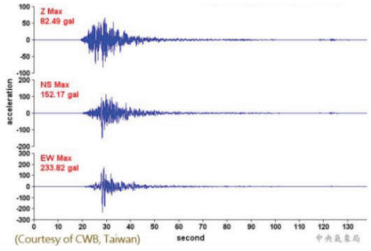


Figure 32. Recorded maximum accelerograms in Tainan City, a_Z=0.82m/s^2; a_{NS}=1.52m/s^2; a_{EW}=2.34m/s^2

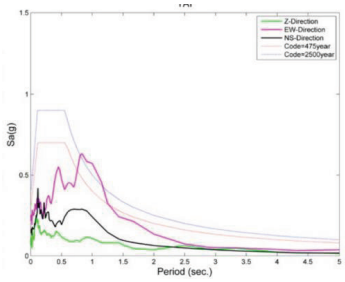


Figure 33. Response Spectra Tainan 2016 earthquake (Stone H, 2016, nonsolidground.blogspot.com, accessed February/March 2016)

RESULTS AND DISCUSSIONS

The comparative analysis of presented numerical data, for Chile 2010 earthquake and Vrancea 1977, leads us to the following conclusions (Dragomir et al, 2010):

- in respect of the peaks of the accelerograms, the records from Chile show higher values than those obtained on 4 March 1977 Vrancea in INCERC;
- in respect of the control period (corner) of the response spectrum, *Tc*, for the recordings in Chile, it does not exceed 1s, indicating that the entire spectral amplification occurs to the left of this value (therefore, all records in Chile betrays a seismic motion of short period);
- the maximum value in the range of 0.2 s of Chile Code was exceeded by about 100%, while in the period T = 0.7s the increase was approximately 250%; in this way, one can explain how some tall buildings of 20 floors, such as the building Torre O'Higgins in Concepcion, were badly damaged.

In terms of peak accelerations recorded in Taiwan, resilience depends greatly on the unique characteristics of the shaking at the particular site.

These characteristics include: duration and number of cycles of strong shaking; predominant frequencies of ground shaking; any directionality in shaking etc.

About the level of accelerations in Tainan city, they are only with 15% higher than the INCERC 1977 record, but they destroyed buildings with quantitatively consistent reinforcement, but with deficient compliance and detailing.

CONCLUSIONS

What is noticeable, are the long periods of motions, although the earthquakes are of surface.

The irregular reinforced concrete buildings, especially the setback and tall structures, exhibit generally a poor seismic performance. It must be accepted that an important role in the overall behaviour of the presented buildings had the higher modes of vibration and shaking time, beyond the technical aspects.

Also, the more accelerograms recorded are, we find that the possible values may be higher than those from design codes and sometimes the codes provisions are taken from other design rules (with other local features).

ACKNOWLEDGEMENTS

This paper is based on some results obtained in Core Programs, PN 09-14 01 01 and PN 16-10 01 01, and BIGSEES Project, financed by the Romanian National Authority for Research and Innovation (ANCS).

REFERENCES

Beca Carter Hollings &Ferner Ltd (Beca), 2011, Report Investigation into the Collapse of the Pyne Gould Corporation Building on 22nd February 2011 Prepared for Department of Building and Housing (DBH).

Decanini L. D., 2010, Advanced Conference on Seismic Risk Mitigation and Sustainable Development, May 2010 Sapienza, Universita di Roma, Dipartimento di Ingegneria Strutturale e Geotecnica Roma ITALY.

Dunning T. Consultants Ltd, 2011,Report on the Structural Performance of the Hotel Grand Chancellor in the Earthquake of 22 February 2011 Prepared, for The Department of Building & Housing.

Dragomir C. S., Dobre D., Georgescu E. S., Borcia I. S., 2010, Cutremurul din 27 februarie 2010 din Chile: comportarea in situ a clădirilor şi învăţăminte pentru România, Conferinţa Naţională cu participare internaţională „Comportarea in situ a construcţiilor", Ediţia a 18-a, Bucuresti

KohrangiM., SullivanT.J., CalviG.M., 2012, Seismic Assessment of a 15-Story Building Damaged in the Chile Earthquake of February 27th 2010, 15 WCEE, Lisbon, Portugal.

Saito T., Kono S., Kusunoki K., Kim Y., Matsui T., Tani M., Hibino Y., Zavala C., Gibu P., 2011, Building Damage Investigation of the 2010 Chile Earthquake and Tsunami Disaster,8CUEE CONFERENCE PROCEEDINGS&8th International Conference on Urban Earthquake Engineering, Tokyo Institute of Technology, Tokyo, Japan.

Stone H, 2016, nonsolidground.blogspot.com, accessed February/March 2016

http://www.kenken.go.jp, accessed February/March 2016

http://www.nehrp.gov/pdf, accessed February/March 2016

www.file:///C:/Documents%20and%20Settings/winxp/My%20Documents/Downloads/Final_Report_Volume_2_Web.pdf

http://www.building.govt.nz, accessed February/March 2016

http://www.nzsee.org.nz, accessed February/March 2016

http://sciblogs.co.nz, accessed February/March 2016

https://dub119.mail.live.com/mail/ViewOfficePreview.aspx?messageid=mg-hktsoPU5RGErAAjfeSnvA2&folderid=flinbox&attindex=0&cp=-1&attdepth=0&n=59790749

http://www.businessinsider.com, accessed February/March 2016

http://200.41.47.36/sismos/archivos/29-08-2013/Silva%20Rodrigo/presentacion%20primer%20dia%20RSilva.pdf

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

AN AUTOMATED HYDROPONICS SYSTEM USED IN A GREENHOUSE*

Murat YILDIRIM, Alper DARDENIZ, Seckin KAYA, Baboo ALI

Canakkale Onsekiz Mart University, Faculty of Agriculture, Canakkale 17100, Turkey

Corresponding author email: myildirim@comu.edu.tr

Abstract

In Turkey, the demand of table grapevine rootstocks is increasing day by day since the value of table grapevine rootstocks increase. On the other hand, production of table grapevine does not meet the demands of market since grapevine rootstock production efficiency is low. So, its production efficiency must be increased. Nowadays, hydroponics system is becoming a quite common and alternative method as compared to traditional farming systems of cultivation of soil, because hydroponics systems offer a wide range of advantages such as high capacity of production, high quality of products and also reduce the use of pesticides as compared to the traditional methods of cultivation. Grapevine variety namely, Yalova Cekirdeksizi has been taken in summer growing season and used its green cuttings as living material in this research work. The obtained cuttings were transplanted to different pots in three different time periods (15th of June, July and August in the year 2015). Grapevine rootstocks were placed to the pots having the dimension of 22 cm in width, 72 cm in length and 17 cm in depth. Each pot in the experiment possessed the same amount of fertilizer and the drip irrigation system has been applied. A microcontroller (PIC16F84) device has been used as an automated controller for supplying the water to the experimental trials. The irrigation system has been comprised with three main parts i.e., submersible pump, power suppliers (12 volt DC) and some other connected apparatus. In this experiment, a time based closed loop hydroponics system has been used aimed to test the performance of the automated hydroponics system for the growth of grapevine rootstocks. Consequently, the system took over the all irrigation procedures successfully throughout the entire growing season.

Key words: *automation, drip irrigation, hydroponics, grapevine, green cutting.*

INTRODUCTION

The word hydroponics is derived from two Greek words i.e., 'hydro' and 'ponos' by the meanings of 'water' and 'work', respectively. So, the word hydroponics means to "work with water" described by Catellane and Araujo in 1995. The word "hydroponics" is used for the systems that applied in agriculture for growing plants without soil and irrigate them with a mixed solution of water and chemical fertilizers. Hydroponics systems have recently been used for some research works, especially on the topics of nutrient solutions as well as plant growth, and also commercial cultivation of vegetables and ornamental plants. Thus, hydroponics system is being used quite successfully for this purpose and offering a wide range of advantages such as high quality of agricultural products and reducing the application of pesticides in this sector (Catellane and Araujo, 1995).

Micro irrigation system is practiced as irrigation method in the hydroponics system which is commonly known as drip irrigation. A combination of automation and micro irrigation systems ensure the proper amount of water supplied for growing plants throughout the growing season. It also becomes a cause of energy savings, reduction in labor costs, and controlling the amount of fertilizer, which are some major advantages while adopting automated techniques into micro irrigation systems (Yildirim and Demirel, 2011).

Manually controlled irrigation systems could not supply a proper amount of water because of its mismanagement (Salam et al., 2012). On the other hand, automated irrigation systems provide high crop yield, save the usage of water (Mulas, 1986), facilitate high frequency and low volume irrigation (Abraham et al., 2000), and also minimize the human error (Castanon, 1992). Automated irrigation system is usually designed for ensuring to supply the proper amount of water for growing up the plants throughout the season. Caceres et al. (2007) developed an automated irrigation control tray and activated it with a water level sensing system. Yilidirim and Demirel (2011) developed an irrigation controller and reported

that the most important point in the automated drip irrigation system is the sensor calibration and installation of the soil moisture sensor in the pot.

Many studies have been carried out related to the hydroponics system mainly focusing the planting density while growing the grapevine rootstocks (Maltabar et al., 1977; Mokan, 1979; Bahar, 1996), different cultural practices to the rootstocks (Perstnev, 1979), determination of the most favourable planting season (Maltabar et al., 1977), the application of different hormones (Gromakovskii and Maklakova, 1979; Perstnev, 1979), determine the appropriate ways of irrigation management (Aleksanyan, 1981), and fertilizer application (Suruzhiu, 1979; Suruzhiu and Adamov, 1979), planting depth to the substrates (Adamova, 1980) and suitable temperature in the root region (Suruzhiu, 1981).

There are few published studies about producing grapevine rootstocks in hydroponics in combination with an automated drip irrigation system. The main objective of this experiment is to present the hardware and software of the automated hydroponics system.

MATERIALS AND METHODS

In this research work, Yalova Cekirdeksizi grapevine variety have been taken in the summer growing season used as green cuttings as living material. The obtained green cuttings (3–4 budded) were taken as samples from Dardanelles (Applied Research Center of Canakkale Onsekiz Mart University) and then transplanted for three different times into pots on the 15th of June, July and August in the year 2015. The dimension of each pot has been consisted of 22cm in width, 77cm in length and 17 cm in depth having an overall surface area of 0.17m^2. Each pot possessed two drainage holes with a diameter of 16 mm from the bottom line shown in Fig 1.

The irrigation system is consisted of a water storage tank (200L), containing Hoagland solution described by Hoagland and Arnon in the year 1950. Hoagland solution has been modified by the researchers aimed to regulate the optimum pH and EC levels for the green cuttings of grapevine. This solution has been diluted with water for 3 times to protect the cuttings from high EC levels, because of the continuous supply of nutrient solution to plants through irrigation applications. Nutrient solution has been renewed when its EC level reached to 1.5–1.8 dS/m along with the final formation of the above mentioned solution containing 6.2 pH and 1.0–1.3 dS/m. Submersible pump operating at 12 volt DC has been installed inside the water storage tank. A steel construction was built to keep pots at height of 1.5 m from the ground level of the greenhouse and water storage tank and controller circuit were installed immediately under the pots. Therefore, it made the excess water easiest to return back to the reservoir by the drainage pipes connected to the drainage holes of the pots.

Electrical conductivity of the irrigation water (ECw) has been measured by an EC59 meter (Martini Institute). Pots were irrigated with the same amount of nutrient solution. The required water has been supplied by using Ø16 pipes with drippers (4L/h) at a spacing of 33 cm, with three drippers serving each pot. In the irrigation system, some connection apparatus and also valves were used to integrate all items.

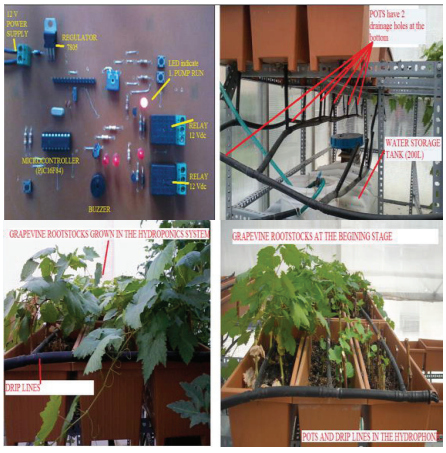


Figure 1. Layout of the experimental components

At the beginning of the experiment, all substrates were filled up to field capacity, then the automated system started irrigation at 4 hours intervals and run the submersible pump only one minute throughout the whole growing season so that this irrigation management kept the soil moisture at the level of field capacity in

each substrate since excess water was drained to the reservoir back after each irrigation event. The most important and basic component of the automated hydroponics system was the controller circuit, in which main power supply was 12 V DC, providing power to the controller and also relays, but it was reduced to 5 V dc for microcontroller (PIC16F84) by a regulator of 7805.

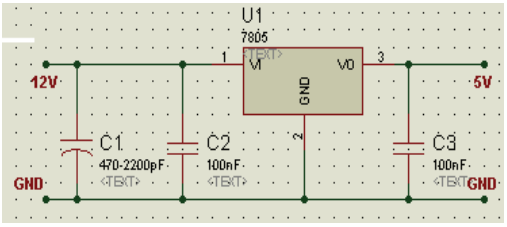


Figure 2. Voltage regulator for the microcontroller

Controller software: the circuit of the automation system is given in Figure 3, showing the all connections between microprocessor, relay and etc. The programme providing the automation in the hydroponics system was simple and basic and also very easy to load into the memory of the microcontroller (PIC16F84).

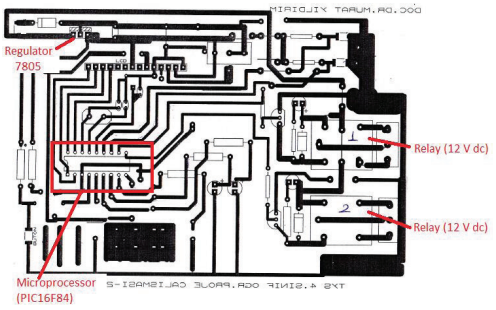


Figure 3. Solder side and components of the circuit.

The programme was written using the PicBasic Pro software programme and in the program the general strategy of the irrigation management was defined to the memory of the microcontroller unit (MCU). After running the system, the MCU repeated the actions throughout the whole growing season. The dosage of water was determined according to the pumping time of water. Some parts of the software is given below.

```
'-----------------------------------
'TIME BASED AUTOMATED SYSTEM
'DATE: 25.03.2015
'WRITTEN BY: DR. Murat YILDIRIM
'COMU AGRICULTURAL ENGINERING, IRRIGATION DEPARTMENT, CANAKKALE
'-----------------------------------
P con 0
P1 con 0
P2 con 0
P3 con 0
C0 con 60
*
*
h2 con 117
        @ DEVICE PIC16F84
        DEFINE OSC 4
        i VAR WORD
        k VAR WORD
        TRISA=%00000000
        TRISB=%00000000
        PORTA=0: PORTB=0
        SYMBOL SES=PORTB.2
        SYMBOL BIR=PORTB.5
KTRL:
        SOUND SES, [100,100]
        PAUSE 1000
        GOSUB DELAY
DONGU:
        SOUND SES, [e2, 63, **, 24]
        BIR=1
        FOR i=0 TO 60
        PAUSE 1000
        NEXT i
        BIR=0
        SOUND SES, [100,100]
        k=0
        GOSUB WAITT
        GOTO KTRL
DELAY:
        ****
        RETURN
WAITT:
        k=k+1
        FOR i=0 TO 300
        PAUSE 1000
        NEXT i
        IF k<30 THEN GOTO WAITT
        RETURN
        END
```

RESULTS AND DISCUSSIONS

The irrigation processes have successfully been completed by the hydroponics system according to the strategy defined to the MCU. The microcontroller switched on relaying to pumping water to the root territory only for one minute as described to the memory of the MCU. After that, supplying of water has been stopped to the pump and then waited for 4 hours of interval for the next irrigation session. The system took over the irrigation events successfully for the whole growing season. The system conveys a properly balanced nutrient solution to the plant root area.

It is very easy to construct the controller circuit given in Figure 3 and also having very low cost. It save water and also fertilizer, but the water level in the reservoir must be checked with 2 or 3 week interval or water level sensor should be added to the controller circuit.

Perlite due to its characteristics has more advantages as being used in the hydroponics system as compared with peat and peat+perlite (1:1, v:v). According to the overall results, the Yalova Cekirdeksizi grapevine variety has been successfully developed and would be used for further applications which have been taken from different period of green cuttings.

Usually small producers from small hydroponic systems that own little capita can use this kind of simple automated hydroponics system, this system seems to be more efficient and successful for small farmers.

ACKNOWLEDGEMENTS

The authors would like to thank to the concerned authority of the Department of Horticulture, Canakkale Onsekiz Mart University, since they provide the opportunity to work in the greenhouse.

REFERENCES

Abraham, N., Hema, P.S., Saritha, E.K., Subramannian, S., 2000. Irrigation automation based on soil electrical conductivity and leaf temperature. Agricultural Water Management. 45: 145–147.

Adamova, N.G., 1980. The production and quality of grapevine transplants in relation to the depth of planting in the sand substrate in hydroponic culture. In Intensifik. Vinogradarstvo Kishinev, Moldavian SSR. 1978. 50–53. (Hort. Abstr. 50 (1): 246).

Aleksanyan, D.S., 1981. Water regime of grapevine transplant in open-air hydroponic conditions soobstcheniya int agrokhim. Prob. I Gidroponiki AN Arm SSR (1980). No: 20, 59–64. From Referativnyi Zhurnal (1980). 10.55.680. (Hort. Abstr. 51: (3).

Bahar, E., 1996. Hidroponik yöntemlerle asılı köklü asma fidanı üretimi. Trakya Üniversitesi Fen Bilimleri Enstitüsü. Bahçe Bitkileri Anabilim Dalı. (Doktora Tezi). (In Turkish).

Caceres, R., Casadesus, J., Marfa, O., 2007. Adaptation of an automatic irrigation-control tray system for outdoor nurseries. Biosystems Engineering. 96 (3): 419–425.

Castanon, G., 1992. The automation irrigation. Maquinas of Tractors Agricolas. 3 (2): 45–49.

Castellane, P.D., Araujo, J.A.C., 1995. Cultivo sem solo: hidroponico. Jaboticabal/SP.

Gromakovskii, I.K., Maklakova, E.M., 1979. Ethrel a preparation in intensive cultivation of grapevine planting material. Sadovotsvo, Vinogradarstvo; Vinodelie Moldavii. (Hort. Abstr. 49 (11): 8412).

Hoagland, D.R., Arnon, D.I., 1950. The water-culture method for growing plants without soil. Circular. California Agricultural Experiment Station. Vol: 347 No: 2nd edit. 32 pp.

Maltabar, L.M., Unguryanu, S.I., Trakhtman, I.M., Shimanovich, B.I., 1977. Raising vine transplants hydroponically in greenhouses twice in one year. Sadovodstvo, Vinogradarstvo; Vinodelie Moldavii (1976). 6: 30–33. (Hort. Abstr. 47 (4): 3448).

Mokan, N.M., 1979. Spacing of grapevine grafts. Sadotsvo, Vinogradartsvo; Vinodelie Moldavii (1979). 3: 33–36 (Hort. Abstr. 49 (12): 9310).

Mulas, P., 1986. Developments in the automation of irrigation. Colture Protelle. 15 (6): 17–19.

Perstnev, N.D., 1979. Pre-planting preparation of grapevine grafts for raising hydroponically in intensifik. Vinogradarstvo. Kishinev, Moldavian SSR. 1978, 34–40. (Hort. Abstr. 49 (12): 9306).

Salam, M.A., Ahmed, A., Ziedan, K., Sayed, M.A., Swify, M., 2012. Asolar wind hybrid power system for irrigation in Toshka area, IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies. pp 1–6. Dec, 2011.

Suruzhiu, V.T., 1979. Potassium nutrition of grapevine transplants grown hydroponically on sand substrate. Referativnyi Zhurnal. (Hort. Abstr. 49 (11): 8370).

Suruzhiu, V.T., Adamov, R.E., 1979. Determination of the solution for growing grapevine grafts hydroponically on a sand substrate. Referativnyi Zhurnal 1978. (Hort. Abstr. 49 (4): 2486).

Suruzhiu, V.T., 1981. Production and quality of grapevine transplants raised hydroponically under different substrate temperatures. In Intensifik. Vinogradarstva. Kishinev, Moldavian SSR. (1980) 48–52, From Referativnyi Zhurnal (1981) 4.55.594. (Hort. Abstr. 51 (9): 6855).

Yıldırım, M., Demirel, M., 2011. An automated drip irrigation system based on soil electrical conductivty. Philipp. Agric. Scientist 94 (4): 44–50

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

ASSESSMENT OF THE DRINKING WATER DEMAND FOR WATER SUPPLY OF THE VILLAGES LOCATED IN THE AREA OF BARLAD HYDROGRAPHIC BASIN

Paula COJOCARU, Gabriela BIALI

"Gheorghe Asachi" Technical University of Iasi,
Faculty of Hydrotechnics, Geodesy and Environmental Engineering,
63-65, Prof. dr. docent Dimitrie Mangeron B, 700050, Iasi, Romania

Corresponding author email: paula.cojocaru@yahoo.com

Abstract

The paper consists of the calculation of drinking water demand for water supply of the villages from Barlad hydrographic basin. We took into account a total of 137 parishes in 6 counties (Vaslui, Bacau, Galati, Iasi, Neamt, Vrancea), 3 municipalities (Vaslui, Barlad and Tecuci) and two cities (Husi and Negresti). The total number was 647 735 inhabitants. The calculation of drinking water demand was done taking into account the distribution of the number of inhabitant for each parish, municipality and town according to the population census conducted in 2013 and also by respecting the Romanian standard STAS-SR 1343/1-2006 regarding to the calculation of drinking water demand for urban and rural areas. This yields to the following flow of drinking water demand for the resident inhabitants in the territory of Barlad catchment: Qzimed = 94575.57m^3/day, Qzimax = 135178.03 m^3/day, Qorarmax = 13963.91 m^3/day. The annual volume of drinking water demand is 34525.024 thousand m^3. During the calculus no account was taken of the water required for fire blow out.

Key words*: drinking water, demand, Barlad catchment, inhabitants, flow.*

INTRODUCTION

Water is the planet resource that underlies the quality of life and its lack or pollution of water resources is a major concern worldwide.

Providing access to drinking water is a prerequisite for social and economic development and environmental protection (Sancin et al., 2015; Wang et al., 2014; Jain, 2012).

An overview of the factors affecting water quality was conducted by V. Goncharuk, 2014. He pointed out current issues in technology for the preparation of drinking water from centralized treated drinking water installations, role of natural organic compounds, he analyzed different technological modern measures of drinking water treatment and he evaluated the influence of the distribution system status towards the water quality.

In order to protect public health, natural resources and ecosystems, monitoring programs are required to provide relevant and timely information, spatial and temporal models of the contaminants and a number of screening strategies (Brands et al., 2008). There are also required risk management strategies for drinking water systems (Marsalek, 2009; Dore, 2014), and in some cases, new standards on requirements and water quality control (V. Goncharuk, 2014), new concepts to provide quality drinking water to the population (V. Goncharuk, 2008). Knowing the chemical situation of water from deep boreholes located in Barlad basin (Cojocaru et al., 2015) in this paper we propose to calculate which water supplies we need for supplying water to the residents of this basin.

MATERIALS AND METHODS

Barlad river basin has a total area of 7354 km^2. In this area there are a total of 137 parishes belonging administratively in 5 counties: Vaslui (70 parishes), Bacau (15 parishes), Galati (23 parishes), Iasi (18 parishes), Neamt (8 parishes) and Vrancea (3 parishes). To all these it must be added a number of three municipalities (Vaslui,

Barlad and Tecuci) and two cities (Husi, Negresti). Population living in all these municipalities, cities and parishes comprises a total of 647 735 inhabitants.

Calculation of drinking water supply for these people was done taking into account the following legal, social and environmental impact prerequisites:

- data on the number of inhabitants, according to population census conducted in 2013;
- compliance of the Romanian standard STAS SR1343/1-2006 regarding the demand calculation of drinking water supply for urban and rural areas; it was not considered also the water demand for firefighting;
- a total demand associated with the actual stage (qg) as it follows:

- of 60 l/capita/day in the case of drinking fountain located in yards without a sewerage system;
- of 120 l/capita/day for the consumers with interior cold and hot water supply and a sewerage system, with individual preparation of the hot water;
- of 180 l/capita/day for the population that lives in a block of flats.

According to STAS 1343/2006 the drinking water demand N is calculated using the following relation:

$$N = U \cdot qg/1000 \quad (m^3/day)$$

where: U is the total number of people from the area in which we want to set up the centralized drinking water supply system; qg - the specific flow for people needs, with its values previous presented.

The water requirement, C, is calculates using the relation:

$$C = K_s \cdot K_p \cdot \Sigma N$$

where: K_s - coefficient that takes into account the technological needs of the installations, K_s=1.05, K_p - coefficient that takes into account the technically permissible water losses in the supply and distribution network, K_{sp}=1.15.

N - the water demand previously calculated;

D - the length of time that was calculated the water demand (s; day or month).

The calculus flow of the water supply system Qszimed, Qszimax si Qsorarmax have been calculated using the following relations:

$$Qszimed = C \quad (m^3/day)$$
$$Qszimax = Qszimed \cdot K_{zi} \quad (m^3/day)$$
$$Qsorarmax = K_o/24 \cdot Qszimax \ (m^3/hour)$$

where: Qszimin is the minimum flow of water requirement, calculated in the hypothesis of normal operation; Qszimed is the average daily flow of water requirement, calculated in the hypothesis of normal operation; Qsorarmax is the maximum hourly flow of water requirement, calculated in the hypothesis of normal operation;

24 - the total number of hours when there is water consumption;

K_s, K_p, N - have previously described meaning;

K_{zi}- ununiformity coefficient of the daily flow; as function of the type of water supply use the value of K_{zi} coefficient is: for areas with block of flats K_{zi} = 1.35; for areas with houses having interior installations for water supply and sewerage: K_{zi} = 1.4; for areas with houses having drinking water fountain without a sewerage system, K_{zi} = 1.8.

K_o - hour variation coefficient, K_o = 3.

RESULTS AND DISCUSSIONS

In Figure 1 we can see land demarcation of parishes and large localities located in Barlad catchment area and in Table 1 shows the distribution of the number of inhabitants on this site, according to the population census conducted in 2013.

Following the realized previously revealed calculus, it resulted the following flow rates of water requirements centralized presented in table 2.

It is noted that the total amount of water needed in a year (WNT) to supply water to all residents of Barlad catchment, is: W_{NT} = $34525 \cdot 10^7$ (m^3/year) the total daily maximum flow is: Qzimax = 135178.03 (m^3/day). The required flow for cities and municipalities represent 65% of the total flow. The highest rate from the total flow is assigned to Vaslui district (76093.46 m^3/day), followed by Galati district (32847.34 m^3/year) and Iasi district (12062.44 m^3/year). These flows depend on and are consistent with the number of inhabitants; Vaslui is the city with the most residents in Barlad catchment.

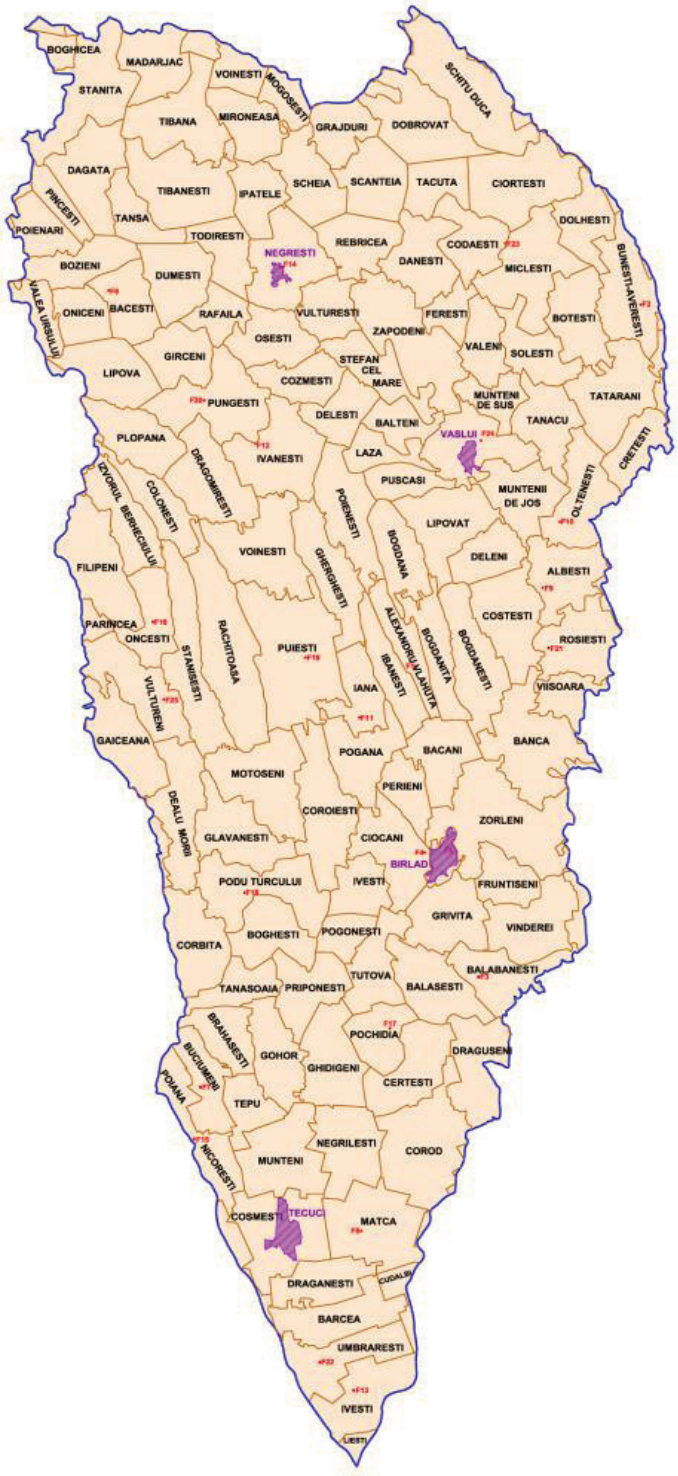


Figure 1. Land demarcation of parishes and large localities located in Barlad catchment area

Table 1. The distribution of the number of inhabitants located in Barlad catchment area

	District	Munic./Town/ Parish	No. inhabitants		District	Munic./Town/ Parish	No. inhabitants
0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
1	VASLUI	Munic. Vaslui	55407	19	VASLUI	Costesti	2953
2		Munic. Barlad	55837	20		Cozmesti	2202
3		Oras Husi	26266	21		Cretesti	1790
4		Oras Negresti	8380	22		Danesti	2205
Total municipalities and cities district Vaslui			**145.890**	23		Deleni	2257
5	VASLUI	Albesti	2893	24		Delesti	2358
6		Alexandru Vlahuta	1550	25		Dragomiresti	4900
7		Banca	5389	26		Duda-Epureni	4397
8		Bacani	2814	27		Dumesti	3334
9		Bacesti	4107	28		Epureni	3081
10		Balteni	1523	29		Feresti	1897
11		Bogdana	1602	30		Fruntiseni	1795
12		Bogdanesti	3242	31		Gherghesti	2595
13		Bogdanita	1437	32		Girceni	2443
14		Botesti	2049	33		Grivita	3293
15		Bunesti-Averesti	2592	34		Iana	3870
16		Ciocani	1638	35		Ibanesti	1451
17		Codaiesti	4362	36		Ivanesti	4495
18		Coroiesti	2014	37		Ivesti	2409
38	VASLUI	Laza	3114	**Total parishes district VASLUI**			**203790**
39		Lipovat	3960	**Total for Vaslui district**			**349680**
40		Malusteni	2462	73	BACAU	Colonesti	2106
41		Miclesti	2636	74		Dealu Morii	2739
42		Muntenii de Jos	3584	75		Filipeni	2286
43		Muntenii de Sus	2763	76		Gaiceana	3069
44		Oltenesti	2515	77		Glavanesti	3321
45		Osesti	3157	78		Huruiesti	2578
46		Perieni	3536	79		Izvorul Berheciului	1537
47		Pochidia	1629	80		Lipova	2890
48		Pogana	2992	81		Motoseni	3505
49		Pogonesti	1561	82		Oncesti	1621
50		Puiesti	4661	83		Parincea	3588
51		Poienesti	2855	84		Plopana	3059
52		Pungesti	3223	85		Podu Turcului	4617
53		Puscasi	3328	86		Rachitoasa	5080
54		Rafaila	1835	87		Rosiori	2097
55		Rebricea	3451	88		Stanisesti	4514
56		Rosiesti	3151	89		Vultureni	2071
57		Solesti	3623	**Total parishes district BACAU**			**50678**
58		Stanilesti	5117	90	GALATI	Mun. Tecuci	34871
59		Stefan cel Mare	3160	**Total municipalities and cities district Galati**			**34871**
60		Suletea	2288	91	GALATI	Balanesti	2080
61		Tanacu	2040	92		Balasesti	2295
62		Tacuta	3248	93		Barcea	4957
63		Tatarani	2171	94		Beresti-Meria	3771
64		Todiresti	3214	95		Brahaiesti	8847
65		Tutova	3311	96		Buciumeni	2326
66		Vsleni	4022	97		Corod	7334
67		Viisoara	1909	98		Cosmesti	5196
68		Vinderei	4025	99		Cudalbi	6319
69		Voinesti	3757	100		Dragusani	4899
70		Vulturesti	2236	101		Draganesti	4852

71		Zapodeni	3724	102		Ghidigeni	5821
72		Zorleni	8595	103		Gohor	3193
104	GALATI	Ivesti	8441	127	IASI	Schitu Duca	4354
105		Liesti	8902	128		Scheia	3067
106		Matca	11605	129		Tibana	7273
107		Movileni	3269	130		Tibanesti	7119
108		Munteni	6791	131		Voinesti	6815
109		Negrilesti	2405	**Total parishes district Iasi**			**63426**
110		Nicoresti	3602	132	NEAMT	Bara	1680
111		Poiana	1686	133		Bozieni	2716
112		Priponesti	2223	134		Gadinti	1983
113		Radesti	1490	135		Oniceni	3388
114		Tepu	2399	136		Pancesti	1350
115		Umbraresti	6628	137		Poienari	1453
116		Valea Marului	3894	138		Stanita	1966
Total parishes district Galati			**125225**	139		Valea Ursului	3874
117	IASI	Ciortesti	3979	**Total parishes district Neamt**			**18410**
118		Dagata	4599	140	VRANCEA	Boghesti	1680
119		Dobrovat	2515	141		Corbita	1793
120		Dolhesti	2638	142		Tanasoaia	1972
121		Grajduri	3563	**Total parishes district Vrancea**			**5445**
122		Ipatele	1865	**Total Municipalities and Cities**			**180761**
123		Madarjac	1587	**Total Parishes**			**466974**
124		Mironeasa	4521	**TOTAL BARLAD CATCHMENT AREA**			**647735**
125		Mogosesti	5242				
126		Scanteia	4289				

Table 2. Flow of water requirement for residents located in Barlad catchment area

District	Qzimed		Qzimax		Qorarmax		Total volume of drinking water requirement (thousands m^3)
	m^3/day	l/s	m^3/day	l/s	m^3/day	l/s	
Vaslui	53685.10	621.36	76093.46	880.71	7180.48	1994.58	19600
Bacau	6608.92	76.49	9638.01	111.55	1204.75	334.65	2412.255
Galati	22899.24	265.04	32847.34	380.18	3503.79	973.28	8358.224
Iasi	8271.38	95.73	12062.44	139.61	1507.80	418.83	3019.055
Neamt	2400.85	27.79	3501.24	40.52	437.65	121.57	876.310
Vrancea	710.08	8.22	1035.54	11.99	129.44	35.96	259.180
Total	**94575.57**	**1094.63**	**135178.03**	**1564.56**	**13963.91**	**3878.87**	**34525.024**

CONCLUSIONS

Following the evaluation of drinking water requirements for the population in Barlad catchment, we have reached to the following conclusions:

- it is necessary to secure a total average flow of Qzimed = 94575.57 m^3/day and a total maximum flow of Qzimax = 135178.03 m^3/day for the inhabitants from Barlad catchment area;
- the total volume of drinking water requirements per year is $W_{NT} = 34525 \cdot 10^7$ m^3/year;
- the highest flow is required to secure for the inhabitants of Vaslui district (880.71 l/s) and the lowest flow for the inhabitants of Vrancea district (11.99 l/s).

REFERENCES

Brands E., Rajagopal R., 2008. Economics of place-based monitoring under the safe drinking water act, part I: spatial and temporal patterns of contaminants, and design of screening strategies. Environmental Monitoring and Assesment, 143(1):75-89.

Cojocaru P., Biali G., 2015. Chemical statement of water from deep boreholes from the Hydrographic Basin Barlad. Scientific papers Journal, Horticulture Series, 58(2):273-278.

Dore M.H., 2014. Drinking Water in Germany: A Case Study of High Quality Drinking Water. Global Drinking Water Management and Conservation, 259-290.

Goncharuk V.V., 2008. A new concept of supplying the population with a quality drinking water. Journal of Water Chemistry and Technology, 30(3):129-136.

Goncharuk V.V., 2014. SOS: Drinking Water. New State Standard "Drinking Water. Requirements and Methods of Quality Control". Physics, Chemistry and Biology, Chapter Drinking Water, Springer International Publishing, 403-416.

Goncharuk V.V., 2014. Drinking Water: Factors Affecting the Quality of Drinking Water. Physics, Chemistry and Biology, Chapter Drinking Water, Springer International Publishing, 105-245.

Jain R., 2012. Providing safe drinking water: a challenge for humanity. Clean Technology Environmental Policy, 14:1-4.

Marsalek J., 2009. Drinking Water Security: Municipal Strategies. Risk Management of Water Supply and Sanitation Systems, Springer Netherlands Publisher, 87-100.

Sancin V., Dine M.K., 2015.Ensuring access to safe drinking water as an imperative of sustainable development. Chapter Legal aspects of sustainable development, Springer International Publishing, 95-108.

Wang H., Song T., 2014.Water Indicator: Proportion of Population Using an Improved Drinking-Water Source. Human Green Development Report, Beijing Normal University Press & Springer-Verlag Berlin Heidelberg, 189-206

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

THE EFFECTS OF DIFFERENT IRRIGATION WATER AND NITROGEN LEVELS ON THE WATER-NITROGEN-YIELD FUNCTIONS OF WATERMELON

Ulas SENYIGIT[1], Riza KANBER[2], Atef HAMDY[3]

[1]University of Suleyman Demirel, 32260 Isparta, Turkey. Phone: +90-246-2118564
[2]University of Cukurova, Adana, Turkey
[3]Mediterranean Agronomic Institute of Bari, Italy

Corresponding author email: ulassenyigit@sdu.edu.tr

Abstract

Different irrigation methods (S: Sprinkler; D: Drip), nitrogen forms (L: Liquid; G: Granule), water and nitrogen levels (based on applied line source sprinkler) and watermelon varieties (P: Paladin; M: Madera) were studied in the experiment. The research was conducted in Research and Production Farm of Cukurova University. Experimental design was strip for the first year and split-strip for the second year. Irrigation water was calculated using cumulative evaporation (Ep) from Class A-pan. Significant linear relationships were obtained between the yield and irrigation water, and between the yield and evapotranspiration at 1% confidence level. Yield response factor (Ky) values were determined as 1.07 for total yield and 1.49 for marketable yield. Since Ky>1, watermelon was sensitive to water deficiency. In addition, total water use efficiencies (TWUE) and irrigation water use efficiencies (IWUE) ranged from 1.80 to 11.33 kg da^{-1} mm^{-1} and from 7.29 to 16.47 kg da^{-1} mm^{-1} respectively. This finding indicated that WUE and IWUE values increased with the decreasing evapotranspiration and irrigation water.

Key words*: watermelon, evapotranspiration, water use efficiency, yield response factor.*

INTRODUCTION

An important portion of the natural water resources are used in agriculture. Decreasing available water resources brings a serious water shortage problem. In order to deal with this problem, the studies for the efficient use of irrigation water by providing water saving gain importance (Li et al., 2001; Fabeiro et al., 2001). However, more studies are still needed for deficit irrigation of vegetables (Chartzoulakis and Drosos, 1995; Mannini and Gallina, 1996). Deficit irrigation aims to increase the efficiency of irrigation water, to generate water stress at a level without excessive yield loss in the production period of the plant and, consequently, to obtain the highest yield corresponding to each unit of water (Stanley and Maynard, 1990; Kirda, 2002). While designing deficit irrigation programs, it should be designed according to the relationship between water and yield. Researches indicated that there is a linear correlation between relative evapotranspiration deficit and relative yield decrease, and this correlation is defined as yield response factor (Ky) (Stewart et al., 1977; Doorenbos and Kassam, 1986). Vegetables are grown widely with commercial purposes and they are very profitable plants. But, there are many differences in the yield quality and quantity among the regions.

These differences appear from some factors such as climate, soil productivity, labour, nutrient and water amount. The factors change more depending on the irrigation and fertilization practices (Doorenbos and Kassam, 1986; Gunay, 1993).

Irrigation is a vital importance for successful vegetable production. Because vegetables need irrigation water during the all growing period and get adequate benefit from irrigation, amount of the irrigation water applied and the irrigation duration must be calculated scrupulously (Cevik et al., 1996; Ertek et al., 2002). The determination of irrigation water amount based on pan evaporation method is very common due to its simple and easy usage (Elliades, 1988).

Nitrogen is also an important nutrient to stimulate growth and water use for watermelon which have very large leaf area, grown on light

soil texture and are able to grow very fast (Yesılsoy, 1985; Pier and Doerge, 1995; Kırda et al., 1996). Selection of irrigation methods takes an importance role due to the water and yield economy.

Generally, pressured irrigation systems are preferred due to watermelon grown as crawl on the ground surface.

Watermelon producers widely use drip and sprinkler systems together with liquid fertilizer (Fertigation). Although the techniques look quite hopeful to use for plants such as watermelon which have a lot of problem with irrigation and fertilization, some problems may occur when these systems are not properly designed and managed.

This research aimed to determine the effects of different water and nitrogen levels under different irrigation methods on the evapotranspiration and water-nitrogen-yield functions of watermelon.

MATERIALS AND METHODS

Site Description

The research area was in the north of Lower Seyhan Plain in Turkey and located at latitute 36°59′ N, longitute 35°18′ E, altitude 20 m.

Soil Characteristics

The soil profile was deep and consists of clay in high rate. Some physical and chemical properties of soil used in the experiment were given in Table 1.

Table 1. Some physical and chemical characteristics of the soil of experimental area

Soil layer (cm)	Clay (%)	Sand (%)	Silt (%)	Texture	Field Capacity (g g^{-1})	Wilting Point (g g^{-1})	Salt (%)	pH	Lime (%)
0-30	32.62	37.72	29.66	CL	30.40	16.93	15.8	7.80	9.29
30-60	31.59	35.68	32.72	CL	29.50	15.07	11.7	7.90	23.42
60-90	29.48	37.87	32.65	CL	23.20	11.56	8.8	7.90	27.51

Climatic Characteristics

Mediterranean climate is prevailing in experimental area with hot and dry summer and rainy and warm winter. According to long-term observation, the annual rainfall is 646.8 mm, average relative humidity, wind speed and temperature are 66%, 2.0 m/s, and 18.9 °C, respectively.

Fertilizers Used in Experiment

Triple super phosphate source of phosphorus (46% P_2O_5), potassium sulfate (50% K_2O) and ammonium sulfate (21% N) were used as granule fertilizer sources. In addition to, as liquid nitrogen source, UAN (Nitrogen of Urea and Ammonium Nitrate) fertilizer was employed during experiment period.

Irrigation Water Supply

Irrigation water was provided from Lower Seyhan Irrigation Project system.

Irrigation water was taken from a closed system with equipped a motor-pump was used to convey to the head of the field. Irrigation water is classified as C_2S_1 quality for irrigation (USSLS, 1954). Some chemical properties of irrigation water were given in Table 2.

Experimental Design and Treatments

The experiment was conducted at the Research and Application Farm of Faculty of Agriculture, University of Cukurova in 1996 and 1997 years. The strip plot design in the first year, and split-strip plot design in the second year with three replications were used. In the experiment, different irrigation methods (S: Sprinkler; D: Drip), nitrogen forms (G: Granule nitrogen; L: Liquid nitrogen), nitrogen and water levels and watermelon varieties (V_1:Paladin; V_2:Madera) were considered. Experimental design and treatments used in the study was shown in Figure 1.

Table 2. Analysis Results of Irrigation Water Used in Experiment

Class	EC (dS/m)	pH	Cations (me/l)			Anions (me/l)				Na (%)	SAR
			Na	K	Ca+Mg	CO_3	HCO_3	Cl	SO_4		
C_2S_1	0.358	7.1	0.45	0.07	3.08	-	1.60	0.94	1.06	12.5	0.36

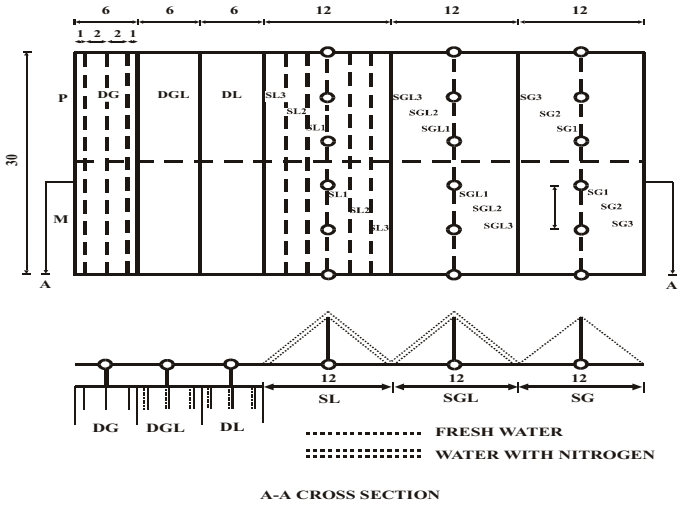


Figure 1. Scheme of experimental area for irrigation and nitrogen treatments

In the experiment, line source sprinkler irrigation technique was utilised because of that both different irrigation and nitrogen levels were proved. Planning and management of the system was made by the methods and principles given by Hanks et al. (1976) and Kanber et al. (1994). Full or half-turning sprinkler heads were placed with 6 m distance along the lateral line. Lateral distances were 12 m. Collecting cups were placed with 2 m distance between two laterals beginning 2 m from first line. In this way, three irrigation levels were created which varied from near the line in which plants received much water to far from line in which plants had less water. In the same condition, different nitrogen levels were obtained. Drip irrigation method was also used in the second year of the experiment. In- line drippers were placed with 50 cm distance along the laterals (q: 4 Lh^{-1}). Drip irrigation plots contain 3 watermelon rows and one lateral employs each row.

Granule Nitrogen (G) was provided from a granule nitrogen source as 10 kg da^{-1} and applied three times (Before sowing, branching period and first fruits became 3-4 cm diameter). Although different nitrogen and water level were not formed in the first year, gradient water level was created with line source sprinkler irrigation technique in the second year. Liquid Nitrogen (L) was provided from liquid nitrogen source and applied by fertigation technique. Any nitrogen application was done before planting and total nitrogen amounts were divided to irrigation number. Granule and Liquid Nitrogen (GL) was provided from a granule and liquid nitrogen source. A part (3 kg da^{-1}) of required total pure N of 10 kg da^{-1} was met by granule nitrogen sources, another part of N was from liquid nitrogen sources. (Conversion rate for 1 kg da^{-1} is equal to 10 kg ha^{-1}). At the end of irrigation events, water samples were taken from collecting cups in sprinkler system and from dripper in drip system during irrigation were analysed for obtaining actual amount of nitrogen applied to the each plot.

Sowing/Planting and Harvesting

The seeds were sown in the torf blocks with 5x5x7 cm in dimension. Then, when seedlings reached to a sufficient size, they were transplanted the experimental area. Seedlings were planted with a row spacing of 2 m and plant spacing of 0.5 m. Watermelon was harvested when atriums dried and peel reached to maturity colour (Gunduz and Kara, 1996).

Plot Dimensions

Sprinkler and drip plots covered an area of 12x30=360m^2 and 6x30=180m^2, respectively. Totally, there were 360 watermelon plants (180 plants for each variety) in sprinkler plots and 180 watermelon plants (90 plants for each variety) in drip plots.

Estimation of Irrigation Water Amount and Determination of Irrigation Time

Irrigation water was calculated using cumulative evaporation values (Ep) from Class A-pan measured between consecutive irrigation (Equations 1 and 2).

$$I = kcp \times Ep \times P \quad (1)$$

$$V = I \times A \quad (2)$$

where I and V, irrigation water, mm, and L; kcp, plant-pan coefficient (Considered to be 1); A, plot area, m^2; P, wetted area percentage (The value was taken as 0.7 in drip plots).

Irrigations were ceased in sprinkler plots, when water amount in the collecting cups next to laterals was equal to either I or V, in drip plots, when the water-meter inside of control units showed that the necessary amount of water was applied.

Measuring of Moisture Variation in the Soil Profile

During the study, moisture content of soil profile in 90 cm depth was measured using the gravimetric method. That practice was started at transplanting, repeated before and after irrigations and ended at harvesting. Moisture samples were taken from mid-point in each plot and every 30 cm depth of the soil profile.

Evapotranspiration

Water budget method was used to determine water consumption (James, 1988). The water budget equation was given in equation 3.

$$ET = I + P - Dp + Cp \pm Rf \pm \Delta S \quad (3)$$

where, ET, I, Dp, Cp, Rf and ΔS are evapotranspiration (mm), irrigation water (mm), precipitation (mm), deep percolation loses (mm), capillaric rise (mm), runoff loses (mm), and moisture storage in soil profile (mm), respectively. Irrigation water amounts, precipitation and soil moisture were measured during the experiment. Rf and Cp were assumed to be zero, because plots were surrounded with a ridge and level of water table was quite depth (more than 6 m) in the experimental area. If the soil moisture content after applied water amount with irrigation was more than field capacity, the difference was assumed as deep percolation (Kanber et al., 1992).

Water-Nitrogen-Yield Functions

Water Use Efficiency

Water use efficiency (kg da^{-1} mm^{-1}) was calculated for various water and nitrogen levels in different irrigation methods. For this purpose, the equation 4 given by Howell et al. (1990) was used.

$$WUE = \frac{MY}{ET \ or \ I} \quad (4)$$

where MY is marketable yield (kg da^{-1}) and ET and IR are evapotranspiration and irrigation water (mm), respectively. ET was used for total water use efficiency (TWUE) and I was used for irrigation water use efficiency (IWUE).

Water-Nitrogen-Yield Relationships and Yield Response Factor

Yield functions were used to determine the relationships between various water amounts and watermelon yields and between nitrogen levels and watermelon yields. Utilising those relationships, relationships between the relative ET deficit and the relative decrease in yield was estimated. The methods and approaches given by Stewart et al. (1977) and Doorenbos and Kassam (1986) were used for referred processes. The formula given in equation 5 was utilised for obtaining yield response factor (Ky).

$$\left(1 - \frac{Y}{Ym}\right) = Ky \left(1 - \frac{ET}{ETm}\right) \quad (5)$$

where, Y, Ym, ET and ETm are actual and maximum yields (kg da^{-1}) and evapotranpirations (mm), respectively.

RESULTS AND DISCUSSIONS

Irrigation and Nitrogen Amounts, Evapotranspiration and Yield

Three water and nitrogen levels were established by allowing water and nitrogen to decrease gradually in only SL applications during the irrigation season of first year. The water amount in SL1 treatment, nearest to lateral, was 164.9 mm. The SL2 and SL3 treatments were taken 77% and 72.3% of the water amount applied to the SL1 treatment, respectively. Second year of the study,

various water levels were created in the all sprinkler irrigation treatments except drip irrigation method (Table 3). Irrigation water was reduced in SG treatment by 18% (SG2) and 26% (SG3), in SGL treatment by 14% (SGL2) and 22% (SGL3), and in SL treatment by 20% (SL2) and 29% (SL3). Differences were occurred between treatments caused by spoiled water distribution uniformity due to effect of wind during irrigation.

Nitrogen amounts varied depending on applied irrigation water amount and irrigation method except granule nitrogen applications. Nitrogen amounts decreased by about 50% were applied to some treatments (Table 3). During irrigation, total nitrogen saving was a result of gradually decreased water amount. For example, nitrogen amount was reduced by 24-31% in SGL, by 54-74% in SL application as compared to SG. The saving under drip irrigation was by 13-43%.

There was no significant difference between ET values of watermelon varieties and irrigation methods (Table 3). This could be resulted from similar irrigation programs. Same ET values were obtained from varying nitrogen levels in this study. Here, it can be concluded that the liquid fertilizer applied in less amount than granule fertilizer had same effect on the growth and water consumption of the watermelon. The results agreed with findings of Gunduz and Kara (1996), Ghawi et al. (1989), Sezgin et al. (1997). Eylen and Tok (1988) found that ET was 226 mm. But, this value is very low for the region of Tarsus that is in Cukurova region. In presented study, ET was 361 mm in the highest yield treatment and this value may more suitable for Cukurova conditions.

Similar differences were observed in total yield as seen in ET. In the second year, the yield increased by 70% according to first year (Table 3). This could be resulted from the changes in climate, plant growth and cultural practices between the years. Marketable yield was similar to total yield amounts and marketable yield varied linearly with changing total yield. It was recorded that the higher yield given the higher marketable yield.

Water-Nitrogen-Yield Functions

Water Use Efficiency

Water use efficiencies of the treatments were calculated from marketable yield. Total water use efficiencies (TWUE) and irrigation water use efficiencies (IWUE) ranged from 1.80 to 11.33 kg da^{-1} mm^{-1} and from 7.29 to 16.47 kg da^{-1} mm^{-1}, respectively (Table 3). TWUE and IWUE values generally decreased with the increasing irrigation water and evapotranspiration. The results obtained in this study were parallel with the studies of Ertek et al. (2006) in the eggplant, Xuesen et al. (2003) in cucumber, Costa and Gianquinto (2002) in pepper, and Erdem et al. (2001) in watermelon.

Water-Yield Relationships and Yield Response Factor

Yields of both varieties were used together in the relationships. There were significant linear relationships between yields (total and marketable) and irrigation water amounts, and ET at 1% confidence level (Figure 2). From this reason, it can be concluded that watermelon yields increased with irrigation water and ET increased.

Relationship between in relative ET deficit and relative decrease in yield were shown in Figure 3. Yield response factor shows yield reduction with respect to reduction in the water amount. The yield response factor (Ky) for total yield was 1.07 and for marketable yield was 1.49 (Since Ky>1, watermelon was sensitive to water deficiency. Yield decreased by 1.49 units in marketable yield and by 1.07 units in total yield with a unit decrease in water.

Table 3. Irrigation water amounts, nitrogen amounts, evapotranspiration, total and marketable yields, total and irrigation water use efficiencies

V	T	1996							1997						
		I	N	ET	Y	MY	TWUE	IWUE	I	N	ET	Y	MY	TWUE	IWUE
P	SG1	174.9	10.0	274	1928	869	3.17	4.97	334.2	10.0	427	4352	3475	8.14	10.40
	SG2								273.5	10.0	369	4832	4056	10.99	14.83
	SG3								246.0	10.0	356	4566	3724	10.46	15.14
	SGL1	170.6	7.3	270	2233	1205	4.46	7.06	346.8	8.7	440	3280	2528	5.75	7.29
	SGL2								297.3	7.7	392	3485	2884	7.36	9.70
	SGL3								270.4	6.9	380	3108	2341	6.16	8.66
	SL1	164.9	4.3	264	2429	1401	5.31	8.50	350.5	5.9	444	3567	3040	6.85	8.67
	SL2	126.6	2.9	228	1630	551	2.42	4.35	280.5	4.6	376	4236	3505	9.32	12.50
	SL3	119.2	2.6	236	1325	425	1.80	3.57	248.3	3.6	358	3611	2546	7.11	10.25
	DG								251.7	10.0	340	3840	3018	8.87	11.99
	DGL								251.7	8.7	346	3421	2801	8.10	11.13
	DL								251.7	5.7	339	3343	2796	8.25	11.11
M	SG1	174.9	10.0	266	2003	1244	4.68	7.11	334.2	10.0	435	4981	4160	9.56	12.45
	SG2								273.5	10.0	376	4466	3953	10.51	14.45
	SG3								246.0	10.0	362	4386	3876	10.71	15.76
	SGL1	170.6	7.3	272	2682	1633	6.00	9.57	346.8	8.7	443	4214	3384	7.64	9.76
	SGL2								297.3	7.7	398	4549	3815	9.59	12.83
	SGL3								270.4	6.9	382	4199	3339	8.74	12.35
	SL1	164.9	4.3	260	2529	1622	6.24	9.84	350.5	5.9	438	3485	2754	6.29	7.86
	SL2	126.6	2.9	238	2530	1465	6.16	11.57	280.5	4.6	380	4832	3972	10.45	14.16
	SL3	119.2	2.6	236	1811	806	3.42	6.76	248.3	3.6	361	5013	4090	11.33	16.47
	DG								251.7	10.0	346	3737	2897	8.37	11.51
	DGL								251.7	8.7	350	3822	3174	9.10	12.61
	DL								251:7	5.7	341	3934	3253	9.54	12.92

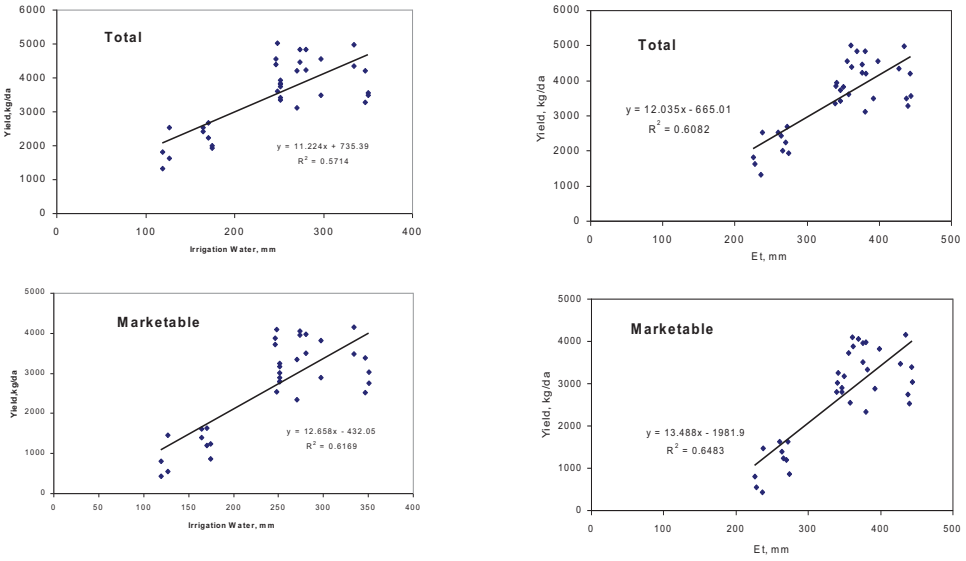


Figure 2. Relationships between yields (total and marketable) and irrigation water, and ET

Nitrogen-Yield Relationships

Parabolic and significant relationships were calculated between the nitrogen amounts and yields (total and marketable) at 5% confidence level (Figure 4).

Similar relationships were obtained between this study and other studies (Gunduz and Kara, 1996; Cetin and Nacar, 1997).

Data from all the treatments (varieties and irrigation methods) were used together to produce the relationships. These relationships indicated that to obtain maximum total yield, a nitrogen amount of 8.7 kg da^{-1} was required while nitrogen amount of 8.5 kg da^{-1} to obtain maximum marketable yield in watermelon. The result agreed with finding of Doorenbos and Kassam (1986); Eylen and TOK (1988). These nitrogen amounts should be provided from a liquid source and it is necessary to apply through irrigation water during the irrigation season.

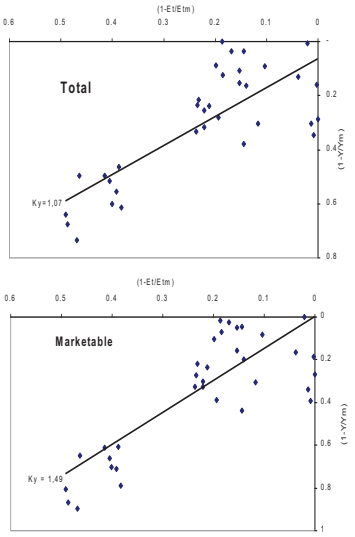


Figure 3. Relationships between relative ET deficit and relative decrease in yield

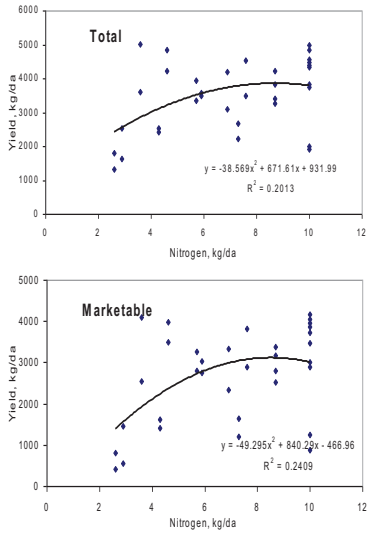


Figure 4. Relationships between nitrogen levels and yield (total and marketable)

CONCLUSIONS

In the study, the effects of different water and nitrogen levels under different irrigation methods on the water-nitrogen-yield functions of watermelon were determined. According to results of the study, TWUE and IWUE values increased with the decreasing evapotranspiration and irrigation water. Varieties, irrigation methods, and nitrogen levels and forms had different influences on water use efficiency. In this case, Madera variety, drip irrigation system, liquid fertilizer, all together, constituted best combination for plant to achieve a better water use efficiency. Significant linear relationships were obtained between the yield and irrigation water, and between the yield and evapotranspiration. Yield response factor (Ky) values were determined as 1.07 for total yield and 1.49 for marketable yield. From the results, marketable yield was more affected by water deficit. It can be concluded that to obtain high marketable yield, plant should not undergo water deficient. Parabolic and significant relationships between the nitrogen amounts and yields indicated that to obtain maximum total and maketable yields, a nitrogen amount of 8.7 kg da^{-1} and 8.5 kg da^{-1} was required.

ACKNOWLEDGEMENTS

This paper is prepared from the part of Master Thesis (The Effects of Different Irrigation Methods and Different Nitrogen Dosses and Forms on the Yield and Quality of Watermelon) accepted by CIHAEM-IAM/Bari, Italy. Authors would like to thanks the Research Fund of Cukurova University and Mediterranean Agricultural Institute (IAM) for their financial support.

REFERENCES

Cetin O., Nacar A.S., 1997. Harran ovasi'nda karpuzun alttan sizdirma (gozenekli borular) sulama sistemiyle sulama olanaklari. GAP 1. Sebze Tarimi Sempozyumu. (Turkish press)

Cevik B., Baytorun N., Tanriverdi C., Abak K., Sari N., 1996. Farklı sulama suyu uygulamalarının serada yetistirilen patlıcanın verim ve kalitesine etkileri. Ankara TÜBİTAK, Turkish J. Agric. For., 2: 175-181. (Turkish press)

Chartzoulakis K., Drosos N., 1995. Water use and yield of greenhouse grown eggplant under drip irrigation. Agricultural Water Management, 28: 113-120.

Costa L.D., Gianquinto G., 2002. Water stress and water-depth influence yield, water use efficiency, and nitrogen recovery in bell pepper: Lysimeter studies. Aust. Journal Agriculture. Research, 53:201–210.

Doorenbos J., Kassam A.H., 1986. Yield response to water. Irrigation and Drainage Paper. Rome FAO. 33: 193 p.

Elliades G., 1988. Irrigation of greenhouse-grown cucumbers. Journal of Horticulture Science, 63: 235–239.

Erdem Y., Yuksel A.N., Orta, A.H., 2001. The Effects of Deficit Irrigation on Watermelon Yieldi Water Use and Quality Characteristics. Pakistan Journal of Biological Science, 4(7): 785-789.

Ertek A., Sensoy S., Yildiz M., Kabay T., 2002. Determination of the irrigation interval and amount of application water in eggplant by using the free surface evaporation values in greenhouse conditions, KSU, Jornal Science and Engineering, 5(2): 57-67.

Ertek A., Sensoy S., Kucukyumuk C., Gedik I., 2006. Determination of plant-pan coefficients for field-grown eggplant (*Solanum melongena L.)* using class A pan evaporation values. AgriculturalWater Management, 85:58–66.

Eylen M., Tok A., 1988. Tarsus Kosullarinda Mini Yagmurlama ve Damla Sulama Sistemleri ile Sulanan Karpuzun Verim, Kalite ve Su Tüketimi. Köy Hizmetleri Arastirma Enstitüsü Yay., Genel No:156, Tarsus, 72 p. (Turkish press)

Fabeiro C., Martin S.F., Juan J.A., 2001. Yield and size of deficit irrigated potatoes. Agricultural Water Management, 48: 255–266.

Ghawi I., Shatanawi M.R., Sharaiheh R., 1989. Water Consumption of Cauliflower and Watermelon in the Jordan Waley. Dirasat, 16(7):7-22

Gunay A., 1993. Ozel Sebze Yetistiriciligi. Ankara Universitesi, Ziraat Fakültesi Yaynları, Ankara, V: 49-56.

Gunduz M., Kara C., 1996. GAP Bolgesi, Harran ovasi kosullarinda acik su yuzeyi buharlasmasina gore karpuz su tuketimi. Toprak ve Su Kaynaklari Arastirma Yilligi:1995, KHGM-APK Dairesi Baskanligi Yayınları, 98: 258-269. (Turkish press)

Hanks R.J., Keller, J., Rasmussen V.P., Wilson, G.D., 1976. Line Source Sprinkler for Continuous Variable Irrigation-Crop Production Studies. Soil Sci. Soc. Am. J. 40: 426-429.

Howell T.A., Cuenca R.H., Solomon K.H., 1990. Crop yield response. In: Hoffman, G.J., et al. (Eds.), Management of Farm Irrigation Systems. ASAE 312.

James L.G., 1988. Principles of farm irrigation system design. John Wiley and Sons. Inc., New York. 543 p.

Kanber R., Yazar A., Koksal H., Oguzer V., 1992. Evapotranspiration of Grapefruit in the Eastern Mediterranean Region of Turkey. Scientia Horticulture, 52:53-62.

Kanber R., Yazar A., Ozekici B., Diker K., Unlu M., Sezen M., 1994. Bitki uretim fonksiyonlarinin eldesinde cizgi kaynakli yagmurlama sistemlerinin kullanilmasi. C.U.Zir. Fak. Dergisi. 9 (1): 133-148. (Turkish press)

Kirda C., Kanber R., Derici R., Yazar A., Sezen M., Koc M., 1996. Wheat Yield Response to Irrigation and Nitrogen Fertilizer Applications. Progress report on TUR/7947 project, FAO- IAEA, Adana, 24 p.

Kirda C., 2002. Deficit irrigation scheduling based on plant growth stages showing water stress tolerance. Deficit Irrigation Practise. Water Report, Rome FAO, 22: 3-10.

Li F., Yan X., Li F., Guo A., 2001. Effects of different water supply regimes on water use and yield performance of spring wheat in a simulated semi-arid environment. Agricultural Water Management, 47: 25–35.

Mannini P., Gallina D., 1996. Effects of different irrigation regimes on two tomato cultivars grown in a cold greenhouse. Hortic. Abstr., 61: 64-65.

Pier J.W., Doerge T.A., 1995. Nitrogen and Water Interactions in Trickle-Irrigated Watermelon. Soil Science Society Of America, 59(1):145-150

Sezgin F., Bas T., Yoltas T., Bas S., 1997. Aydin bolgesinde degisik ekim zamani sulama araliginda yetistirilen karpuz bitkisinin verim ve kalite ozelliklerinin belirlenmesi. GAP 1. Sebze Tarimi Semp. Urfa. pp. 223-230. (Turkish press)

Stanley C.D., Maynard D.N., 1990. Vegetables. “Irrigation of agricultural crops. Edit. B.A. Steward ve D.R. Nielson” ASA, CSSA, ve SSSA, Agronomy No. 30, Madison, Wisconsin, pp. 921-949.

Stewart J.I., Cuenca R.H., Pruitt W.O., Hagan R.M., Tosso J., 1977. Determination and utilization of water production functions for principal California crops. W-67 CA Contributing Project Report. University of California, Davis, USA.

United State Salinity Laboratory Staff (USSLS) 1954. Diagnosis and improvement of saline and alkali soils. Agriculture Handbook No: 60, USDA, 160p.

Xuesen M., Mengyu L., Xinyuan W., Changming L., Zhimin H., Jinzhi S., 2003. Effects of deficit irrigation on yield and water use of greenhouse grown cucumber in the North China Plain. Agricultural Water Management, 61:219-228.

Yesilsoy S.M., 1985. Toprak-Bitki-Su Iliskileri. Ç.Ü.Ziraat Fakültesi Ders Notlari. No.22, Adana, 80 p. (Turkish press)

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

EVALUATION OF TAIL AND DRAINAGE WATERS ACCEPTABILITY FOR REUSE IN AGRICULTURE IN DRY REGIONS

Recep ÇAKIR

Prof. Dr. Çanakkale Onsekiz Mart University, Lapseki Vocational College, Çanakkale- Turkiye

Corresponding author email: rcakir@comu edu.tr; crec56b@yahoo.com

Abstract

Evaluations have been done on the basis of data the author obtained during his stage in Turkmenistan as an expert of Islamic Development Bank on Water Resources Development and Effective Water Use in the country. Drainage and tail water discharge data evaluated in the paper are collected from different drainage system structures constructed in different Willayets (Provinces) of Turkmenistan. As a result of the investigations the total volume of the drainage water was estimated as 5.6 – 6.0 km^3 per year. About 1.2 km^3 volume of the drainage water, as in the case of some collectors in Ahalskii and Dashoguzkii Region is with low salinity level and suitable for the purposes of irrigation. Relatively low salinity levels in the ranges of 2-2.6 g/l or 3.13- 4.06 dS/m were determined in waters of Gaurskii Main Collector, Ashgabatskii Collector, Geok-Tepinskii Drainage in Ahalskii Region of Turkmenistan. It was concluded that application of drainage waters with relatively law salinity level and ground waters for irrigation could increase the yearly irrigation water volume of the country from 26 km^3 to approximately 30-32 km^3. In addition, as a consequence these measures will promote enlargement of the irrigated lands in the country and will permit more agricultural food production.

Key words*: evaluation, drainage water, irrigation, Turkmenistan.*

INTRODUCTION

Turkmenistan is located in Central Asia between 35^0 08' and 52^0 48' N and 52^0 27' and 66^0 41' E, between the Caspian Sea in West and Amu Darya river in East. Climate of the country is sharply continental or subtropical desert with the exception of the inshore zone of the Caspian Sea.

The highest average amounts of the precipitations on the territory of the country is measured as 398 mm in the mountains, while the smallest amounts of 95-105 mm are observed in the regions above Kara-Bogaz Bay and Northeaster part of Turkmenistan (Çakir, 2005).

The land fund of the country is 488 100 km^2 and major part covered with pastures. On the other side, the soils are reported as poor on humus and rich in carbonates that is typical for dry regions. The desert occupies up to 80% of the whole territory of Turkmenistan. Karakum appears to be one of the largest deserts in the world and occupies the whole central part of the country stretching up to Kazakhistan (FAO, 1997; FAO, 2013).

The territory of Turkmenistan belongs to the zone of deficient watering. Annual average rainfall is 76-380 mm, while annual evaporation from the water surface reaches up to 1000-2300 mm levels. Therefore evaporation is many times as much as rainfall, which makes irrigation application a limitation factor for agriculture. At the same time, land area suitable for irrigation and agricultural cultivation in Turkmenistan constitutes 17 million hectares. Since prevailing climatic conditions are typical for the arid regions, only little more than 10% of them (about 2 million ha) are under agriculture, due to irrigation water shortage (Çakir, 2005). Although the perception of Central Asia, including Turkmenistan, as being a uniform area was (indirectly) promoted during the Soviet Union era, ecologically this region is very heterogeneous (Kienzler et. al., 2012).

According to O'Hara (2000) agriculture in the newly independent republics of Central Asia, is almost entirely dependent on irrigation. That's why access to water is essential and it plays an important role in the social and economic well-being of the country. Due to inadequate rates of season precipitations in all crop production in Turkmenistan is irrigated (Bucknall et al., 2003). Though, water resources which could be delivered for irrigation are strongly limited.

Pender and Mirzabaev (2008) reported that most of the irrigated crop land of the country is in the vicinity of the Syr Darya and Amu Darya rivers, and is irrigated by surface irrigation.

On the other side, the matter of water logging and salinisation of Turkmenistan's soils is widely accepted as one of the most serious environmental problems along with the sharp water scarcity (Çakir, 2005). O'Hara (1997) reported that evaluations from the mid-1980s onwards indicates that there has been a significant increase in the area of land where the water table is less than 2 m below the surface and more and more land is becoming saline.

Declining soils and water quality has significant implication for future agricultural development in the country.

In Turkmenistan, investment in improved drainage has been among the highest priorities of the government, which is constructing the vast Turkmen Lake (also called the Golden Age Lake) in the Karakum Desert to collect saline irrigation drainage water (Stone, 2008).

The prevailing desert climatic conditions with extremely low rainfall quantities on the one hand, and very limited fresh water resources on the other, makes the evaluation of drainage waters of relatively low salinity as a possible water source for agricultural irrigation an unavoidable requirement.

MATERIALS AND METHODS

Drainage and tail water discharge data evaluated in the paper are collected from different drainage system structures constructed in different Wilayets (Provinces) of Turkmenistan shown on Figure 1.

While the location of the hydraulic structures observed from specialist of the governmental institution as Ministry of Water Economy and Ministry of Agriculture (MWE, 1998); and specialists from the "Turkmensuvylymtaslama" Institute are schematically presented on Figure 2.

Figure 1. Map of Turkmenistan

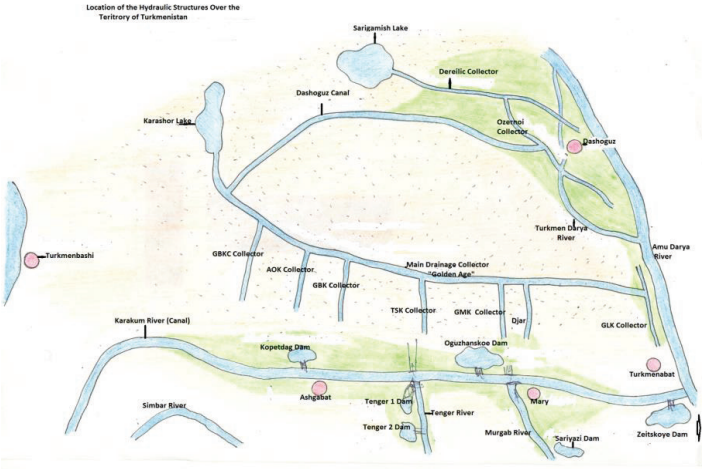


Figure 2. Schematically presentation of drainage structures over irrigated lands of Turkmenistan

In order to determine salinity levels and chemical compositions of salt into drainage-tail water mixture, water samples were taken periodically from different parts of drainage system laid on the figure.
Water salinity analysis was carried out in the laboratories of the Ministry and the Institute "Turkmensuvylymtaslama" in Ashgabat using methods given by Arinuskina (1952). While evaluations of the laboratory data and classification of investigated waters were performed on the basis of world-wide criteria published in Richards (1954).

RESULTS AND DISCUSSIONS

a) Short overview on Fresh Water Resources and Water Storing Facilities in Turkmenistan

Main water resources of Turkmenistan are the Amu-Darya river (22.0 km^3), Murgab (1.6 km^3), Tedjen (0.9 km^3), Atrek (0.4 km^3) and small rivers of Kopetdag (Table 1).

Table 1. Mean annual runoff and ground water withdraw in Turkmenistan

Nature of the Source	Source name	Water Amount mln m^3/year
1. Surface Water (Rivers)	1.1 Amu-Darya including Karakum Artificial River	22.000
	1.2 Murgab River	1.631
	1.3 Tedjen River	169
	1.4 Atrek River	354
	1.5 Small Rivers	150
	Total surface water	24.304
2. Underground water		1.269
Total 1 + 2		25.573
Dam capacity		6.220

Water resources of Turkmenistan differ by extremely irregular placement on the territory of the country: 95% of all the water resources of the country are provided by Amu-Darya river, while a share of 5% belong to all other rivers, small rivers, springs and underground aquifers withdraw.
Agriculture in Turkmenistan is totally dependent on irrigation. Even sheep grazing in the desert need watered pastures to survive (Stanchin and Lerman, 2007).
The largest and most important waterway in Turkmenistan is the Kara Kum canal, constructed in the 1950s and is at 1.400 km the longest canal in the world (Balakayev, 1979; FAO, 2013). The river (Canal) crosses the country and actually supplies almost all the water required for agricultural, industrial and other purposes of the country. Actually it appears to be the largest hydraulic structure in the world, with recent flow up to 600 m^3/s which is projected reach 800m^3/s after the reconstruction and caring 11 km^3 water per a year (Çakir, 2005). The importance of the Karakum river for Turkmenistan agriculture is much more visible from the figures pointing out that about 80% of land suitable for agriculture is located in the south and south-east of the country, while Amu-darya supplying more than 95 % of water resources flows in the east of Turkmenistan (FAO, 2013). The canal brings water to the capital Ashgabat and to the oases in the south. Each year the canal takes 10-12 km^3 from the Amu Darya river (Orlovsky and Orlovsky, 2002).
According to evaluations in FAO (2013), in 2004, wastewater production was estimated as 1,275 km^3 and treated wastewater 0.336 km^3 all of which was directly reused. Nevertheless it could be concluded that wastewater do not play a significant role in Turkmenistan. Agricultural drainage water, however, is a substantial additional source for pasture irrigation, growing salt-resistant trees and forage crops and for fisheries.

b) Drainage Water Availability and Degree of Water Salinity

The prevailing dry climatic conditions with extremely low precipitations amounts on one side, and domestic and agricultural water requirements of the country on the other, requires evaluation of drainage waters of relatively low salinity as a possible water source to alleviate the problem of water scarcity in Turkmenistan. It could be said that drainage water is another source that could also attribute to water resources from the point of agricultural water use.
As a result of the investigations the total volume of the drainage water was estimated as 5.6-6.0 km^3 per year. Some part of the drainage water, as in the case of some collectors in Ahalskii (Table 2) and Dashoguzkii Region (Table 4), is with low salinity level and suitable for the purposes of irrigation.

Table 2. Average discharge, volume and average salinization value of drainage waters in Ahalskii Region (Welayet) of Turkmenistan

Drainage system	Average Discharge (m^3/s)	Drainage volume (mln.m^3/year)	Average Salinity Level (g/l)	Average Salinity Level (dS/m)
Prikopetskaya Zone				
Kahiskii Main Collector	0.18	5.65	14.10	22.08
Gaurskii Main Collector (GMK)	1.84	58	2.14	3.34
Ashkabatskii Collector (AK)	3.00	95	2.00	3.13
Geok-Tepinski Drainage System (GTDS)	4.31	136	2.60	4.06
Tedjenskaya Zone				
Tedjenskii Main Collector (TMK)	6.34	200	20.00	31.25
Tedjenskii South-western Collector (TSWK)	1.40	44	15.00	23.44
Total:	17.10	538.65	9.30	14.55

Relatively low salinity levels in the ranges of 2-2.6 g/l or 3.13-4.06 dS/m were determined in waters of Gaurskii Main Collector (GMK), Ashgabatskii Collector (AK) Geok-Tepinskii Drainage (GTDS) from Prikopeteskaya Zone in Ahalskii Region of Turkmenistan.

On the other side, while waters from most of the collectors in Dashoguski Wilayet, neighboring Uzbekistan were determined to have relatively low salinity levels fluctuating in the ranges of 2.31-3.26 g/l or 3.61- 5.10 dS/m (Table 4), drainage waters from all collectors in Mariiski regions (Table 3) appeared to have high salinity level in the ranges of 6.15-15.0 g/l or 9.60-23.43 dS/m and unusable for the purposes of irrigation.

Chemical characteristics and amounts of drainage water sources acceptable for irrigation purposes in the region are summarized in Table 5.

As could be concluded from data in the mentioned table, the yearly average total volume of water suitable for irrigation is about 1,255 mln.m^3/year which seems to be a valuable figure for the countries as Turkmenistan with serious water shortage.

Major part (852 mln.m^3/year) of drainage water of acceptable quality are those from the Main Leftside Collector (MLK) of Lebapskii Region, with salinity and alkalinity (SAR) levels of 2.45 dS/m and 3.19; and classified in S4A1 salinity-alkalinity class.

While less total water amounts of 135 and 268 mln.m^3/year, are provided respectively by Geok - Tepinskii Eastern Collector (GTEK) and Gaurskii Main Collactor (GMK) in Ahalskii Region.

Table 3. Average discharge, volume and average salinization value of drainage waters in Mariiskii Region (Welayet) of Turkmenistan

No	Drainage system	Average Discharge (m^3/s)	Drainage volume (mln.m^3/ year)	Average Salinity Level (g/l)	Average Salinity Level (dS/m)
1	Djar	14.00	441	8.72	13.63
2	Kese-yab	8.18	258	6.15	9.60
3	Djar-say	1.77	56	9.95	15.55
4	Oguzhan	9.64	304	15.00	23.43
	Total:	33.59	1059	9.95	15.55

Moreover the chemical composition of waters from the former collector appeared to be worse with salinity and alkalinity levels up to 4.38 dS/m and 7.38 (SAR) respectively.

Table 4. Average discharge, volume and average salinization value of drainage waters in Dashoguzkii Region (Welayet) of Turkmenistan

No	Drainage system	Average Discharge (m^3/s)	Drainage volume (mln.m^3/year)	Average Salinity Level (g/l)	Average Salinity Level (dS/m)
1.	Ozernii (at border with Uzbekistan)	62.40	1.968	2.87	4.48
2.	Daryalyik (at border with Uzbekistan)	41.76	1.317	2.31	3.61
3.	*All at the border*	*104.16*	*3.285*	*2.71*	*4.23*
4.	Final Part of Ozernii System o	88.60	2.794	3.26	5.10
5.	Ozernin (at the territory of Dashoghuz Region)	26.20	825.6	4.22	6.59
6.	Final part of Daryalyik Drainage System	81.42	2.570	2.83	4.42
7.	Daryalyik Drainage System (in territory of Dashoghuz Region)	39.66	1,250.6	3.22	5.03
8.	*Total of Ozernii and Daryalyik at territory of Dashoghuz Region*	*65.86*	*2.077*	*3.16*	*4.94*
9.	*Total of Ozernii and Daryalyik*	*170.02*	*5.362*	*3.04*	*4.75*

Water quality parameters of drainage waters from Gaurski Main Collector could be accepted as highest of all waters included in Table 5, since salinity and alkalinity levels and salinity-alkalinity class of mentioned water source were determined as 2.05 dS/m, 4.41 and S3A1.

Table 5. Summary of data for waters appropriate for irrigation

No	Region	Drainage System	Total water volume (mln.m^3/year)	Salinity level (dS/m)	Alkalinity (SAR) level	Salinity-Alkalinity Class
1	Lebapskii Region	Main Leftside Collector (MLK)	852	2.45	3.19	S4A1
2	Ahalskii Region	Geok-Tepinskii Eastern Collector (GTEK)	135	4.38	7.81	S4A1
3		Gaurskii Main Collector (GMK)	268	2.05	4.41	S3A1
	Total:		1255			

Very limited quantities of water with relatively low salinity in the ranges of 3.61-5.10 dS/m were recorded in some of the collectors in Dashoguzkii Region (Table 4).

Turkmen lake, being constructed nowadays in the Karakum desert, is an important drainage water collecting structure in Turkmenistan. Design capacity of the artificial lake is 132 km^3 with annual average flow of 11 km^3. Turkmen lake is projected to collect flows by means of two main drainage canals, i.e. Dashoguz branch and Golden Age Main drainage canal from all regions of the country (Çakir, 2005).

Dashoguz (210 m^3/s discharge) branch stretching for 383.8 km will divert drainage water from the left bank of the Amu-Darya and from Dashoguz region.

While main drainage canal stretching for 720 km across the Karakum desert will collect waste water from all regions.

Schematically presentation of hydraulic structures as water storing reservoirs and drainage collector system is given on Figure 2.

In general, renewable water sources especially in non-arid regions are important part of the total water volume which could be allocated for agricultural crops irrigation.

However, the total volume of groundwater in Turkmenistan is estimated to be as low as 3.36 km^3/year, 3km^3/year of which is estimated to be formed by the infiltration from the rivers and surface runoff generated in upstream countries.

Due to lack of enough equipment for the extraction of water, only about 1.27km^3/year is being extracted and used for irrigation (Table 1).

Currently all available fresh water resources of Turkmenistan are totally used however acute water shortage is available in all regions of the country. Growing need of irrigation water and shortage of water resources require integrated measures aiming development of measures on improvement of water resources management in Turkmenistan.

Taking into account that crops prevailing in the agricultural structure of country are cotton (42.0%), wheat (49.0%) and forage crops (5.0%) (data not included), all ft which relatively resistant to low and moderate water salinity levels (Ayers and Westcot 1976); Ayars et al. 1993; Maas and Grattan 1999; Tanji and Kielen 2002), drainage voter volumes included in Table 5 reaching up to 1,250-1,300 mln.m^3/year could be accepted as a valuable reserve to decrease deficit of irrigation water source of the country.

CONCLUSIONS

Turkmenistan owns very limited water resources which appear a restricting factor for agricultural activities over larger areas, under the conditions of dry desert climate.

Total fresh water resources about25 mln.m^3/year is not adequate for the needs of the country. The requirement for alternative supplemental water sources is obvious.

Significant part of the drainage water available in Ahalskii, Lebapskii and Dashoguzkii Regions containing low salt quantities are suitable for irrigation.

A programme related to reuse of drainage waters of low salinity level should be developed.

Though, special measures need to be taken in order to prevent any additional salinization of the soil due to low quality water application. Use of the ground water potential of the country also could alleviate water shortage problem of the country. Presently less than

25 % of the potential is being extracted and used for irrigation.

Application of drainage water volume with relatively law salinity level and underground waters for irrigation could increase the yearly irrigation water volume of the country from 26 km^3 to approximately 30-32 km^3. As a consequence these measures will promote enlargement of the irrigated lands in the country and will permit more food production.

ACKNOWLEDGMENTS

The author is acknowledged to the authorities from Islamic Development Bank, especially to Mr. Mohammad Awward and Raja Anayat from the Technical Cooperation Office for their technical and financial support prior, during and after his stay in Turkmenistan. He also appreciated the contributions of Mr. Altiyev Tekabay Altiyevic, First Deputy Minister of Water Resources Ministry and Mr Cumageldi İzmailov, Head of the Department for International

Relationships in the Ministry of Agriculture of Turkmenistan. Special thanks to Mr. Hanmmamedov Mohammad Agayevic, Director of the Institute "Turkmensuvy-lymtaslama", his Deputy Mr. Chichayev Durdi Chichayevich and to the members of the research team in the Institute, Dr. Bashim Balakayev, Dr. Ovez Nazarmammedov, Mr. Dovran Basarov and Dr. Kurbanmurat Obezmuradov for their cooperation and valuable help in the process of evaluations executed by the expert during his stay in Turkmenistan. The technical contributions of Dr. Davlet Babayevic, Director of National Cotton Research Institute in Ashkabat are also appreciated.

REFERENCES

Arinuskina E.V., 1952. Ximiçeskiy analiz poçv i gruntov. Rukovodstvo po ximiçeskomu analizu poçv. Moskova, İzdatelstvo MGU, 488 s. İzdatelstvo Moskovskogo Universiteta. p 240.

Ayars J.E. et al., 1993. Long term use of saline water for irrigation. Irrig Sci (1993) 14:27-34.

Ayers R. S. and Westcot D. W., 1976. Water Quality for Agriculture. Irrigation and Drainage Paper. FAO Report No.29. Food and Agriculture Organization of the United Nations (FAO), Rome.

Balakayev B. K., 1979. Karakumskii Kanal. Ministerstvo Melioratsii i Vodnova Hozyaystva SSSR., p 196.

Bucknall J. et al., 2003. Irrigation in Central Asia. Social Economic and Environmental Considerations. The World Bank, Washington, DC.

Çakir R., 2005. Water Resources Development and Effective Water Use in Turkmenistan. Expert Report for the ISLAMIC DEVELOPMENT BANK, p 38.

FAO, 1977. Irrigation in the countries of the former Soviet Union in figures. FAO Water Report No. 15.

FAO, 2013. Irrigation in Central Asia in figures - AQUASTAT Survey – 2012, FAO Water Reports 39.

Maas E.V. and Hoffman G.J., 1977. Crop salt tolerance - current assessment. J. Irrig. and Drainage Div., ASCE 103 (IR2). p 115-134.

Maas E. V., Grattan S. R., 1999. Crop yields as affected by salinity. In R. W. Skaggs and J. van Schilfgaarde (eds) Agricultural Drainage. Agron. Monograph 38. ASA, CSSA, SSA, Madison, WI p. 55-108.

MWE, 1998. Report on water & soil survey of the irrigated land of Turkmenistan. Water & soil monitoring service under the Ministry of the Water Economy (Russian). Ashgabat.

O'Hara S.L., 1997. Irrigation and land degradation: implications for agriculture in Turkmenistan, Central Asia. Journal of Arid Environments 37. p 165-179

O'Hara S.L., 2000. Central Asia's Water Resources: Contemporary and Future Management Issues. International Journal of Water Resources Development, 16: 3, 423-441.

Orlovsky N., Orlovsky L., 2002. Water resources of Turkmenistan: use and conservation. Israel, The Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev.

Pender J., Mirzabaev A., 2008. Economic Analysis of Sustainable Land Management Options in Central Asia. Progress Report for Asian Development Bank.

Richards H.D., 1954. Diagnosis and improvement of saline and alkali soils. Washington: USDA, 1954. (USDA. Handbook, 60).

Stanchin I., Lerman Z., 2007. Water in Turkmenistan. The Center for Agricultural Economic Research. Discussion Paper No. 8.07.

Tanji K.K., Kielen N.C., 2002. Agricultural Drainage Water Management in Arid and Semi-Arid Areas. FAO Irrigation and Drainage Paper, Report No. 61. FAO, Rome.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

DETERMINATION OF THE EFFECTS OF HYDROGEL ON IRRIGATION PROGRAM FOR MAIZE CULTIVATED IN THE FIELD CONDITIONS

Murat TEKİNER, Murat YILDIRIM, Cafer TÜRKMEN, Ayhan ORAL, Bahri İZCİ

Canakkale Onsekiz Mart University, Canakkale 17020, Turkey

Corresponding author email: mtekiner@yahoo.com

Abstract

The experiment was carried out at the research center of Canakkale Onsekiz Mart University in Turkey in summer of 2010 and 2011 to determine the effects of hydrogel (organic polymer) on the grain yield and plant development parameters. Maize DKC 5783, a commonly used variety by farmers in Turkey, was used as an indicator plant and the seeds were sowed to different lysimeters having a volume of 1 m^3.
The chemical properties of hydrogel and its water holding capacity were determined under laboratory conditions. According to the treatments, certain amounts of hydrogel were mixed to the first 20 cm of the soil from the surface level. Irrigation water was applied in a controlled manner by a scaled container to the root area of maize. Plant development parameters were observed in each development stage. As a result of this study, it was seen that the amount of hydrogel mixed to the soil in different amounts had a significant effect on the plant development parameters, grain yield and also irrigation water use efficiency.

Key words*: hydrogel organic polymers, water use efficiency, maize, lysimeter.*

INTRODUCTION

In the world, one of the most important issues today is to meet the food demand of increasing population and this case put a heavy burden over the resources of water and agricultural areas. Therefore, researchers have recently been trying to get a higher yield per unit area by saying "per drop per crop". Irrigation sector has drawn much more attention to provide food supply for constantly increasing population and to achieve that there is only one way which is that the irrigation water use efficiency must be increased by applying a proper irrigation management. The management of irrigation systems, efficient use of water is now often a major goal, as well as production of the crop. Hence, it becomes necessary to quantify the performance of irrigation systems.
Nowadays, many research works have been trying to determine whether they can save water in agriculture or not by using hydrogel. Hydophilic gels called hydrogels are absorbing large quantities of water without dissolving, being characterized as a soft biocompatible material and also having three-dimensional structure consisted of hydrophilic network polymers.
Network of hydrogel is covalently crosslinked or physically involved, which can be produced either synthetically or naturally (Peppas, N.A. and Klier J., 1991). The network is formed by chemical or physical crosslinking. To do that, either chemical material are introduced to connect polymer chains or interactions between molecules are formed to provide links between chains, this feature makes that the hydrogel to absorb and maintain large quantities of water (Ratner and Hoffman, 1976; Peppas et al., 2000) and water holding capacity can also vary depending on the rate of crosslinking. A formation of hydrogel is given in Figure 1.

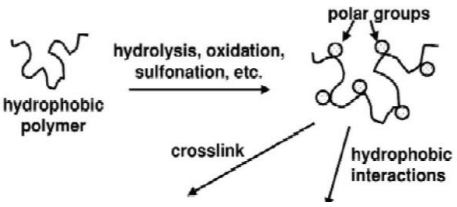


Figure 1. The chemical structure of the hydrogel

In irrigation, the general idea is to increase the soil moisture level up to field capacity (Kirda et al., 1999). Braunworth and Mack (1990) reported that the yield values of maize were very close together when the water level in the root depth never fell below 50% of available soil moisture and it was also reported in the

same study that 15% of water restriction is be able to be applied since this application provided to get a higher yield of maize rather than decreasing yield (Yildirim and Kodal, 1996).

It is well known that irrigation is the most important parameter influencing crop yield. Deficit irrigation, especially applying in the vegetative growing period, is a great risk for the yield of maize (Moser et al., 2006). On the other hand, limited water use has also an important impact on the intake of fertilizer N, which is also, be affected in different varieties of maize (Kirda, 2007).

Kaman (2007) reported that to get an economical yield, at least 50% of water demand of maize must be applied to the root area of maize. Tayel and El-Hady (1981) treated soil with different rates of hydrogel in laboratory conditions to determine soil-water relations. Hydrogel was mixed with the rate of 0%, 0.05%, 0.10%, 0.15% and 0.20% to the soil and reported that hydrogel increases some physical properties of the soil such as total porosity, macro pores, water holding capacity and hydraulic resistance, while it decreases soil bulk density, hydraulic conductivity, leakage and evaporation. However, some researcher states that it shouldn't be used for plants with higher economical values since it has not been tested in all environmental conditions yet. El-Hady et al. (1981) mixed hydrogel to the sandy soil at the rates of 0 g, 0.05 g, 0.10g, 0.15g and 0.20g per 100g of soil and determined the increasing intake rates of urea, N, P, K, Mn and Zn and also water use efficiency, plant height, dry matter of plants with the increased amount of hydrogel. A research was carried out by Sayed et al. (1991) to determine the germination condition of the seeds of tomato, cabbage and cucumber under saline conditions. Seedlings were sown to the mixture of sand and hydrogel (25% sand + 75% hydrogel) and Hoagland as a nutrient solution was added to the mixture. After germination, the seedlings were transplanted to the mixtures as follows: 0:100, 25:75, 50:50, 75:25 and 100:0. Different solutions (NaCl, $CaCl_2$ and $MgCl_2$) in the rates of 0, 2000, 4000, 8000 and 32000 ppm were added to mediums every two weeks. All treatments, except for the solution of 3200 ppm, increased plant growth.

Naeem et al. (2004) tried to determine the effect of synthetic polymers (Kemisol and Kurasol) on water holding capacity and the yield of bitter gourd. The treatments were as follows; T1 was control treatment, T2 was including only 0.1% kemisol, T3:0.2% kemisol, T4:0.3% kemisol, T5: 0.1% kurasol, T6: 0.2% kurasol, T7: 0.3% kurasol, T8: 0.1% kemisol + 0.3% kurasol, T9: 0.2% kemisol + 0.2% kurasol, T10: 0.3% kemisol + 0.1% kurasol and added fertilizers of N, P, K at a rate of 100-80-40 kg ha^{-1}, and then reported that both of the two synthetic polymers increased water holding capacity, vegetative growth as compared with the control treatment.

Therefore, the main objective of this study was to determine the most optimal amount of hydrogel to be mixed into the soil without lowering the grain yield of maize, in open field and under controlled conditions in lysimeters.

This research supported by Canakkale Onsekiz Mart Univercity Comission of Scientific Research Projects during two years.

MATERIALS AND METHODS

Experimental Design and Irrigation: The field experiment was carried out at the Dardanos Agricultural Research Station of Canakkale Onsekiz Mart University in Canakkale (Dardanelles), Turkey, in the summer of 2010 and 2011. The location of the experimental area was 40.08°N, 28.20°E. The seeds of maize were sown to the lysimeters, located on the farm land and at an altitude of 3 meters above sea level. Lysimeters are made of 2 mm sheet plate, and surrounding soil did not cause any disturbance effect on the soil and plant enclosed by the lysimeter, which are also capable of reliable and accurate and long term measurements of water loss by evaporation and transpiration.

The dimension of each lysimeter has been consisted of 1 m in width, 1 m in length and 1 m in depth having an overall surface area of $1m^2$ and volume of 1 m^3. Each lysimeter has had one drainage hole controlled by a valve at the bottom edge with a diameter of 10 mm (in Figure 2).

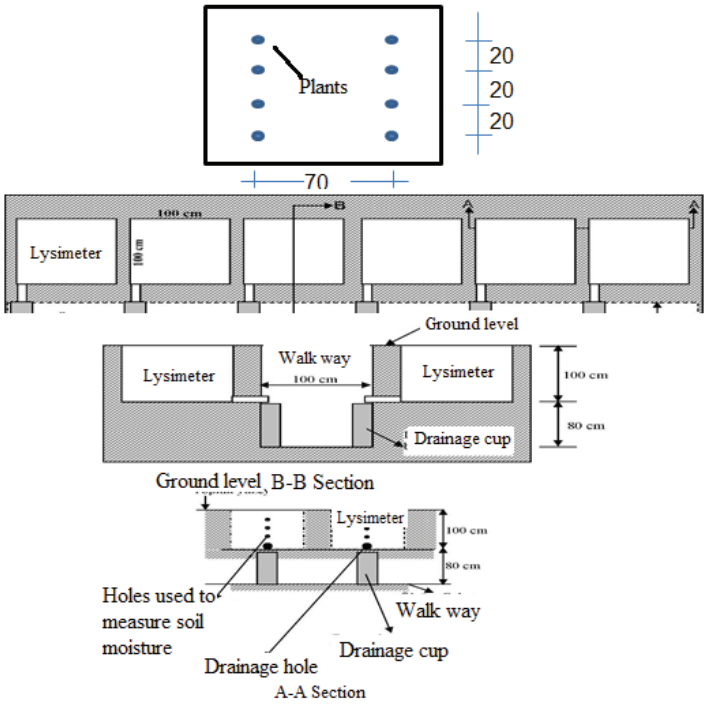


Figure 2. Top view of the experimental layout

At the site where the lysimeters were installed, soil was excavated. After that the top level of lysimeters was level with the soil surface and further soil was removed and a narrow trench was dug between two rows both to remove excess water from the lysimeters, if available and to measure the soil moisture level. Distance apart was 20 cm and placed some stones to prevent from excessive heating of side walls of the lysimeter. Distance between two rows was 70 cm to provide a comfortable walk between two lysimeters row (Figure. 2).

In the experiment, there were totally 12 lysimeters. Eight seeds of maize (DKC 5783) were sown in one lysimeter in the form of two rows. The seeds were spaced 0.7 m apart and spacing between plants in each row was 0.20 m, hence one plant had a surface area of 0.14 m^2 in the lysimeter.

Irrigation attempt was made before sowing to provide a suitable environment for seeds of maize and water was refilled up to field capacity. Irrigation was initiated on 4th July 2010 and 6th July 2011, and a similar irrigation volume was applied to all treatments in May to establish a good vegetative and root development.

After seedlings provided a good development, irrigation treatments commenced.

Each lysimeter in all treatments took the same recommended amount of fertilizer; triple super phosphate (20 kg da^{-1}), amonium nitrate (40 kg da^{-1}) and K_2SO_4 (5 kg da^{-1}) in both years (1 da =1000 m^2). The total amount of P and 40% of the N and K fertilizers were applied at planting thoroughly mixed with irrigation water. The remaining 60% of the N and K were added equally twice at 15 and 20 day intervals.

Water was conveyed from the well at the site, which was 5 m away from the lysimeters, by PVC pipes and soil moisture was determined gravimetrically with 7 day intervals. According to the soil moisture level in the medium, the amount of irrigation water to be applied was calculated and applied to the each lysimeter by using scaled container. The experimental treatments included four different applications as follows:

L0 = control treatment (not including hydrogel);

L1 = the amount of hydrogel mixed in the medium was to absorb water only 50% of the field capacity;
L2 = the amount of hydrogel mixed in the medium was to absorb water up to field capacity;
L3 = the amount of hydrogel mixed in the medium was to absorb water two times higher than field capacity.
Hydrogel in changing amounts according to the trials was mixed with the soil in the depth of 20 cm from the surface level.
The experiment was laid out using a randomized complete block design with 3 replications. Each replicate included 8 plants.
The irrigation water use efficiency (IWUE) (kg m^{-3}) was defined according to Howell et al. (1990):

$$IWUE = Y / I$$

where Y is yield (kg ha^{-1}), and I is applied water (mm).
Physical properties: some physical soil properties as field capacity, wilting point, water holding capacity, and infiltration rate and bulk density were determined in the irrigation laboratory of agricultural faculty of Canakkale Onsekiz Mart University.
Chemical properties: some chemical properties of hydrogel and also the capacity to absorb water were determined in the chemistry laboratory of Science Faculty of Canakkale Onsekiz Mart University. The following properties for the soil used to grow maize were determined: soil pH, electrical conductivity, and total available N, P and K.
Evapotranspiration (ET) was calculated with the water balance equation given below:

$$ET = I + P + C_r - D_p - R_f \pm \Delta SW$$

where ET is evapotranspiration (mm), P is rainfall (mm), and ΔSW is the change in soil water content (mm) determined gravimetrically. In the equation, Capillary rise (C_r), Deep percolation (D_p) and Runoff (R_f) were ignored since there was no drainage water in each treatment.

Plant and fruit development parameters were observed during the experiment and plant height, stem diameter, grain yield, the length and diameter of corncob were determined for each plant in the treatment. Data on plant development parameters and yield and quality parameters were analyzed using MINITAB software. Means were separated by Duncan's Multiple Range Test at the probability level of 1% and 5% ($p < 0.01$, $p < 0.05$).

RESULTS AND DISCUSSIONS

Some physical properties of maize obtained in the experiment are given in Table 1. The average grain yield values, as seen in Table 1, decreased in 2011 as compared to 2010. All yield and plant development parameters were higher in both years in the L3 treatment, in which the amount of hydrogel is to absorb water as much as twice of field capacity and on the other hand, the lowest of these parameters were obtained from the treatment not including hydrogel (L0). Information related with irrigation is given in table 2.
The average grain yield values, as seen in table 1, decreased in 2011 as compared to 2010. All yield and plant development parameters were higher in both years in the L3 treatment, in which the amount of hydrogel is to absorb water as much as twice of field capacity and on the other hand, the lowest of these parameters were obtained from the treatment not including hydrogel (L0). Information related with irrigation is given in table 2. In the similar manner with plant growth parameters, the amount of applied irrigation water was lower in 2011 as compared to 2010. While the highest amount of water was applied in the treatment of L3. the lowest was in the L2. in which the amount of hydrogel was to absorb water up to field capacity. Irrigation water use efficiency (IWUE) is given in table 3.
Even though the yield was higher and the highest amount of water was applied in the treatment of L3. IWUE was lower than the treatments of L1 and L2. Even in these treatments (L1 and L2). The amount of applied water and grain yield were lower than the L3 treatment.

Table 1. Yield and development parameters of maize in 2010 and 2011

2010												
	Plant height (cm)							Stem diameter (mm)				
	1. Tek.	2. Tek.	3. Tek.	Average				1. Tek.	2. Tek.	3. Tek.	Average	
L0	108	114	87	103.0	d		**L0**	11.2	10.2	9.9	10.4	d
L1	139	159	187	161.7	b		**L1**	12.7	16.6	17.5	15.6	b
L2	156	168	134	152.7	c		**L2**	14.8	13.5	14.3	14.2	c
L3	176	196	213	195.0	a		**L3**	16.3	20.8	22.1	19.7	a
	The length of corncob (cm)							The diameter of corncob (mm)				
	1. Tek.	2. Tek.	3. Tek.	Average				1. Tek.	2. Tek.	3. Tek.	Average	
L0	14.8	14.2	14.0	14.3	c		**L0**	29.8	27.8	27.9	28.5	c
L1	16.2	19.8	20.4	18.8	b		**L1**	33.4	38.6	38.6	36.9	b
L2	17.8	16.6	17.3	17.2	b		**L2**	35.6	33.5	34.6	34.6	b
L3	19.5	22.9	23.9	22.1	a		**L3**	38.7	44.7	45.9	43.1	a
	Thousand grain weight (gr)							Grain yield (kg/da)				
	1. Tek.	2. Tek.	3. Tek.	Average				1. Tek.	2. Tek.	3. Tek.	Average	
L0	252	249	312	271.0	b		**L0**	751	735	908	798.0	b
L1	289	261	334	294.7	b		**L1**	872	798	1012	894.0	b
L2	267	248	305	273.3	b		**L2**	805	749	920	824.7	b
L3	346	337	389	357.3	a		**L3**	1028	1007	1158	1064,3	a
2011												
	Plant height (cm)							Stem diameter (mm)				
	1. Tek.	2. Tek.	3. Tek.	Average				1. Tek.	2. Tek.	3. Tek.	Average	
L0	101	98	86	95.0	c		**L0**	12.3	9.9	10.2	10.8	c
L1	132	145	177	151.3	b		**L1**	11.8	15.6	16.9	14.8	b
L2	145	155	125	141.7	b		**L2**	13.3	12.8	13.5	13.2	b
L3	168	176	198	180.7	a		**L3**	17.5	19.8	21.6	19.6	a
	The length of corncob (cm)							The diameter of corncob (mm)				
	1. Tek.	2. Tek.	3. Tek.	Average				1. Tek.	2. Tek.	3. Tek.	Average	
L0	13.4	13.5	15.3	14.1	c		**L0**	28.7	26.7	26.7	27.4	c
L1	15.8	18.7	19.8	18.1	b		**L1**	32.6	37.6	37.8	36.0	b
L2	16.5	15.8	16.3	16.2	b		**L2**	32.4	31.4	33.5	32.4	b
L3	17.8	21.8	23.4	21.0	a		**L3**	36.9	43.2	44.5	41.5	a
	Thousand grain weight (gr)							Grain yield (kg/da)				
	1. Tek.	2. Tek.	3. Tek.	Average				1. Tek.	2. Tek.	3. Tek.	Average	
L0	235	239	228	234.0	b		**L0**	718	733	698	716.3	b
L1	265	255	287	269.0	b		**L1**	799	786	881	822.0	b
L2	260	255	276	263.7	b		**L2**	777	762	827	788.7	b
L3	355	324	365	348.0	a		**L3**	1032	935	1057	1008.0	a

Table 2. Irrigation performance during the experiment

Treatments	FC (%)	**2010** – Number of irrigation and amounts in each irrigation (mm)							Total
		1	2	3	4	5	6	7	
L0	27.40	21.8	13.4	33.2	52.2	48.2	43.7	45.0	257.4
L1	25.07	20.1	20.6	35.6	46.7	45.2	39.3	41.9	249.6
L2	23.59	19.6	16.4	30.5	39.6	40.4	38.8	39.6	225.0
L3	26.71	38.0	28.8	44.8	55.6	52.0	52.1	46.5	317.7
Treatments	FC (%)	**2011** – Number of irrigation and amounts in each irrigation (mm)							Total
		1	2	3	4	5	6	7	
L0	27.40	21.5	31.5	37.2	45.7	34.9	41.8	39.6	252.2
L1	25.07	20.9	23.5	30.6	34.7	33.3	48.0	47.1	238.1
L2	23.59	18.7	24.7	31.2	39.1	30.3	35.1	43.6	222.7
L3	26.71	23.7	38.0	49.2	53.0	41.5	48.3	56.5	310.2

Table 3.Plant development parameters and irrigation amounts

Treatments		Plant height (cm)	Stem diameter (mm)	The length of corncob (cm)	The diameter of corncob (mm)	Thousand grain weight (gr)	Grain yield (kg/da)	Irrigation amounts (mm)	IWUE (kg/da mm)
2010									
Control	L0	103.0	10.4	14.3	28.5	271	798	257	3.1
FC/2	L1	161.7	15.6	18.8	36.9	295	894	250	3.6
FC	L2	152.7	14.2	17.2	34.6	273	825	225	3.7
FCx2	L3	195.0	19.7	22.1	43.1	357	1064	318	3.4
2011									
Control	L0	95.0	10.8	14.1	27.4	234	716	252	2.8
FC/2	L1	151.3	14.8	18.1	36.0	269	822	238	3.5
FC	L2	141.7	13.2	16.2	32.4	264	789	223	3.5
FCx2	L3	180.7	19.6	21.0	41.5	348	1008	310	3.2

FC: Field Capacity

As a result, the highest water use efficiency was obtained in the L2 treatment in 2010 and it was obtained in the L1 and in the L2 treatments in 2011. In both years, the IWUE was the lowest in the L0 treatment not including hydrogel every two years.

CONCLUSIONS

In conclusion, while L2 treatment seems to be suitable in terms of irrigation water use efficiency. However, overall results indicate L1 treatment is more appropriate since the used amount of hydrogel is the half of L2 and quarter of L3 treatments. therefore it is important to use less amount of synthetic material (hydrogel) for the environment.

In the studies conducted out on hydrogel used in agriculture indicated that the use of hydrogel provides more advantageous in irrigation practices than those not including hydrogel. However, many of those research works had been conducted in the greenhouse conditions and they mixed the hydrogel inside the medium in pots uniformly but it is almost impossible to mix it into the depth of effective root area uniformly under open field conditions.

In the present study, we can suggest the most suitable application of hydrogel was achieved from the L1 treatment. However, we can recommend also the following things for further research works.

If we mixed the hydrogel in 30 cm depth from the surface level rather than 20 cm what would have happened the grain yield plant development parameter and irrigation water use efficiency.

If we used other water sensitive plants instead of maize what would have happened to those parameters.

REFERENCES

El-Hady O.A., Tayel M.Y. and Lofty A.A., 1981. Super Gel As A Soil Conditioner II- its Effect On Plant Growth. Enzymes Activity. Water Use Effıciency And Nutrient Uptake. Acta. Hort. (ISHS) 119:257-266.

El-Sayed H., Kırkwood R. C. and Graham N. B., 1991. The Effects of a Hydrogel Polymer on the Growth of Certain Horticultural Crops under Saline Conditions. Oxford University Press. Journal of Experimental Botany. V.42. N.7. Pp. 891-899.

Güngör Y., Erözel A.Z. and Yıldırım O., 2004. Sulama. A.Ü. Ziraat Fakültesi Yayınları. Yayın No:1540. Ders kitap No:493. Ankara.

Hoffman A. S., 2002. Advanced Drug Delivery Reviews. 43. 3-12.

Howell T. A., Cuenca H.A. and K.H. Solomon. 1990. Crop Yield response. Management of Farm Irrigation Systems. Trans. ASAE Monograph Chap S. USA.

Kacar B., 2009. Toprak Analizleri. Nobel Bilim ve Araştırma Merkezi. Yayın No: 1387-90-44. Ankara.

Kaman H., 2007. Geleneksel Kısıntılı ve Yarı Islatmalı Sulama Uygulamalarına Bazı Mısır Çeşitlerinin Verim Tepkileri. Çukurova Üniv. Fen Bil. Enst. Tarımsal Yapılar ve Sulama ABD. Doktora tezi. Adana. 127 s.

Kırda C., Moutonnet P., Hera C., and Nıelsen D.R., 1999. Crop Yield Response to Deficit Irrigation. Kluwer Aca. Pub., Dordrecht. The Netherlands. pp. 258.

Naeem M.A.,Rashid M. and Hussain A., 2004. Water holding capacity of soil and yield of bitter gourd as affectedby synthetic polymers. Pakistan Journal of Soil Science. V. 23(1-2). p. 95-102.

Peppas N. A., Klier J., 1991. Controlled release by using poly (Methylene Acid-G Ethylene Glycol) hydrogels. J.Control Release 16: 203-214.

Peppas N. A., Bures P., Leobandung W. and Ichikawa H., 2006. European Journal of Pharmaceutics and Biopharmaceutics. 50. 27-46.

Ratner B. D. and Hoffman A. S., 1976. ACS Symposium Series. Vol. 31. Chapter 1. p 1. Tayel. M.Y. and El-Hady. O. A. 1981. Super Gel As A Soil Conditioner 1.-its Effect On Some Soil - Water Relations. Acta. Hort. (ISHS) 119:247-256.

Taş İ., Kırnak H., 2011. Damla Sulama Yöntemiyle Sulanan Şanlıurfa Biberinin (Capsicum annum L.) Sulama Programı. Gazi Osman Paşa Üniversitesi. Ziraat Fakültesi Dergisi. 28(1). 103-112.

Tüzüner A., 1990. Toprak ve Su Analiz Laboratuarları El Kitabı. TC. Tarım Orman ve Köyişleri Bakanlığı. Köy Hizmetleri Genel Müdürlüğü Yayınları. Ankara.

Yıldırım Y. E. ve S. Kodal, 1996. Ankara koşullarında Mısır Su Tüketiminin Tahmininde Kullanılabilecek Yöntemler. Tarım Bilimleri Dergisi. 2(1):13-18. Ankara

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

USE OF ARTIFICIAL GROUNDWATER RECHARGE METHODS FOR THE WATER RESOURCE MANAGEMENT IN THE CONTEXT OF CLIMATE CHANGE

Oana CIUGULEA, Ioan BICA

Technical University of Civil Engineering Bucharest, Lacul Tei Blvd, 124, Bucharest 020396, Romania

Corresponding author email: oanaciugulea@yahoo.com; bica@utcb.ro

Abstract

Artificial groundwater recharge is of great importance in the sustainable and integrated management of water resources, particularly in the context in which our country shows a water deficit in certain areas, which is expected to increase over the next few years under the influence of climate change. Due to the fact that the artificial groundwater recharge systems are commonly designed with the aim of increasing the groundwater resources and/or improving their quality, implementing these systems may result in solving the issues relating to water resource management in the context of climate change. In this respect, this paper reviews a case study that describes how water discharges coming from an artificial canal infiltrate in order to provide the recharge rates needed for the safe operation of the drillings of Voronet capture zone, Suceava County. This canal poses two problems, namely the fact that it is not located parallel to the capture zone, and therefore the drillings located at greater distances do not capture sufficient water discharge and the second one, the fact that this canal might get silted. The results obtained from the analytical calculation of the wells discharges in the context of water infiltration from canal, have pointed out that the solution proposed leads to increase in water demand for that capture zone.

Key words*: artificial recharge methods, climate change, water resource management.*

INTRODUCTION

The influence of climate change on water resources is a matter of interest worldwide requiring an in-depth analysis which should correlate and compare the results of various studies and projects within a thorough study.

The main effects generated by climate change phenomenon consist of: air temperature rise, change in precipitation regime, groundwater level decrease, favouring the occurrence of drought phenomenon, as well as of severe meteorological phenomena.

Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.

From 1880 to 2012, average global mean temperature increased by 0.85ºC (from 0.65 ºC to 1.06 ºC) and from 1951 to 2012 by 0.72 ºC. The last three decades (from 1983 to 2012) have been successively warmer than any preceding decade since 1850. The decade 2003 – 2012 was the warmest, exceeding the records of all preceding years (IPPC, 2014).

Effects of climate change in Romania have reflected in changes in air temperature, which have been observed since 1901. In comparison with the increase in the global average annual temperature by 0.6ºC from 1901 to 2000, in Romania the annual mean recorded an increase by merely 0.3ºC, and from 1901 to 2006 the increase was 0.5ºC as compared to 0.74ºC worldwide (1901-2005) (the Ministry of Environment and Sustainable Development, 2008).

The change in the climate regime of Romania falls within the global context, taking into account the regional conditions: the temperature rise will be even higher in summer, whereas, in the north-western Europe the highest increase is expected in winter. Thus, a rise in the annual average temperature is expected in Romania compared to the period 1980 – 1990, similar to the entire European space, with small differences between the results of the patterns with respect to the first decades of the XXIst century and higher with

respect to the end of the century (National Administration for Romanian Waters, 2014):

- from 0.5^{0}C to 1.5ºC, for the period 2020 – 2029;
- from 2.0ºC to 5.0ºC, for 2090 – 2099, depending on the scenario (example: from 2.0 ºC to 2.5 ºC in case of the scenario projecting the lowest rise in global average temperature and from 4.0 to 5.0 ºC in case of the scenario with the highest rise in temperature).

From the precipitation point of view, from 1901 to 2000, a notable general tendency of decrease in the annual amounts of precipitation occurred, with an intensification of the drought events in the southern part of the country after 1960. For certain regions, an increase in the annual frequency of very rainy (the highest 12% daily amounts) and extremely rainy (the highest 4% daily amounts) days occurred from 1946 to 1999. From 2000 to 2007 two opposite extreme rainfall events were recorded at the level of Romania, namely the drought in 2000 and 2007 and the floods in 2005. An extreme temperature event was recorded in 2007. The winter of 2006 – 2007 was the warmest winter ever occurred since observational measurements started in Romania, when major deviations of maximum/minimum temperature in relation to the multiannual average regime persisted over long periods of time (GASC, 2008).

In terms of precipitation regime, from 1901 to 2010 the analyses conducted show the existence, particularly after 1961, of a general decreasing trend of the annual amounts of precipitation at the level of the entire country and particularly a pronounced increase in the deficit of precipitation to the south and east of Romania (ANAR, 2014).

According to (EEA, 2010) there are projected seasonal changes in river flows due to climate change. For example, higher temperatures will push the snow limit in Northern Europe and mountainous regions upwards and reduce precipitation in the form of snow. This would result in a marked drop in winter retention and higher winter run-off in Northern European and Alpine rivers such as the Rhine, Rhône and Danube. As a result of the declining snow reservoir, earlier snow-melt and a general decrease in summer precipitation, longer periods of low river flow may be observed in late summer and early autumn in many parts of Europe.

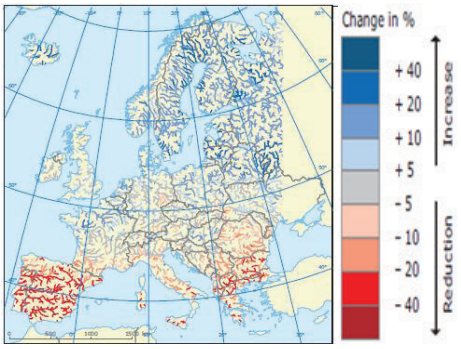


Figure 1. Relative change in annual river flow and change in seasonal river flow for three large European rivers between scenario (2071–2100) and reference period (1961–1990) (EEA, 2010)

According to the Ministry of Environment and Sustainable Development, 2013, „adaptation to climate change is the capacity of natural and human systems to respond to (actual or expected) climate change effects, including climate variability and extreme meteorological events to moderate potential damages, to take advantage of opportunities and to properly cope with climate change consequences, considering that society and ecosystems feel the individual and cumulated effect of all these components".

Adaptation requires actions at all levels– local, regional, national and international – and in all fields – industry, agriculture and fishing, tourism, public health, civil engineering and infrastructure, transport, water resources, forests, power, biodiversity, insurance, recreational activities and education.

As a measure to adapt to the climate change effects, this article shows the possibility of using artificial groundwater recharge methods for water resource management, for the purpose of increasing the groundwater storage capacity.

Artificial groundwater recharge may be globally defined as the recharge generated when the natural groundwater recharge is deliberately modified to increase the groundwater resources.

The artificial aquifer recharge consists of all human activities monitoring surface water infiltration into the aquifer at flow rates higher than those naturally occurring.

This technique solves a wide range of surface and particularly groundwater resource management problems at the local and regional levels, but thorough knowledge on the application conditions for the correct selection of technical and economic solutions is required to this end.

MATERIALS AND METHODS

A case study has been reviewed in order to highlight the possibility to use artificial groundwater recharge methods as a solution for solving the problems relating to water resource management. This case study shows how water discharges coming from an artificial canal infiltrate in order to provide the recharge rates needed for the safe operation of the drillings of Voronet capture zone, Suceava County(Figure 2).

Figure 2. Layout plan of Voronet capture zone and of the artificial recharge canal

In terms of soil stratification in the wells area, the following have been taken into account: at the surface, a 0.5-1.4 m thick topsoil followed by a 0-3 m thick yellowish-sandy clay layer. The unconfined aquifer is formed of large heterogeneous gravel with cobble and boulders, in different sand, 5-11 m in thickness. Below this layer, there is a grey, continuous clay layer, forming the impermeable bed of the phreatic layer.

Both alternatives with functional (unsilted) and silted canals were reviewed in order to analyse the discharges infiltrated in the artificial recharge structure.

This canal poses two problems: (1) it is not located parallel to the capture zone, therefore the drillings located at greater distance do not capture sufficient water discharge and (2) this canal might get silted.

Considering the abovementioned conditions, this study attempted to determine the following issues:

- The discharges coming from the recharge canal the capture zone is to be recharged with, for the provision of a flow rate of 3.6 – 4 l/s and well;
- The minimum and maximum distances from the wells for the execution of the canal;
- The qualitative forecast of canal siltation over time taking into account the water extraction from surface source.

An analytical calculation of the well discharges in the context of infiltration from canal was performed in order to determine these issues.

For the purposes of determining these aspects, an analytical calculation of the wells flow rates was performed considering infiltration from canal.

The discharge of the row of wells supplied by infiltration from canal was determined using the equivalent perfect drain method, considered in the same site and with the same discharge extracted per capture zone unit.

In the first calculation stage, this makes the row of wells replaceable with a perfect drain with the same flow rate per ml front, creating the same general dislevelments in the field. The parameters typical of the row of wells shall be determined in the second stage: flow rates for certain distances between wells and additional dislevelments in the well.

In this case, calculation was performed using two assumptions:

a) Unsilted canal

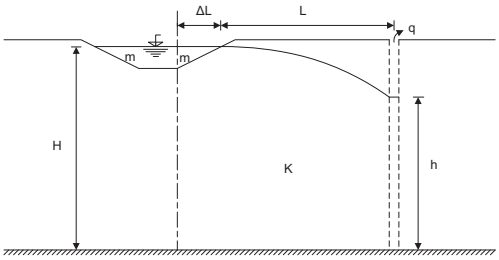


Figure 3. Calculation scheme for unsilted canals

Discharge extracted per drain unit length:

$$q = \frac{k(H^2 - h^2)}{2(L + \Delta L)}$$

where $\Delta L = \lambda H$ and $\lambda = \frac{m}{1+2m}$

where m – canal slope.

Dupuit equation to determine the discharge q can be used when infiltration into the permeable layer is made through a vertical gradient of elevation H.

As in this case infiltration into the permeable layer is made from the canal slope and bottom situated in the permeable layer thickness, an equivalent schematic with vertical gradient situated at a distance ΔL from the intersection line of the water level in its canal and gradient shall be adopted.

The extension of the infiltration domain substitutes the load losses resulted from curving the current lines at the normal infiltration into the canal.

b) Silted canal

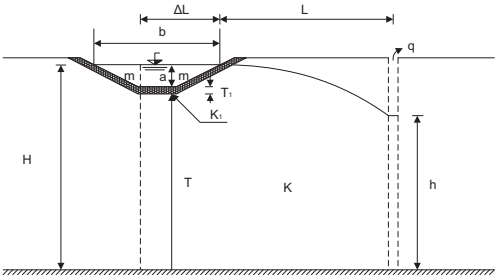


Figure 4. Schematic for silted canal

If water in canal contains suspended solids, which will settle due to low movement velocity and will be partly entrained into the soil pores under the action of infiltration thus causing siltation, the schematic changes according to the previous figure.

The discharge captured by the equivalent perfect drain shall be in this case:

$$q = \frac{k(H^2 - h^2)}{2(L + \Delta L)}$$

where:

$$\Delta L = \sqrt{\frac{K}{K_1} T T_1}\, cth\left(b\sqrt{\frac{k_1}{kTT_1}}\right)$$

T_1 and K_1 are the thickness and permeability coefficient of the silted layer.

After the flow of the equivalent perfect drain is determined, the actual capture conditions are considered, using wells, determining the flow of a well and the additional dislevelment in the well.

The flow rate of a well is obtained from the following relationship:

$$Q = \sigma \cdot q$$

Where σ is the distance between wells, and q is the specific discharge (m^3/sm) of the equivalent perfect drain.

For the calculation of the additional dislevelment in well (ΔS) it was used the relationship:

$$\Delta S = \frac{Q}{2\pi K h_{mediu}} \ln \frac{\sigma}{\pi D}$$

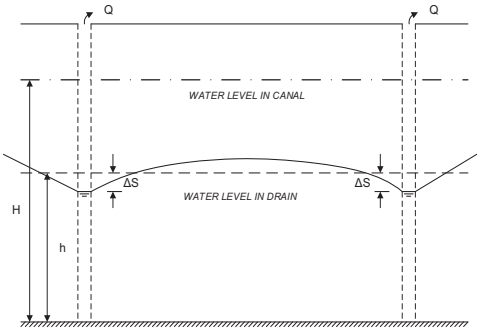


Figure 5. Schematic for additional dislevelment

RESULTS AND DISCUSSIONS

To show the variety of design elements resulted, the hydraulic calculations were performed taking into account several values of these parameters. Using them and the formulas shown above, tables containing the values of q/K depending on the distance between the canal and the equivalent perfect drain *(L),* the dislevelment created in drain *(S),* and the thickness of the groundwater layer *(H)* were prepared

a) Unsilted canal

The design elements used in this case were: H, h, L, m and s, which were assigned various values.

The graphs in Figure 6 and 7, where the variation of q/K for various values of H and $s$depending on L was represented, were prepared based on such values.

By reviewing these graphs, note than the flow rate decreases with the increase in distance *L* and also decreases in proportion with *H*.

a) Silted canal

The values of *q/k* for the silted canal were determined using the following assumptions: thickness of silted layer was considered constant and the permeability coefficient of the silted layer was considered to decrease to 1/10, 1/50, 1/100 in relation to the initial value of the permeability coefficient of the aquifer, and also the values for the remaining parameters were varied.

Using these data, corresponding data tables were prepared $\frac{k_1}{k} = 0.1$; $\frac{k_1}{k} = 0.02$ and $\frac{k_1}{k} = 0.01$. Graphs (Figures 8, 9, 10) representing the variation of qc/k depending on $\frac{k_1}{k}$, *L, H,* and *s* were prepared using these data.

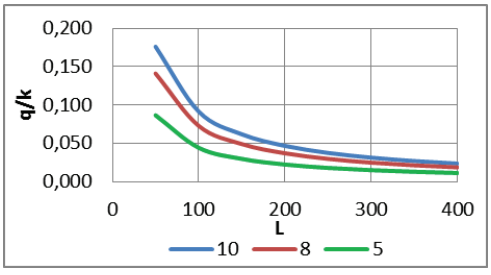


Figure 6. Unsilted canal, s = 1 m.

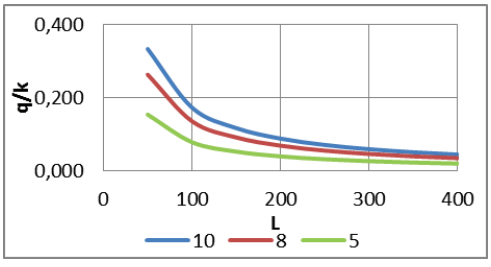


Figure 7. Unsilted canal, s = 2 m.

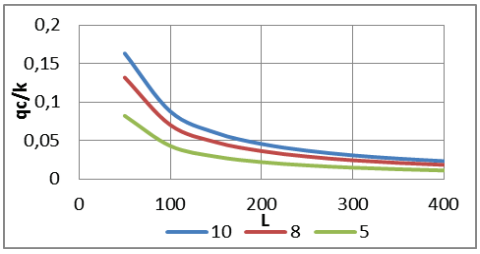


Figure 8. Silted canal k1/k=0.1; s=1 m; a=1.00 m.

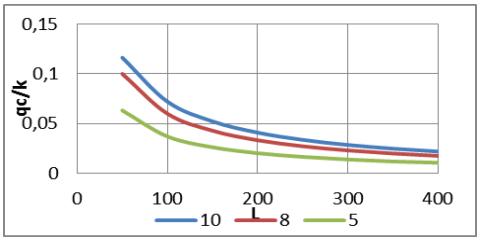


Figure 9.Silted canal k1/k=0.02; s=1 m; a=1.00 m

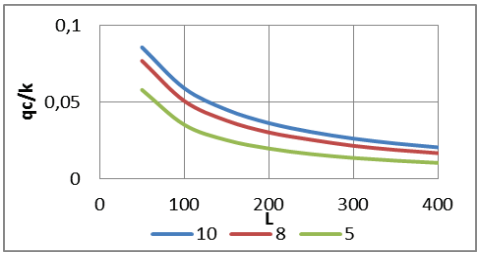


Figure 10.Silted canal k1/k=0.01; s=1 m; a=1.00 m

The graphs show a decrease in the flow rate with the increase in the distance *L* and with the decrease of *H*. These graphs can easily determine the value of *qc/k* for a certain distance of the row of wells in relation to the canal and for *H* and *s* values proposed.

After the value of this ratio is determined, knowing the permeability of the aquifer, the captured discharge can be found. Thus, the discharge for any well of the capture system can be calculated, by knowing the required soil elements.

The graphs in the Figures 11,12,13 highlight the variation of the values *qc/q* depending on the distance *L*, the phreatic layer thickness *H* and the siltation degree $\frac{k_1}{k}$.

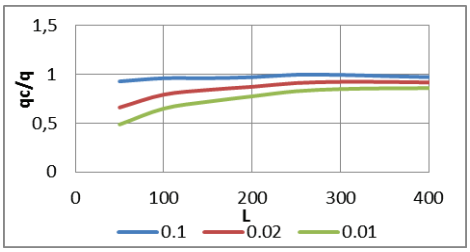


Figure11. Silted canal, H=10 m, s=1 m, a=1m

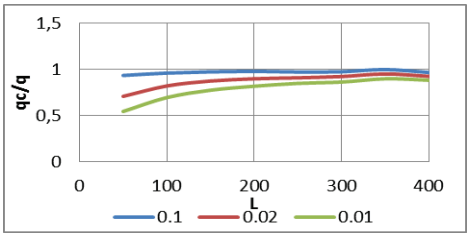


Figure 12.Silted canal, H=8 m, s=1 m, a=1m

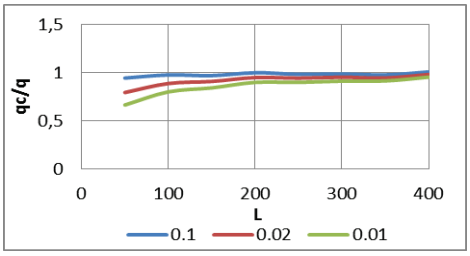


Figure 13. Silted canal, H=5 m, s=1 m, a=1m

Note that for short distances, for great depths of the phreatic layer and in particular for $\frac{k_s}{k} = 0.01$, the discharge for the silted canal decreases by about 50%.

The decrease is less felt as distance *L* increases. This is explained by the fact that for long distances, the discharge is relatively low for the unsilted canal, too.

By systematic measurements of the discharge of each well, the siltation degree can be determined by means of these graphs, therefore the moment when dredging of the canal should be performed may be determined.

CONCLUSIONS

Using the artificial recharge methods for water resource management in the context of climate change is an up-to-date technical solution.

The solution analysed in this paper connects an artificial groundwater recharge canal to a row of wells extracting groundwater. The alternatives subject to review have led to the following conclusions:

- The distance between the canal and the capture system line greatly influences the infiltrated and respectively captured discharges;
- The dislevelment created between the water level in wells and canal is important as long as the distance between the two systems is short; the longer the distance the smaller the importance of this factor;
- The canal siltation over time contributes to the reduction in the infiltrated discharge; but the intensity of this influence decreases as the distance between the row of wells and canal increases;
- The aquifer thickness is of little importance on the discharge, with increasing trend as the distance between the capture line and the infiltration line decreases.
- Consequently, the correct selection of the design solution is very important; the efficiency of the maintenance measures (e.g. desilting) is highly dependent on the constructive solution adopted.

REFERENCES

Administratia Nationala a Apelor Romane, 2014.Proiectul Planului National de Management aferent portiunii nationale a bazinului hidrografic international al fluviului Dunarea.

European Environmental Agency, 2010. Thematic assessment, Water resources: quantity and flows.

Intergovernmental Panel on Climate Change (IPPC), 2014. Climate Change 2014 - The Synthesis Report of the Fifth Assessment Report .

Ministerul Mediului si Dezvoltarii Durabile, 2008. Ghid privind Adaptarea la efectele Schimbarilor Climatice – Anexa nr 1 a OM nr. 1170/2008.

Ministerul Mediului si Dezvoltarii Durabile, 2014. Strategia nationala a Romaniei privind schimbarile climatice, 2013-2020 – Anexa la Hotararea nr. 529/2013.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

MONITORING OF SIZE-SEGREGATED PARTICULATE MATTER FRACTIONS WITH OPTICAL INSTRUMENTS IN URBAN AREAS

Daniel DUNEA[1], Tom SAVU[2], Leif MARSTEEN[3]

[1]Valahia University of Targoviste, Campus, Aleea Sinaia no.13, RO-130004, Targoviste, Romania,
[2]University Politehnica of Bucharest, Splaiul Independentei no. 313, București, RO-060042, Romania
[3]Norwegian Institute for Air Research, Instituttveien 18, PO Box 100, NO-2027 Kjeller, Norway

Corresponding author email: tomsavu@gmail.com

Abstract

The assessment of harmful PM concentrations i.e. particles with an aerodynamic diameter below 2.5 μm, requires continuous monitoring conducted for 24 hours a day, for 365 days a year. Monitoring campaigns for screening the PM levels in a particular urban area facilitate the conceiving of a continuous monitoring plan by establishing where to deploy optimally the optical instruments for on-line measurement. The paper presents the practical efficiency of the outdoor monitoring of PM size fractions using a new optical equipment i.e. Dusttrak DRX 8533 with environmental enclosure and heating module. The experiments were carried out in Targoviste city, Romania, between 2014 and 2015 within the first two phases of the ROkidAIR project (http://www.rokidair.ro) to perform a screening of the PM concentrations existing in these urban areas and to calibrate the prototype of the PM2.5 microstation developed within the project .The utilization of the DustTrak instrument showed that in heavy traffic conditions without significant industrial emissions, the most frequent PM fraction is the submicrometric one (PM1).The results pointed out the usefulness of monitoring four size segregated mass fractions and their relationship with the potential PM emission sources. Outdoor PM2.5 measurements provide key information for evaluating population exposure, planning of air quality and establishing of reliable measures that allow the lowering of PM emission.

Key words*:PM2.5, PM1, size segregated mass fractions, photometric measurement, DustTrak DRX 8533.*

INTRODUCTION

Recent years showed a constant increase of the interest of authorities and research entities in finding new monitoring and modeling solutions using multi-criteria approaches to mitigate the impact of air pollution on the health of city residents by limiting exposure using early warnings during air pollution episodes with high concentrations of pollutants (Brauer et al., 2012). The governmental programs concerning the air quality monitoring and the dissemination activities of the monitoring results require cooperation, compatibility and mutual interest to access a wider monitoring network, enabling a comprehensive analysis of the state of air quality at various spatial scales (Dunea, 2014; Iordache et al., 2015). The information collected from monitoring programs followed by its dissemination using reports regarding the state of environment supports the decision-making in society regarding the management strategies and their adaptation to the existing conditions resulted from the socio-economic pressures and impacts (Iordache and Dunea, 2015).

Particulate matter in the ambient air of urban areas is mainly occurring because of the emissions from anthropogenic sources (industrial sources, traffic, combustion of fossil fuels and biomass, domestic heating, etc.), and emissions from natural sources (dust transported by wind, marine aerosols, emissions of volatile organic compounds, biomass decay, etc.). Furthermore, most of the anthropogenic sources that are responsible for the presence of PM in ambient air are located in urban areas with high population densities (Iordache and Dunea, 2015).

The airborne PM is a complex heterogeneous mixture. The size and chemical composition of this mixture may change in time and space depending on emission sources, atmospheric conditions, topography and weather. Regarding their potential to affect human health, PM presents the highest risk from the air pollutants

because they penetrate the sensitive regions of the respiratory system and can lead to health problems and even premature deaths (WHO 2013; Olsen et al., 2014).

The following terminology is widely used to indicate the relative penetration of a particle in the respiratory system: inhalable particles - penetrate the bronchi; thoracic particles - enter directly into the bronchioles; and respirable particles - penetrate to the alveoli (gas exchange area) and therefore in the circulatory system. PM10 fraction is known as coarse particles (particle diameter - $\phi \leq 10$ μm), while PM2.5 represents the fine fraction ($\phi \leq 2.5$ μm) and PM0.1 is the ultrafine fraction ($\phi \leq 0.1$ μm). Respirable particles have a diameter lowerthan4 μm (PM4). Latest researches (AQEG, 2012; WHO, 2013; Liu et al., 2013; Iordache et al., 2015) have pointed out that fine particles are most responsible for adverse health effects in urban population.

EN 12341European standard is the reference method for PM10 allowing the use of three systems i.e., Wide Range Aerosols Classifier WRAC, high volume sampler HVS (flow of 68 m3 h-1), and low volume sampler LVS PM10 (2.3 m3 h-1) that is commonly used in United Kingdom (AQEG, 2012).

Each of these sampling devices has a PM10 inlet (impactor or cyclone) which is directly connected to a filter-substrate and a controlled flow regulator. After completion of the sampling period, PM10 particulate mass that was collected on the filter is determined gravimetrically. The filter must be weighed at a temperature of20 °C and a relative humidity of 50%.

In EU, the reference method for the measurement of PM2.5 is also a manual gravimetric method for estimation of daily concentrations and is described in EN 14907. On 21 May 2014, a revised standard for measuring PM10 and PM2.5, namely EN 12341: 2014 was provided describing the procedures regarding the use of sequential samplers with automated filter changer.

PM2.5 reference methods are not able to provide real-time data. EU regulations allow the use of equivalent methods where equivalence is defined in the guide for proving the equivalence methods (CEN/TS 16450: 2013). It establishes a procedure for quantifying the correspondence between the reference and equivalent methods through a series of parallel measurements resulted on field. The objective is that the equivalent instruments provide daily data with a measurement uncertainty less than that required by the Directive on ambient air quality i.e., ± 25% with a confidence level of 95% at concentrations close to the limit.

In present, the main measurement instruments for continuous monitoring of PM are TEOM, BAM (beta attenuation monitor), and optical analyzers (e.g., nephelometric analyzers fitted in automated air quality stations).

The ability of a new instrument to measure correct values of PM concentrations must be evaluated by comparing the 24-hour averaged values with the 24-hour results of a reference sampler (e.g., European Leckel SEQ 47/50). The reference method is a gravimetric one based on 24-hour sampling on filter. The results from this comparison will be used to establish a correction factor between the new instrument and the reference method. The repeatability of measurements will be evaluated by inter-comparing the measurement results. The ability to measure short-term values, e.g. 1, 5 or 60-minute averages must be evaluated by comparing the instrument results with the results of other calibrated online analyzers, e.g. TEOM, Eberline monitor etc.

In this context, the paper presents the practical efficiency of the outdoor monitoring of PM size fractions using a new optical equipment i.e. DustTrak DRX 8533 with environmental enclosure and heating module. The experiments were carried out in Targoviste city, Romania, between 2014 and 2015, within the first two phases of the ROkidAIR project (http://www.rokidair.ro) to perform a screening of the PM concentrations existing in these urban areas and to calibrate the prototype of the PM2.5 microstation developed within the project.

MATERIALS AND METHODS

Optical monitoring system for measuring PM fractions-TSI DustTrak™ DRX 8533 Monitor

The DustTrak 8533 monitor is an optical instrument that simultaneously measures in real time the size segregated mass fraction

concentrations i.e. PM1, PM2.5, PM4, PM10, and TPM over 0.001–150 mg/m3asconcentration range. The method combines a photometric measurement to assess the mass concentration range and a single particle detection measurement to allow the sizing of the sampled aerosol (TSI, 2016). Aerosol is directed into the sensing chamber in a continuous stream using a diaphragm pump. Part of the aerosol stream is split ahead of the sensing chamber and passed through a HEPA filter being injected back into the chamber around the inlet nozzle as sheath flow (TSI, 2016). The remaining sample flow passes through the inlet entering the sensing chamber. In this chamber, a sheet of laser light illuminates the sample. A laser diode forms the sheet of laser light. In the first step, the light emitted from the laser diode passes through a collimating lens and then through a cylindrical lens to create a thin sheet of light (TSI, 2016). A gold-coated spherical mirror captures a significant fraction of the light scattered by the particles and focuses it on to a photo detector (www.tsi.com).

Figure 1. TSI DustTrak DRX 8533 particulate matter (PM)monitor, which allows the simultaneous measuring of various PM fractions i.e. PM1/submicrometric, PM2.5/fine, Respirable/PM4, PM10/Thoracic, and Total PM (http://www.tsi.com)

The measurement performed by DustTrakDRX 8533 Aerosol Monitor with environmental enclosure to size segregated mass fraction has the size resolution of an OPC together with a much higher mass concentration range like a typical photometer (www.tsi.com).The particle mass is calculated and recorded in one of the four size segregated mass fractions i.e. PM1 – sub micrometric fraction, PM2.5 – fine fraction, PM4 – respirable fraction, PM10 – Thoracic fraction, and Total PM. The aerosol contaminants such as dust, smoke, fumes and mists can be monitored using this type of instrument.

The 8533 instrument uses a sampling compartment with one 37 mm filter that can be attached in line with the flow of the aerosol at the exit of the optical camera. This allows the gravimetric analysis without using an external pump and a special filter holder.

Technical specifications of the DustTrak DRX Monitor

- Measuring domain: 0.001 - 150 mg/m3
- fractions of PM: PM1, PM2.5, PM4, PM10 and total PM
- resolution: 0.001 mg/m3
- pump flow: 3.0 l/min
- accuracy of pump flow: ±5%
- operating temperature: 0 – 50°C.

Aspects considered during the field monitoring:

1. Monitoring was conducted as much as possible during the “rush” hours (7.00-13.00 a.m. and 3.00-7.00 p.m.).
2. The next monitoring campaign was conducted in a random sequence of points order.
3. If the time or weather parameters did not allow the measurements of all points in the same day, the screening analysis was conducted in two stages in two consecutive days: the western half points in the first day and the eastern half in the following day.
4. The monitoring campaigns were carried out with a measurement time per point for determining PM fractions of 60 minutes.
5. Two campaigns per month were performed for determining the PM levels.
6. The screening measurements were performed at least two days after a rainfall event.
7. After each measurement, the sampled PM disks that were collected were coded for identification (attaching a label with the point

number, location, time of sampling, the pump flow (start-stop) and the characteristics of the micro-climate (such as atmospheric pressure, air relative humidity, air temperature, wind speed and wind direction).
8. All the elements were noted in a specific field book adapted for the requirements of PM monitoring in urban environments.

Each monitoring campaign implied the PM measurements in ten sampling points that were disposed in a quasi-radial spatial arrangement in relation to the shape of the city (Figure 1). The instrument was placed out in the open on a tripod at a height of 1.50 m, away from obstructions that may disturb wind currents.

RESULTS AND DISCUSSIONS

The monitoring campaigns performed during 2013-2014 using another optical monitor i.e. Casella Microdust Pro, and in 2015 using both Casella and DustTrak instruments allowed the drawing of maps concerning the PM levels occurring in Targoviste city, Romania. The developing of the corresponding layers was performed in QGIS (www.qgis.org).

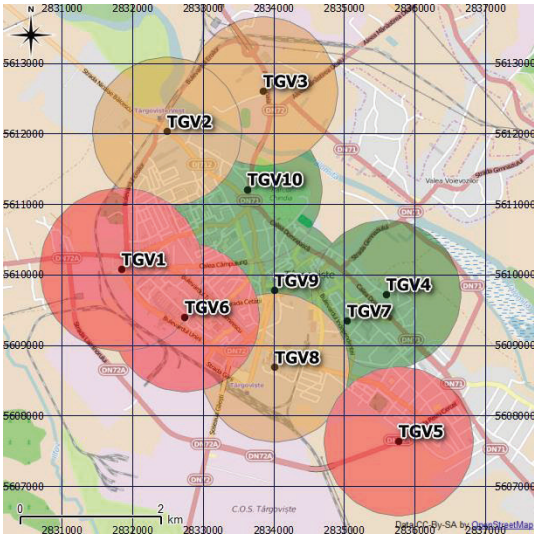


Figure 2.Potential PM2.5 levels in the city of Targoviste based on the measurements performed in 10 sampling points and modeling of emissions from stationary sources using AERMOD dispersion model (red circles – annual high concentrations 13-23 µg m-3; orange – moderate concentrations 7-9.5 µg m-3; green – low concentrations 4-6.5 µg m-3); circles have an area of representativity with a radius of 800 m (±25% of concentration); grid with UTM coordinates.

Figure 2 shows an example for the assessment of annual exposure in Targoviste urban areas by overlapping in situ PM data recorded in various campaigns performed between 2013 and 2015 together with the results of dispersion modeling of point sources existing in the area.
The main point sources in Targoviste city area are as follows: a metallurgical plant for special steels production and several metalworking facilities located in the south of the city; a company that produces rigs located in the middle of the town, most of the installations were dismantled and the buildings and chimneys were demolished; and a coal thermal plant, which stopped functioning in 2009 and some chemical point sources located in the northwest of the city. The household heating has been insured by decentralized systems (mainly small gas boilers and wood stoves) because the firm that operated the centralized cogeneration system went bankrupt. Most of the major industrial point sources that had significant PM emissions in the past are not functioning in the present or were dismantled or demolished because of the economic recession.
Consequently, the main sources of PM emissions remained the heavy traffic and the residential heating, together with some active industrial point sources. Because the residential

heating is based on numerous individual systems, the dispersion modeling of these sources is a difficult task. A reliable option is to develop a monitoring network using continuous monitors that will complement the existing official infrastructure (one UNITEC PM10 optical analyzer located in the EPA air quality station from Targoviste) for PM monitoring.

Table 1.Example of a DustTrak DRX 8533 monitoring file obtained during one hour in the "rush" time interval showing the size segregated mass fraction concentrationsi.e. PM1 – submicrometric fraction, PM2.5 – fine fraction, PM4 – respirable fraction, PM10 – Thoracic fraction, and Total PM (TGV6).

Instrument Name	DustTrak DRX
Model Number	8533EP
Test Start Time	1:24:42 PM
Test Length [D:H:M]	0:01:00
Test Interval [M:S]	0:01
PM1 Average [mg/m3]	0.017
PM1 Minimum [mg/m3]	0.007
PM1 Maximum [mg/m3]	0.148
PM1 TWA [mg/m3]	0.002
PM2.5 Average [mg/m3]	0.017
PM2.5 Minimum [mg/m3]	0.007
PM2.5 Maximum [mg/m3]	0.148
PM2.5 TWA [mg/m3]	0.002
PM4 Average [mg/m3]	0.017
PM4 Minimum [mg/m3]	0.007
PM4 Maximum [mg/m3]	0.148
PM4 TWA [mg/m3]	0.002
PM10 Average [mg/m3]	0.017
PM10 Minimum [mg/m3]	0.007
PM10 Maximum [mg/m3]	0.148
PM10 TWA [mg/m3]	0.002
TOTAL Average [mg/m3]	0.017
TOTAL Minimum [mg/m3]	0.007
TOTAL Maximum [mg/m3]	0.148
TOTAL TWA [mg/m3]	0.002
Photometric User Cal	1
Size Correction User Cal	1
Flow User Cal	0
Number of Samples	3600

In this context, the monitoring campaigns performed in Targoviste provided the screening of concentrations that established the most polluted areas, where it is most likely to locate a PM2.5 continuous monitoring instrument. Based on the results, and the multi-criteria correlation with the objectives of the ROkidAIR project, three monitoring locations were established for Targoviste city area i.e. TGV3, TGV6 and TGV8 points on the map (Figure 1). The PM2.5 fraction was selected to be monitored in Targoviste because:

- includes the nanoparticle fraction (PM0.1) that is difficult to be measured in outdoor conditions and was found to have the most negative health effects,
- has a recent revised standard and well-defined thresholds in correlation with the adverse health effects using the classification in index bands as recommended by USEPA 2012,
- the existing optical instruments and sensors performs adequate continuous measurements of this fraction.

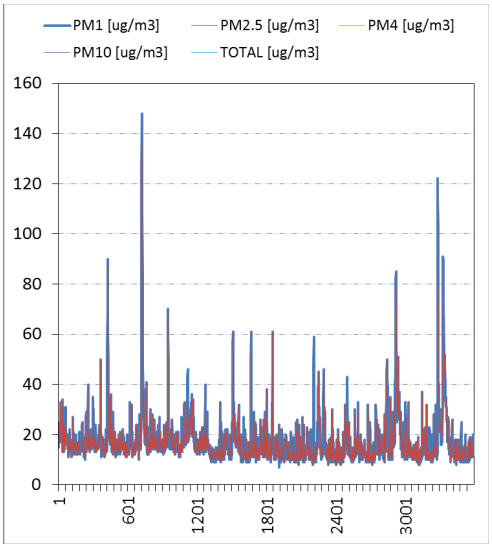


Figure 3.Time series of size segregated PM fractions recorded in TGV6 sampling point in Targoviste City (time scale in minutes)

The utilization of the DustTrak instrument showed that in heavy traffic conditions without significant industrial emissions, the most frequent PM fraction is PM1 (e.g. Figure 3).

Table 1 presents in detail the log file of a

monitoring event that was selected to show the influence of the diesel vehicle emissions in an urban area with heavy traffic during "rush hours". The results show that the submicrometric fraction was the only recorded fraction during the testing interval (1 hour). Furthermore, the system recorded significant variations of the PM concentrations, probably associated to the passing of a specific vehicle near the sampling location as well as to the wind currents (Figure 2). The recorded peaks have also importance in the early warnings of sensitive population, especially if a person is exposed to these high concentrations.

CONCLUSIONS

The air quality estimations are important to establish correlations with potential health effects and thus provide useful information about the unsafe environmental conditions in a certain urban area. This information is very valuable especially for sensitive population groups, such as asthmatics and children, who can act accordingly by avoiding certain areas or try to stay indoors during the critical hours of air pollution. The results pointed out the usefulness of monitoring four sizes segregated mass fractions and their relationship with the potential PM emission sources. Outdoor PM2.5 measurements provide key information for evaluating population exposure, planning of air quality and establishing of reliable measures that allow the lowering of PM emission.

ACKNOWLEDGEMENTS

The research leading to these results has received funding from European Economic Area Financial Mechanism 2009 - 2014 under the project ROKIDAIR "Towards a better protection of children against air pollution threats in the urban areas of Romania" contract no. 20SEE/30.06.2014.

REFERENCES

AQEG, 2012.Fine Particulate Matter (PM2.5) in the United Kingdom. Defra London.

Brauer M., Amann M., Burnett R.T., Cohen A., Dentener F., et al., 2012. Exposure assessment for estimation of the global burden of disease attributable to outdoor air pollution. Environ. Sci. Technol. 46, 652–660.

DuneaD., 2014.An exploratory analysis of PM10 particulate matter relationships with weather data and spatial variation, Proc.14th International Multidisciplinary Scientific GeoConference, SGEM2014, Book 4 ,Vol. 2, 273-280.

Dunea D., Iordache St., 2015.Time Series Analysis of Air Pollutants Recorded from Romanian EMEP Stations at Mountain Sites, Environ. Eng. Manag. J., 14 (11), 2725-2735.

Dunea D., Pohoata A., Iordache St., 2015. Using wavelet - feedforward neural networks to improve air pollution forecasting in urban environments, Environ.Monit.Ass., 187: 477, 1-16.

Iordache St., Dunea D., 2015.CurrentTrends of Major Air Pollutants in an Urban-Industrial Area from Ploiesti City, Proc.15th International Multidisciplinary Scientific GeoConference, SGEM2015, Book4, 913-920. doi: 10.5593/SGEM2015/B41/S19.118

Iordache St., Dunea D., Lungu E., Predescu L., Dumitru D., Ianache C., Ianache R., 2015. A cyber infrastructure for air quality monitoring and early warnings to protect children with respiratory disorders – Proceedings of 20th International Conference on Control Systems and Computer Science, 789 - 796, doi: 10.1109/CSCS.2015.39

IordacheSt., DuneaD., 2013.Cross-spectrum analysis applied to air pollution time series from several urban areas of Romania, Environ. Eng. Manag. J. 12 (4), 677-684.

Liu H.Y., Skjetne E., Kobernus M., 2013. Mobile phone tracking: in support of modelling traffic-related air pollution contribution to individual exposure and its implications for public health impact assessment. Environ. Health 12:93, doi:10.1186/1476-069X-12-93

Olsen Y., Karottki D.G., Jensen D.M., Bekö G., Kjeldsen B.U., Clausen G., et al., 2014. Vascular and lung function related to ultrafine and fine particles exposure assessed by personal and indoor monitoring: a cross-sectional study. Environ. Health 13(1), 112.

OpreaM., IanacheC., MihalacheS.F., DragomirE.G., DuneaD., IordacheSt., SavuT., 2015. On the development of an intelligent system for particulate matter air pollution monitoring, analysis and forecasting in urban regions. In: Proc. 19th International Conference on System Theory, Control and Computing (ICSTCC), 711 - 716, doi: 10.1109/ICSTCC.2015.7321377

TSI, 2016.http://www.tsi.com/dusttrak-drx-aerosol-monitor-8533/

WHO Regional Office for Europe, 2013. Review of evidence on health aspects of air pollution – REVIHAAP Project Technical Report, on http://www.euro.who.int/_data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf?ua=1.

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

STUDY ON CHEMICAL ANALYSIS OF SOIL IN THE COUNTY OF GORJ, IN TERMS OF THE CONTENT OF HEAVY METALS AND CHLORIDES

Roxana-Gabriela POPA, Irina-Ramona PECINGINA

Constantin Brancusi University of Targu Jiu, Eroilor Street No.30, Targu Jiu, Gorj, Romania

Corresponding author email: roxanna_popa@yahoo.com

Abstract

The soil is the most complex environmental factor, but also the most important in ensuring existential and material support evolving generations of plants, animals and humans, succeeding in time. Gorj county shows the variability of the natural and thus a highly diversified soil cover. The main sources of soil pollution in the Gorj county are mining, energy and oil industry, sources that radically alter the physical indicators of soil quality and pollute with significant quantities of dust, oxides acids, polycyclic aromatic hydrocarbons, chlorides and heavy metals. To highlight the chemical pollution of the soil, samples were collected from representative areas of Gorj county and they were analysed in terms of heavy metals content, by atomic absorption spectrometry. Also, it was made a correlation between pH and chloride content which aimed soil characterization in terms of salinity. Concentrations obtained were compared with normal values and alert thresholds. Study demonstrates that they were recorded exceeding the normal values for heavy metals analysed in some areas of the county, without exceeding the alert thresholds. The pH indicated neutrality soils and in terms of salinity, these are weak saline or moderately saline. In Gorj county it is necessary to apply a strategy to increase the capitalization of potential soil.

Key words*: soil, pollution, heavy metals, chlorides.*

INTRODUCTION

Last year were celebrated 43 years from the famous United Nations Conference in Stockholm on the Human Environment**,** having met in 1972 and considered the historic moment of the general consciousness awakening, by launching the alarm signal „we have a single Earth and have to preserve it” *(Hera, 2014).*

The researches show that from the global share of the land, which is 29%, only 6.4% represents suitable soil for farming and: *the global food production of any kind is about 4.6 billion tones and 2.3 billion tons of edible dried matter; of this total, 98% is produced in earth and less of 2% is from the oceans and from freshwaters; the vegetable products represent 92%of human diet; about 30 of cultivated species provide the majority of the calories and proteins in the world, 8 cereal species providing 69% of food sources; the animal products concur with 8% at the humanity diet, but these are circumlocutory from plants, too (Toncea et al.)*

In this respect, it is widely appreciated the fact that, of the essential resources of life on Earth, the soil disputes the supremacy with the water resources, air and biodiversity, with which cooperates, ensuring the evolving and existential material support for the plant, animal and human generations, to succeed in time. The soil is formed through a slow process of natural transformations, which lead for a millennium at the forming of a 3 cm layer, for 20 cm tilth (the minimum layer necessary to develop a plant) being required up to 7000 years.

The landscape non-uniformity of the Gorj County created a very diversified soil cover, in the county being identified 9 classes of soil, which include 15 types of soil (www.recolta.eu) (Figure 1).

The soil types in the Gorj County and the occupied surfaces are shown in Table 1.

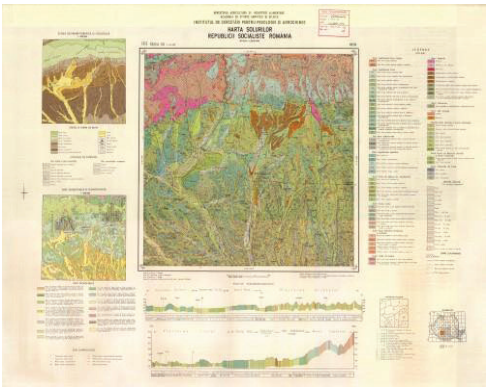


Figure 1. Gorj county soil map

Table 1.Soil distribution by type of use

Soil category	Surface (ha)
Arable land	98 239
Pastures	87 212
Meadow	41 685
Vine	4 191
Orchards	7 473
Total agricultural land	238 800

In Gorj county, the soil environmental factor is mainly wasted because of natural polluting sources, but of anthropic sources, too. Among these, the most important are:
- the mining indutry, which is based on glory-hole of the lignite in the mining fields of Rovinari, Jilt, Rosia, Motru and has an effect upon 13000ha, resulting huge surfaces of technogene soils, deprived them of basic property, the fertility;
- the power industry, is based on obtaining of electricity in two big thermo electrical power plants Rovinari and Turceni, and pollute the soil with SOx, NOx, COx, heavy metals and important quantities of ash and breeze, having an effect upon 250 soil ha;
- the petroleum industry, which has a chemical effect upon about 1000 ha from Ticleni, Stoina area, by polluting with multi-ring hydrocarbons, hydrochlorides and salt water;
- stock raising industry, which pollutes the soil with livestock wastes and residues, due to the hennery activities (in the society SC AVI INSTANT SRL, Farm no. 2 and 3 from Danesti township, Farm no. 4 from Preajba village), the growth and the operation of the laying hens (in SC ASSANI IMPEX SRL, Branesti township), the growth and the operation of the pigs (in the societies SC SUNIPROD SA and SC FARMASN from Bumbesti-Jiu and Tg-Jiu Penitentiary), the growth and the operation of dairy cows (pilot rehabilitation center for disabled persons from Tg-Carbunesti, Tg-Jiu Penitentiary, SC FERMA MORAGIB SRL from Scoarta township);
- agriculture, by polluting the soils of Balesti area with nitrates due to uncontrolled and excessive use of nitrous chemical fertilizers and pesticides, highlighted by a permanent increase of the herbicide quantities used per hectar;
- the clearings, contribute to the occurence of erosion phenomena (166.099 ha) and to the landslides in furrows, in waves, in steps, with mounds, flowings or crashes (48.406 ha)
In the whole Gorj county, it predominates the acid soils, the nitrogen supply is weak, and the moving phosphorus is very weak.

MATERIALS AND METHODS

To analyse the soil quality in Gorj County, there were collected soil samples from representative areas of the county, potentially polluted with heavy metals and chlorides. The collection was performed using the pedologic probe, in depth levels of 0-10 cm and 10-20 cm (Popa et al., 2011). The collection points are the following:
- Targu Carbunesti (town entrance);
- Scoarta (crossroads);
- Dragoieni (across the Agrochemical and Soil Survey Register);
- TarguJiu (city beltway, Margaritarului street, Meteor street – Meteo Station);
- Rovinari (Vart – 2000 m N of thermo electrical power plant, Rogojelu II – 300 m V of thermo electrical power plant, convey belt area – 1000 m SV of thermo electrical power plant, drilling neighborhood – 1500 m S of thermo electrical power plant, bridge Moi – 800 m SE of thermo electrical power plant);
-Rovinari – from the Cicani-Beterega ash deposit (5m N1 slope of the deposit, 5m N2 slope of the deposit, 5m V1 slope of the deposit, 5m V2 slope of the deposit);
- Motru (from the neighborhood of the Rosiuta deposit, from Rosiuta – Osnaga family, from 200 m V and 400 m S of the U.A.T.A.A.);
-Ticleni (from the injection station, Turbo A area, Park no. 14 and the Big Park);

-Turceni (from 200 m V of the thermo electrical power plant – to the right by the bridge , 800 m V of the thermo electrical power plant – way to Ionesti, 500 m E of the thermo electrical power plant – by PECO, 700 m S of the thermo electrical power plant – after Cursaru, to the right);
- Coltesti – Hurezani (gauge board Hurezani, affected area, Madalan Ana family, Vadulescu family).
The soil samples were transported in the laboratory and were analysed for heavy metal content: Cu, Pb, Zn, Cd and As, using the atomic absorption spectrometry, in flame variant method (Stoica et al., 1986).
The obtained concentrations were compared to the normal values and to the threshold of alert, for each heavy metal, in accordance with the law (Order 756/97) (Table 2).

Table 2. Normal value and thresholds for heavy metals indicators

Chemical indicator of quality - heavy metal	Normal value (VN) [mg/kg dry substance]	Thresholds (PA) [mg/kg dry substance]
Cu	20	100
Pb	20	50
Zn	100	300
Cd	1	3
As	5	25

The samples pH was analysed using the automatic pH-meter and the degree of salinity, for all sampling points and the depth levels in which there have been analysed the heavy metals (Popa et al., 2011).
The chlorides were determined using the volumetric method, after Mohr.

RESULTS AND DISCUSSIONS

After analysis and comparison of the obtained concentrations with the normal values and with the alert threshold, the followings were resulted:
- there were recorded overruns of VN, without overrunning PA, for the Cu, Pb, Zn, Cd indicators in the following sample points:
- the Cu indicator in Targu Carbunesti area (at the entrance in town, on both depth levels), Scoarta area (in the crossroad, on both depth levels), in Targu Jiu area (at beltway level -2m and 10 m distance of DN67, in the Margaritarului street and Meteor street - Meteo Station, on both depth levels);
- the Pb indicator in Dragoieni area (across OSPA, at 5 m distance of DN67, on both depth levels), in TgJiu area (in Margaritarului street and Meteor street - Meteo Station, on both depth levels);
- the Zn indicator in Targu Jiu area (at the city beltway, at 2 m distance of DN67, on the depth of 10-20 cm, but, also, at the depth of 10 m of DN67, at both depth levels);
- the Cd indicator (in Targu Jiu area, at the city beltway level, at 10 m distance of DN67, at depth of 0-10 cm, in Rovinari area);
- theAs indicator (in Rovinari area);
- the threshold of alert was overran only for the Pb indicator, in Targu Jiu area, Margaritarului street.
Concentrations of heavy metals determined in soil samples harvested from representative contaminated areas on two levels deep 0-10 cm and 10-20 cm, are shown in tabular: chemical analysis of heavy metals in soil samples from the area Targu Carbunesti, Scoarta, Dragoieni and Targu Jiu (Table 3), Rovinari and deposit Cicani Beterega - Rovinari (Table 4), Motru and Ticleni (Table 5), Turceni and Coltesti Hurezani (Table 6).

Table 3. Chemical analysis of heavy metals in soil samples from the area Targu Carbunesti, Scoarta, Dragoieni, Targu Jiu

Area	Sampling point	Profile depth (cm)	Quality indicator (heavy metal) [mg/kg dry substance]			
			Cu	Pb	Zn	Cd
Târgu Cărbunești	imput city	0-10	**67.5**	11	44.2	0
		10-20	**78.1**	6	42.8	0.6
Scoarta	intersection	0-10	**74.6**	10	46.8	0.2
		10-20	**63.9**	6	60	0
Drăgoieni	5m distance DN67, opposite Office of Soil Survey and Agrochemicals	0-10	15,2	**26,6**	88,2	0,8
		10-20	13	**41,2**	76,8	0,4
	10m distance DN67, opposite Office of Soil Survey and Agrochemicals	0-10	13,6	3,8	59,6	0,6
		10-20	14,2	3,0	77	0,2
Târgu Jiu	Belt city, 2m distance DN67	0-10	**63,9**	9	69,4	0,2
		10-20	**67,5**	1	**178**	1
	Belt city, 10m distance DN67	0-10	**74,6**	15	**106**	**1,4**
		10-20	**71**	16,4	**101**	0,8
	Street Mărgăritarului	0-10	**72.6**	**64.0**	38.2	0.6
		10-20	**54.6**	**38.0**	40.0	0.4
	Street Meteor, Meteorological station	0-10	**21.6**	**22.0**	98.2	0.2
		10-20	**26.4**	**20.4**	82.2	0.2

Table 4. Chemical analysis of heavy metals in soil samples from the area Rovinari

Area	Sampling point	Profile depth (cm)	Quality indicator (heavy metal) [mg/kg dry substance]				
			Cu	Pb	Zn	Cd	As
Rovinari	Vârt, 2000m N thermoelectric plant	0-10	**20.2**	5.49	60.6	0.4	1.42
		10-20	**21.4**	3.67	72.8	0.2	2.97
	Rogojelu II, 300 m V thermoelectric plant	0-10	**33.8**	4.11	**133.0**	1	**8.31**
		10-20	**36**	11.7	**105.0**	1	**9**
	The conveyors,1000m SV thermoelectric plant	0-10	**40.4**	2.47	**124.6**	**1.6**	**10.85**
		10-20	**36.2**	5.26	**116.2**	1	**10.32**
	Drilling neighborhood, 1500m S thermoelectric plant	0-10	**28.4**	0	60.6	**1.6**	0.59
		10-20	**22**	0	57.6	**1.4**	0.6
	Moi bridge, 800m SE thermoelectric plant	0-10	12.4	0.87	44.4	**1.8**	2.62
		10-20	12.6	0	39.8	**1.6**	0.63
Cicani-Beterega deposit, Rovinari	5m N1 slope deposit	0-10	21.6	8.2	43.6	0	3.45
		10-20	**27.8**	1.2	49.2	0	4.98
	5m N2 slope deposit	0-10	**37.4**	4.2	36.4	0.4	4.4
		10-20	**31.2**	0.0	37.0	0	4.2
	5m V1 slope deposit	0-10	19.8	1.2	40.6	0	2.93
		10-20	10.8	3.8	31.8	0.4	**6.23**
	5m V2 slope deposit	0-10	**24.6**	0.0	57.6	1	**5.35**
		10-20	**20.6**	0.0	52.0	1	**6.67**

Table 5. Chemical analysis of heavy metals in soil samples from the area Motru and Ticleni

Area	Sampling point	Profile depth (cm)	Quality indicator (heavy metal) [mg/kg dry substance]			
			Cu	Pb	Zn	Cd
Motru	warehouse neighborhood Rosiuta	0-10	**39.6**	13.4	58.2	0.2
		10-20	**34.8**	8.4	64.0	0.2
	Rosiuta family Osnaga	0-10	**24.2**	5.6	74.8	0
		10-20	**21.6**	7.4	69.6	0
	200 m V U.A.T.A.A.	0-10	**30.4**	12.2	57.6	0
		10-20	**20.8**	9.8	60.4	0
	400 m S U.A.T.A.A., warehouse neighborhood Rosiuta	0-10	**24.8**	6.4	55.8	0
		10-20	**34.4**	11.8	62.8	0
Ticleni	Department injection	0-10	13.8	0.0	33.2	0
		10-20	10.2	0.0	23.8	0
	AreaTurbo A	0-10	**20.8**	1.2	59.2	1
		10-20	18.8	0.8	47.6	0.8
	Park number 14	0-10	11.2	0.0	49.2	1
		10-20	16.6	0.0	59.0	1.4
	Large Park	0-10	13.2	2.8	41.2	0.8
		10-20	14.8	0.0	42.2	0.4

Table 6. Chemical analysis of heavy metals in soil samples from the area Motru and Ticleni

Area	Sampling point	Profile depth (cm)	Quality indicator (heavy metal) [mg/kg dry substance]				
			Cu	Pb	Zn	Cd	As
Turceni	200m N thermoelectric plant, right near bridge	0-10	**24.2**	19.4	99.6	0.27	2.72
		10-20	**27.4**	**21.4**	**107.2**	0.3	3.49
	800m V thermoelectric plant, road to Ionesti	0-10	15.4	13.4	60.6	0.07	2.91
		10-20	16.8	16.6	67.2	0.07	3.04
	500m E thermoelectric plant, near PECO	0-10	15.4	15.4	57.2	0.01	1.12
		10-20	20.0	16.6	74.4	0.09	1.71
	700m S thermoelectric plant, after Cursani, in the right	0-10	16.4	18.4	53.0	0.04	2.24
		10-20	19.6	19.8	71.4	0.05	1.97
Coltesti-Hurezani	Panel measure Hurezani	0-10	19.6	0.8	47.2	0.2	0.54
		10-20	19.8	3.8	44.4	0.2	1.79
	Affected area	0-10	8.2	2.2	15.4	0	0.55
		10-20	**25.0**	1.4	47.0	0	0.5
	Family Manolache	0-10	**21.0**	0.4	84.8	0.2	0.72
		10-20	**29.8**	0.0	**112.8**	0.4	0.78
	Family Trocan	0-10	**22.2**	0.2	71.0	0	0.69
		10-20	**26.6**	0.2	88.0	0.2	0.74

For all the soil samples collected at the Gorj county level, pH indicates soils with neutral character and achieving a correlation pH and chlorides (in mg Cl/100 g soil) it demonstrated that in the Dragoieni, Targu Jiu, Rovinari, Turceni and Coltesti Hurezani areas, the soil is moderately salinated, in the Targu Carbunesti and Motru areas, the soil is weak salinated, and in the Scoarta area, the soil is desalted.

CONCLUSIONS

The soil disputes the supremacy with the water resources, air and biodiversity, with which cooperates, ensuring the evolving and existential material support for generations, which succeeding in time.

In Gorj County, the soil environmental factor is mainly wasted because of natural polluting sources, but of anthropic sources, too: the mining, power, petroleum industry, stock raising industry, agriculture.

To analyse the soil quality in Gorj County, there were collected soil samples from representative areas of the county, potentially polluted with heavy metals and chlorides, in depth levels of 0-10 cm and 10-20 cm.

They were analysed in terms of heavy metals content, by atomic absorption spectrometry. Also, it was made a correlation between pH and chloride content which aimed soil characterization in terms of salinity.

Concentrations obtained were compared with normal values and alert thresholds.

Study demonstrates that they were recorded exceeding the normal values for heavy metals analysed in some areas of the county, without exceeding the thresholds alert.

The pH indicated neutrality soils and in terms of salinity, these are weak saline or moderately saline.

REFERENCES

Hera C., 2014, Romania strategic resurses - the soil-essential features, Economistul, journal on line, no. 17

Popa R.G., Pecingina I. R., 2011, Soil quality assessment, Academica Brancusi Publishing House, Targu Jiu, 161-171

Stoica E., Rauta C., Florea N., 1986, Methods of chemical analysis of the soil, ICPA, 50-52

Toncea I., Simion E., Ionita Nitu G., Alexandrescu D., Toncea V. A., Instructions organic agriculture, www.agriculturadurabila.ro/manual

Order 756, 1997, Regulations on environmental pollution assessment - The soil

www.recolta.eu

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

CONSIDERATIONS ON THE WAYS OF DETERMINING THE MOVEMENT OF THE EARTH'S SURFACE DUE TO THE PHENOMENON OF SUBSIDENCE

Ioan VOINA[1], Maricel PALAMARIU[2], Iohan NEUNER[1]

[1]Technical University of Civil Engineering of Bucharest, 122-124 Lacul Tei Blvd, Postal code 020396, Bucharest, Romania
[2]1 Decembrie 1918 University of Alba Iulia, 11-13 N. Iorga Street, Postal code 510009, Alba-Iulia, Romania

Correspondent author email: nutu_rc@yahoo.com, mpalamariu@gmail.com

Abstract

The paper aims to present some theoretical and practical aspects related to the movement over time of the land surfaces affected by the groundwater exploitation of multi-layered deposits in the area.
The methods and techniques described are intended to facilitate a rigorous observation of the evolution of risk and hazard phenomena, presenting a complex summary of the way of obtaining specialized information, as efficiently and precisely as required by the Romanian legislation regulations.
Given that the phenomenon of subsidence keeps on being of a broad interest through its implications on urban planning, environmental protection and on the surface buildings, the issues described in this paper lead to short, medium and long-term forecasts regarding the subsidence due to the exploitation of multi-layered deposits. These forecasts are very important in the sustainable development of the areas affected by underground mining.

Key words**:** *movement, surveying, subsidence.*

INTRODUCTION

In the context of the current worldwide energy crisis, recent years have led to intense concerns for the discovery of new chemical and energetic elements, for deposits' improvement, for a closely management of reserves and not least for the increase of multi-layered deposits production capacity.
In the case of underground mines, the phenomenon of subsidence results in filling the void created by extracting the ore and its spread to the earth's surface, with repercussions over tens of meters on the affected the area.
Underground exploitation of multi-layered deposits in Jiu Valley mining basin frequently leads to the surface's displacement and deformation, as well as to the deterioration of industrial and civil objectives placed at mines surfaces.
In order to solve the issue of protecting the industrial and civil objectives placed at mines surfaces, certain measures are needed for the surface's protection against sinking. It is also necessary to monitor the earth surface's movement and deformation, as well as the tension of the building elements on the surface.
For observations on how the earth's surface displaces and distorts, as well as for observations on the surface targets, surveys are most frequently used.
Often, observations are confined to carrying out middle geometrical levelling paths over a network of tracking marks, and to measuring the distances between them.
Following the topographical measurements carried out, we can determine the values of movement parameters horizontal sinking and movement), and the deformation parameters (inclination, curvature, horizontal deformation).

Solving the problem makes it possible to anticipate the effects of underground mining on the surface, and it also allows taking appropriate measures for the protection of surface industrial and civilian targets (Ortelecan, 1997).

MATERIALS AND METHODS

Topographic methods used in determining the ground surface movement

The topographic methods used for surface movement tracking were the first to reveal the influence that underground mining has on the ground surface.

The topo-geodetic methods used to determine the occurrence of the phenomenon of subsidence, are the most often used due to their peculiarities in providing the absolute and relative sizes of the deformations observed.

Parameters are determined through direct and indirect measures, which are grouped into the following methods: geodetic, topographic, photogrammetric, laser scanning and interferometery.

The geodetic methods for determining the parameters of the land surface's displacement and deformation are run according to rigorous instructions, mandatory to be followed, established and approved by resort ministries (Ortelecan, 1997).

According to the existing guidelines, geodetic methods are classified into regional measurements carried out for the entire surface of the mining basin, and local measurements conducted over each mining perimeter.

Regional measurements are carried out regularly, through high-precision levelling measurements, using certain fixed points outside the mining zones of influence.

Local measurements consist in determining the coordinates (x, y and z) of fixed point's networks or of tracking alignments which lead to the movement parameters. Surveys are run by conducting observations in the tracking marks placed above the topographic mines.

Observations in the tracking marks may be made by topographic methods using specialized instruments such as: classical precision theodolite, precision level, total station, GPS technology and the new mixed system of the total station with integrated GPS system.

Figure 1. Smart Station integrated system

The mixed system of the total station with integrated GPS (Smart Station) is actually a dual frequency (L1 and L2) RTK GPS. Each frequency has 12 channels in direct connection with the total station. This revolutionary system of the last decade has a special feature in that it provides an absolute and/or relative positioning of the GPS points, inclusively through the RTK kinematic differential process. Total stations' possibilities, in turn, are remarkable both in individual determinations (angles and distances) and in determining the coordinates.

The photogrammetric methods provide further data necessary to clarify certain phenomena that cannot be captured by surveying. These methods assure a unique fidelity in determining the shape of the sinking riverbed, but they offer very little precision in determining the specific movement parameters.

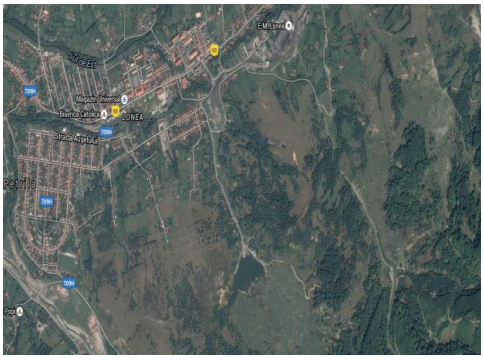


Figure 2. Ortophotomap – Lonea, Hunedoara County, Romania

The method of laser scanning is a method of geodetic technique through which a structure's geometry can be fully and automatically

measured without the aid of a reflective environment, with high precision and high speed. The measurement results are highlighted by a lot of points, which in literature is called points cloud.

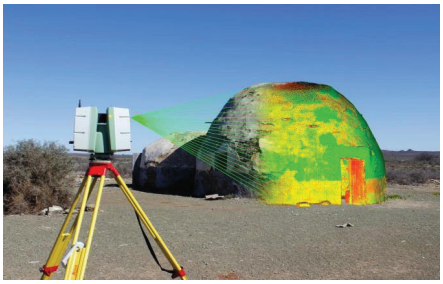


Figure 3. Terrestrial laser scanning system

The interferometry method is one of the most revolutionary methods used for satellite monitoring of earth movements and is made of a satellite equipped with a radar whose antenna is pointing toward the land area. Antenna's tilt is called the nadir angle.
The use of interferometry aims to detect and to measure the surface movements on a small scale. This method involves the generation of two interferograms from three images: a reference interferogram and the second one to capture the changes that took place at the ground surface (Palamariu et al., 2015).

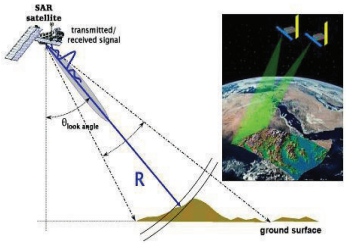


Figure 4. Data acquisition through DinSAR technology

Topographic determinations made within the tracking networks

The earth's surface movement is determined either by geodezic-topographic methods held in the influence area of exploitation works, either by analytic methods, applying methods known in the technical literature or coming from the interpretation of personal topographical measurements.
The surveying conducted for the tracking network can be grouped into: measurements for the support network, which takes the form of a micro-triangulation network or of a precise poligonometric network, placing thus the support network so that it frames the tracking station by stable and sufficient points; primary measurements consisting of framing the alignments' support parts within the triangulation network and of determining the parts' position before displacement on the surface; control measurements that are run near the working face, in the marginal area, in order to capture the moment when the surface movement occurs; current measurements, which are run periodically, at well-defined intervals depending on the three phases of the phenomenon of surface movement.
Systematic measurements for tracking the vertical and horizontal movements of the tracking marks are performed in the alignments of the tracking networks in order to determine the parameters of the surface movement.

Topographic methods for determining horizontal displacements

The methods used in determining the horizontal displacements of the tracking marks, following the land movement under the influence of groundwater exploitation, are the direct and the indirect methods.
Direct methods for determining the horizontal displacements of tracking marks consist of periodic measurements along the tracking alignments, at times established in accordance with the construction project.
Longitudinal horizontal displacements are determined after measuring the distances between points, while transversal movements are determined as the differences between points' deviations from the direction of the observation line.
When ground conditions do not allow direct measurements, indirect methods are used. Indirect measurements consist in defining the planimetric and the altimetric position of tracking marks, through methods such as: triangulation method, the method of

intersections or traversing, through which horizontal or vertical displacements are determined, based on the observations made.
One of the most commonly used methods is the direct method of alignments. This method requires a team made of an operator and two assistants.
Thus, the following accessories will be used: tensioners 1, ribbon or tape 2, sheets 3, dynamo-meter 4, and milestones 5.

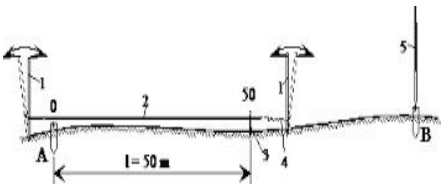


Figure 5. Direct measurement of lengths

Due to the fact that topographical plans trace only the distances in sight, all inclined distances measured directly on the ground, will be reduced to the horizon, depending on the alignment's slope angle (α) or the zenith angle (z).

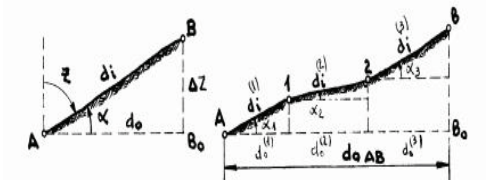


Figure 6. Reducing distances to the horizon

Another method for determining the horizontal displacements is the observation of parallaxes angles.
This method involves the creation of an alignment as close to the line joining the points of the elements under observation.
Thus, as points of the alignments support network, there is point S1 and point S2, which serve as fixed reference points for the equipment used. Metal bushings are embedded within the points under observation. During measurements, inside the bushings there will be installed stable trademarks or simple metal parts, to be targeted for determining the horizontal angles.
Determining the horizontal angles corresponding to a deviation of the observed points (1, 2...n) is preferable to be run with a highly accurate theodolite. The theodolite must be placed in point S1, from where φ_i angles are measured towards the alignment S1 -S2, and analogously, from station S2, ψ_i angles are measured against the same alignment. Thus, the angle measurements are being performed on both faces of the theodolite's telescope (Neamtu et al., 1988).

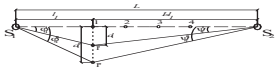


Figure 7. Alignment method - parallactic angle measurement

The distances between points S1 and S2 of the support network towards the observed points are determined by direct or optical measurement. The horizontal angle measurements of the observed points, made in the two positions of the theodolite's telescope, lead to a series of comments and an observation cycle may comprise between 3 and 5 series of observations. Each series implies the calculation of the φ_i, respectively ψ_i averages measured for each item under observation (Neamtu et al., 1988).

Topographic methods for determining vertical displacements

Topo-geodetic methods are in many cases the only methods suitable for determining the absolute deformations and displacements. In other cases they serve as means of controlling the sizes of deformations and displacements strains defined by other unconventional methods.
The principle of measuring the vertical displacements and strains is to repeatedly determine the quantities measured within the tracking marks.
As long as topo-geodetic measurements only allow an analysis based on the vertical displacements' character and sizes, they need to be linked to the observation and study of the underground system, to the rock mechanics, in order to discover the origin of these displacements and to indicate the possibilities of eliminating them.

The errors resulting from surveying the vertical displacements are of particular importance in the calculation of derived quantities such as inclination and curvature (Ortelecan, 1997).
Vertical displacements for scientific purposes are determined with high-precision level meters that provide a measurement error of m0 =±0.5 mm/km.
The error of determining the values of tracking marks depends on the topographic tracking network, on the length of each line and the distance between mobile landmarks.
In order to determine the vertical displacements at least two instruments are needed: a precision topographic level and an invar rod. The topographic level is an optical instrument equipped with a telescope that can rotate only horizontally. Through the telescope we can read the height on the rod, located on the point for which we want to determine the altitude.

Figure 8. Topographic level and rod

Further, we shall present two of the methods mostly used to determine the vertical displacements: geometric leveling method and trigonometric leveling method.
In the first instance (middle geometric leveling), the station is built with the level in the middle of the alignment between points 1 and 3.
The difference in level between the two points, 1 and 3, will be equal to the difference between the value registered on the rod in point 1 and the value indicated on the rod in point 3.
Trigonometric leveling is based on the fact that, knowing the altitude of the station point and the land's inclination, one can determine the vertical movement and then the altitude of the point where the rod is placed.

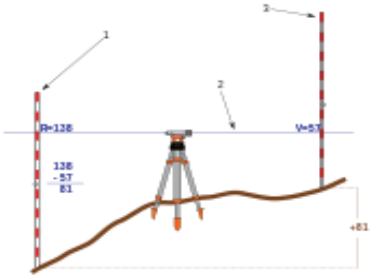


Figure 9. Middle geometric levelling
(https://ro.wikipedia.org/wiki/Nivelment)

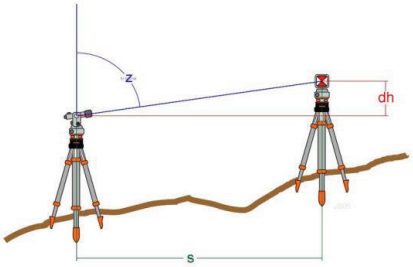


Figure 10. Trigonometric levelling
(https://ro.wikipedia.org/wiki/Nivelment)

Between the point where the precision theodolite is set and the point of reading, there is a right-angle. We know the angle's length S and the angle of fall α.
The difference in level between the two points is given by:
dh = s *tg α, where α = 100g-z

CONCLUSIONS

The topographic methods used to study the surface displacements and strains require a surveillance station consisting of transversal and directional alignments towards the deposit direction or of alignments networks.
Tracking networks fairly determine the surface movement, but require a large number of parts and a considerable amount of observations.
Direct topographic methods consist of measuring the absolute movements of the marks which ultimately reduce to the direct measurement of the distances between the measuring marks and to determining their heights through geometric leveling from the middle.

Since direct topographic methods provide high accuracy in determining the parameters of surface displacement and deformation, they are most often used in practice.

Indirect topographic methods consist in determining the marks' coordinates (x, y, z), which help defining the surface displacements and deformations by applying analytical relations.

Indirect methods have experienced a poor development due to the difficulties of placing the support network and due to the lack of the working parts' visibility.

The absolute and differential surface movements for specific given conditions are determined through topographic methods, without taking account of the rocks' physico-mechanical properties. Also, these methods do not clarify the movement of the whole package of rocks from the mining to the surface layer. However, topographic methods are still the most used methods for assessing the parameters of movement and deformation of transitional or final sinking river beds.

Topographic methods also give the possibility to verify the hypotheses and theories established on the partition functions and on the abstract models for specific geo-mining conditions.

REFERENCES

Akimov. D.G.,Sdvijenie gornîh parod pri padzemnoi razrabotke ugolnîh slontevin Mestorojdenie, Ugletehizdat, Moscov, U.R.S.S., 1970.

Betournay M.C., Underground Mining and Its Surface Effect, Interstate Technical Group on Abandoned Underground Mines, Fourth Biennial Abandoned Underground Mine Workshop, Davenport, Iowa, 2002

Marian D.P., Urmarirea topografica si analiza deformarii suprafetei terenului afectat de exploatarea subterana, Universitas Publishing House, Petrosani, Romania, 2012.

Neamtu M., Onose D., Neuner I., Masurarea topografica a deplasarilor si deformatiilor constructiilor, Institute of Civil Engineering in Bucharest, Romania, 1988.

Ortelecan M., Studiul deplasarii suprafetei sub influenta exploatarii subterane a zacamintelor din Valea Jiului, Teza de doctorat, University of Petrosani, Petrosani, Romania, 1997.

Palamariu M., Popa A., Urmarirea comportarii terenurilor si constructiilor, Didactica Series, "1 Decembrie 1918" University of Alba Iulia, Alba Iulia, Romania, 2008.

Palamariu M., Voina I., Modern Means and Techniques for the Research upon the Analyse of the Subsidence Phenomenon, GeoPrevi 2015 Symposium, Faculty of Geodesy in Bucharest, Bucharest, Romania, 2015.

Singh M.M, Experience With Subsidence Due to Mining, Proceedings international Conference on Evaluation and Prediction of Subsidence, ASCE, New York., U.S.A., 1978.

Shi J., Song W., Zhang J., The application of modern surveying technology in mining survey, Journal of Coal Science & Engineering, Vol. 14, China, 2008.

https://ro.wikipedia.org/wiki/Nivelment

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

DATABASE SEARCH IN A GIS APPLICATION INTENDED FOR MAPPING THE USE CATEGORIES AND ANTI-EROSION SYSTEMS IN ANTOHESTI WATER CATCHMENT AREA, BACAU COUNTY

Gabriela BIALI, Paula COJOCARU

"Gheorghe Asachi" Technical University of Iasi, Faculty of Hydrotechnics, Geodesy and Environmental Engineering, 63-65 Blvd D. Mangeron, 700050, Iasi, Romania

Corresponding author email: gbiali@yahoo.com

Abstract

There is no news that the use of GIS technique in the engineering field takes place at high level, and has a very well defined place in environment engineering.
This paper shows a sequence of a GIS application in the field of quantification of soil loss as a result of water erosion. The GIS application is exemplified in a water catchment of approximately 4000 ha in Berheci Superior of Bacau County, with intensive water erosion processes, both at the surface and in gullies.
After the development of databases (graphic and alphanumerical), the determination of connections (keys) between them is very important, in order to enable interrogation. Interrogation ensures the value of GIS application, and in this application we can notice 2 interrogation methods. The development method of the interrogations, as well as the response manner in the own designed concept, with a relational alphanumerical database are shown.
This paper shows the importance of correlated databases in the context of statistical analyses for large areas. Following these analyses and by means of the GIS, the most intelligent ecologic and anti-erosional management solutions can be taken in torrential hydrographic water catchments.

Key words*: database, interrogation, erosion, GIS, agricultural management.*

INTRODUCTION

The use of Geographic Information Systems technique for the management of certain parameters on the environment became a current usual fact. These techniques are widely used both for the studies conducted on small areas (of few hectares) as well as for impact studies at regional or even national level.
The region monitoring and management operations imply a significant volume of data and processing and analysis means. In this context, the determination of the quality of soil and in particular of those impaired by erosional degradation becomes extremely important both for the agricultural owners and for the decision makers in agricultural management area.
If we refer to the determination of the erosional risk, particularly for large areas, this implies the thorough knowledge of all factors that intervene in the performance of the degradation process, namely the parameters which characterize the climate, landscape, soil, use of lands, agricultural operating technologies etc. However, considering that all these parameters have a spatial distribution, namely receive a certain value at each point in space, the complex monitoring action can only take place within a Geographic Information System
The implementation of these techniques also enables an integrated ecological monitoring, through which the competent bodies can permanently monitor the status of natural resources, generally of the environment factors and anthropic impact, based on the spatial and temporal parameters and coverage indicators, which ensure the information framework required for the strategy and tactics on the prevention of consequences of environment and human activity factors, for the development of forecasts and for the exercise of the operative control on the actions concerning the recovery (improvement) of the ecological status.
In the activity of fight against soil erosion, the purpose of a GIS consists of ensuring the data acquisition, storage and processing. But the most important part is that of providing information (results) which can synthetically characterize, at all times, the status and progress of the degradation process of lands as

a result of torrentiality, drainage and sedimentation, in order to take decisions in due time (Statescu Fl., Zauca D.C., Pavel V.L., 2013).

The use of GIS is required and justified in particular as a result of the provided opportunities related to the review of the multitude of spatial distribution factors which intervene in the triggering and performance of the erosional processes, high costs and long time required for the monitoring thereof through other methods, in particular with respect to large areas.

One of the main components of a Geographic Information System is the database which consists of a graphic database (layouts or georeferenced maps in a projection system) related to an alphanumeric or attribute-type (non-graphic) database (Renard K.G., Foster G.R., 1996).

MATERIALS AND METHODS

Study area

This paper sets out a study, performed through GIS techniques, concerning the evolution of land degradation process through erosion in the reception basin of Antohesti water catchment area, of Berheci river higher water catchment area, Bacău County (Figure 1).

The reception area is of 3963 ha, with a highly fragmented relief, hilly type and average slopes of more than 15 %. The slopes are affected by surface erosion, deep and. The sloping land was affected by sheet erosion, gully erosion and by active landslides.

Dominant soils are chernozems and brown soils, and the most extended uses are: arable land – 47.2%, pasture land – 26.78% and forest - 16.8%, (Biali and Popovici, 2003).

Data and methodology

In order to determine the soil loss following the surface erosion we used the Universal Soil Loss Equation (USLE) in the form used in Romania – ROMSEM (Moţoc M., Tuhai A., 1998.) and which includes the parameters of spatial distribution concerning: the pluvial erosivity (K), the soil erosivity (S), the gradients and length of discharge on versants (i, L), the purposes of the land (C) and the existing anti-erosion arrangements (Cs).

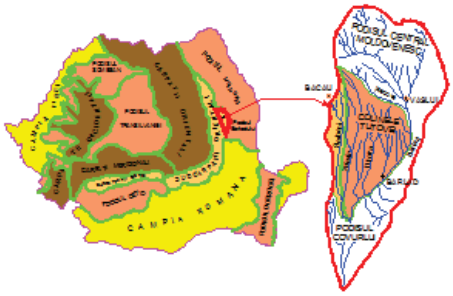


Figure 1. Location of research (Berheci catchment)

In order to develop the geo referenced database and an attribute-type database, respectively, required for the storage and processing according to the algorithm of the above mentioned equation, the raster procedure was used, which consisted of the overlap of the cartographic documentation (site plans 1:25.000) of a rectangular grid with the cell / pixel size of 25 x 25 m. The USLE equation was successively applied within GIS project, in order to determine the potential soil loss (potential risk) and the actual soil loss (actual risk) corresponding to each cell.

The GEO-GRAPH Geographic Information System, a GIS - type software, developed by Suceava IT Service Company was used in this application for the implementation of techniques of the Geographic Information Systems.

The GEO – GRAPH system is distinguished as an open system through the structure of the ASCII format input data. This structure enables the access to the drawing information located outside the system, thus facilitating the data integration with other systems or with files generated by the user by means of own software. The user is able to generate own software which will generate input data recognized by the GEO – GRAPH system, such as: data taken over from the total stations as files of coordinates and outline or data from files such as *.dxf* type, generated following vectorization (Biali Gabriela, Cojocaru Paula, 2015).

The GEO – GRAPH Geographic Information System contains the following primary modules:

- CAD module for the representation of vectorial drawings and raster images.

- The alphanumeric data interrogation module with spatial graphic localization.
- The import / export module of vectorial drawings.
- The module for generation of symbols and representation of cartographic elements on digital plans.
- The module of "drivers" for the connection with input / output peripherals.
- The module of background raster image vectorization.
- The interrogation module

The interrogation module of this GIS application performs the interrogation of alphanumeric data by means of SQL controls, both in xBase data management system and in relational S.G.B.D. in the client / server system. This module enables powerful facilities provided to the user in order to develop the own application. In this context, we could mention:

- definition of the database structure;
- definition of the index keys for access to the database;
- definition of relations between the tables (joins);
- definition of views (hypothetic tables defined by the user);
- definition of the connection relation between the graphic information and the alphanumeric information (rule setting);
- SQL controls editing by the user.

The alphanumeric database was developed and managed with FoxPro 2.6 in Windows. This S.G.B.D. is a relational system for the management of databases. In a simple meaning, a relational system implies several databases (commonly referred to as "tables") opened at the same time, connected by means of common fields. The number of databases and common connecting fields define the complexity of the Satabase management system. Figure 2 shows the number of tables which set out the alphanumeric database in the application.

The *.dbf* tables of the database were automatically generated following several processing actions (except for "Coef S" table, which refers to the soil characteristics according to the soil unit sheets, based on which the S erodability coefficients were determined).

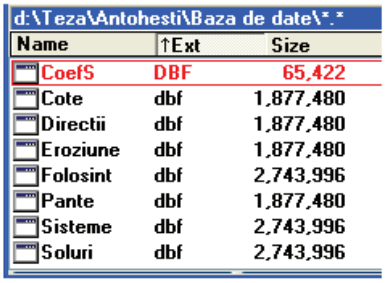


Figure 2. "*dbf*" files which set out the alphanumeric database of the GIS project

For each *.dbf* table, the structure was defined first by: the names of fields, the type and length thereof, depending on the nature of data to be uploaded.

The structure defined in a first stage can be changed by the user at all times, by means of the "*modi stru*" control, but it is extremely important to remain unchanged as of the moment of defining the "connection keys" between the alphanumeric database and the graphic database, otherwise the interrogation turns out incorrect and even impossible.

The key of a GIS consists of creating the connection between the alphanumeric database and the graphic one.

In order to enable the database interrogation both by "Fox keys" and "SQL keys", the projection of correlation between the files of the alphanumeric database and the graphic one is required in the stage following the completion of .dbf tables.

The *.ast* type are thus developed, based on the following rules:

- the files with *.ast* extension should have the same name as the *.dbf* files (tables);
- the creation in the work directory of the file referred to as "Catalog.ast" which contains the list of all tables regarding which an interrogation "connection" is intended and the fields indexed for the connection between tables (Figure 3);
- these files should be edited by maintaining the structure of each table in FoxPro through the "disp stru" control, by specifying the connection fields between tables for interrogation purposes.
- indexation of fields in the database, required for interrogation purposes (Figure 4).

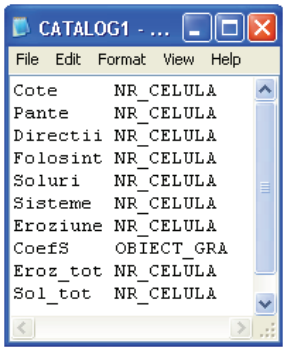


Figure 3. Sequence with the "Catalog.ast" work directory

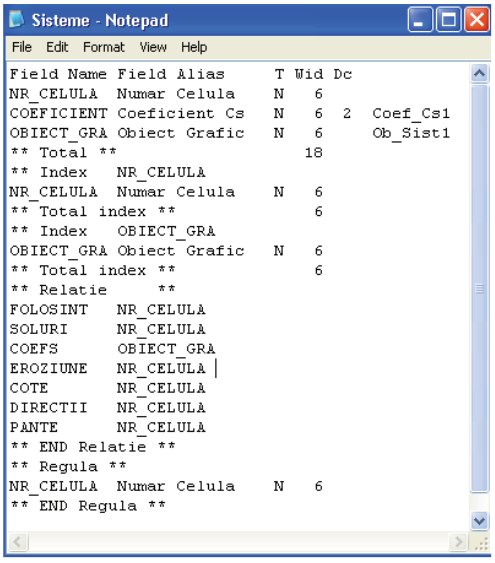


Figure 4. Editing syntax of an *.ast* type file

Few rules to comply with:

➪ The "Field Name" should be as identical as possible with the one set out in the *.dbf* table;

➪ "Field Alias" represents the description of fields (not more than 15 characters);

➪ The "*Coef_Cs1*" and "*Ob_Sist1*" provisions mentioned on the right side mean that, upon the database interrogation for the two fields, supporting tables, called dictionaries, shall be displayed; these dictionaries are developed by the user, with no specific format requirements, in order to provide additional and extremely fast information for interrogation;

➪ For each separate table there should be specified the indexed field, as well as the "Relation" of the relevant table with the other tables of the database (by means of the field description).

RESULTS AND DISCUSSIONS

Two types of interrogation were used in the GIS project contemplated herein: through "Fox Keys" and through "SQL language".

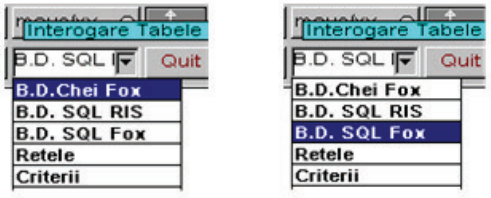


Figure 5. Sequence of the potential interrogation types of the application

The main menu of the Geo – Graph system enables the user to select the interrogation options.

In the first option, ***Relation – Fox keys***, the interrogation takes place from the graphic database towards the alphanumeric database (as in the example set out by Figure 6).

The interrogated graphic object (cell in this case) shall be highlighted compared to the rest of the graphic background (the chosen selection color is white).

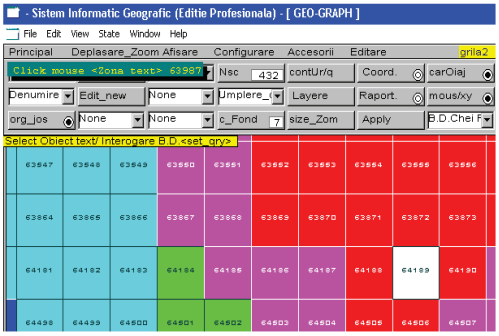


Figure 6. Interrogation of the database by means of "Fox Keys"

Immediately after the click, the first table of the Catalogue shall be displayed in the screen area (Figure 7) with the information computed and saved in the database.

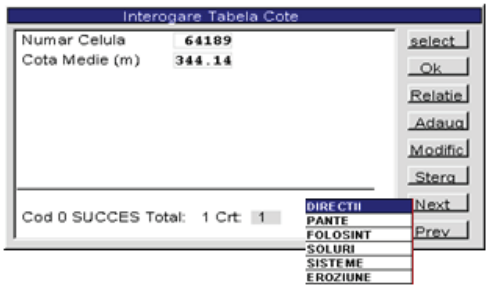


Figure 7. Answer of the interrogation by means of the function "Relation –Fox keys": first "Cote" table

By accessing the "Relation" button, a window will be opened next to the table, which enables the selection for interrogation of the other tables with which the active table has connection keys defined by the index; thus, the other elements may also be displayed for the same cell, solely by switching from one table to another (Figure 8 - 13).

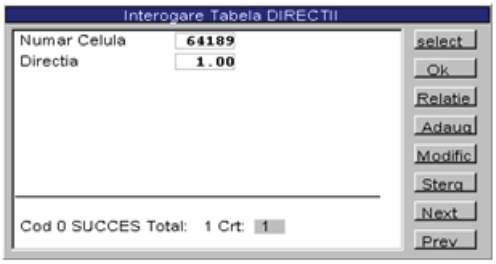


Figure 8. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Directions" table

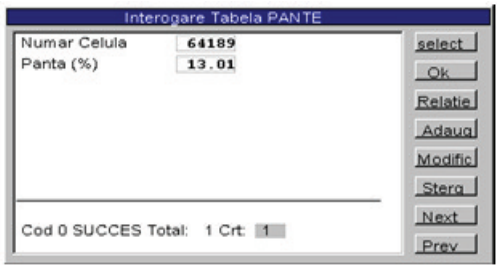


Figure 9. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Gradients" table

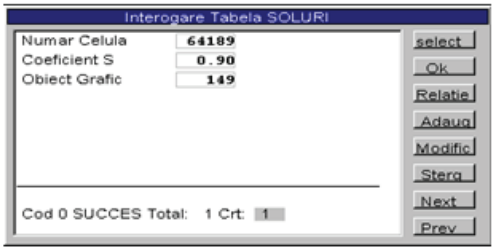


Figure 10. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Soil" table

The update of the alphanumeric database can be easily performed by clicking the "Add", "Change", "Delete" buttons.

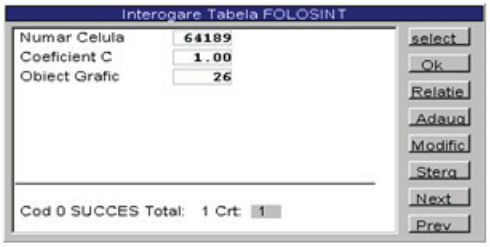


Figure 11. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Purpose" table

The "Next" button enables the user to view, one by one, the interrogated graphic objects.

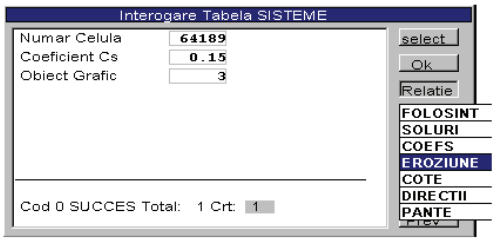


Figure 12. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Systems" table

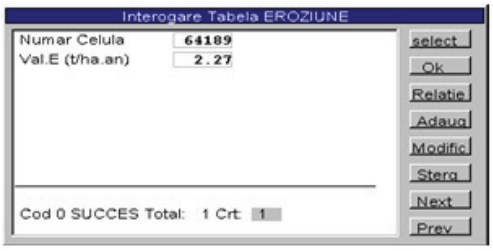


Figure 13. Answer of the interrogation by means of the "Relation – Fox keys" function with the "Erosion" table

In case of interrogation through the SQL language, click on the "Table" button in order to select the intended interrogation topic, either by selecting a table of the database, or by selecting a virtual table, (the „views" can be recognized based on the contents of the "underline" character of the name thereof).
Following the selection of the table or view, the interrogation key is automatically selected. The key represents a group of fields which will receive values in order to meet the interrogation requirement, and afterwards the system performs the search of entries in the database.
Figure 14 shows and example of answer of the interrogation in a virtual table, namely "Tabel Eroz_tot". Thus, when the interrogation topic is selected, the system tries to fill-in values that meet the set out requirements, the fields defined through the "Eroz_tot.ast" file, by using the name of the selected object (cell) as input data.
The second interrogation type based on SQL keys can take place by clicking the "Select" button and setting out, with the keyboard, numeric values, the cell or cells which meet the interrogation requirement following to be displayed (Figure 14). Thus, the "Select" button enables the performance of an interrogation from the alphanumeric database towards the graphic database (Biali Gabriela, Statescu Fl., 2013).
The following example shows another SQL interrogation: it aims at identifying the areas of the water catchment with the "non-productive" use category (Wischmeier W.H., Smith D.D., 1978); thus, only the "C coefficient" field is filled-in by specifying the interrogation requirement (Figure 15).

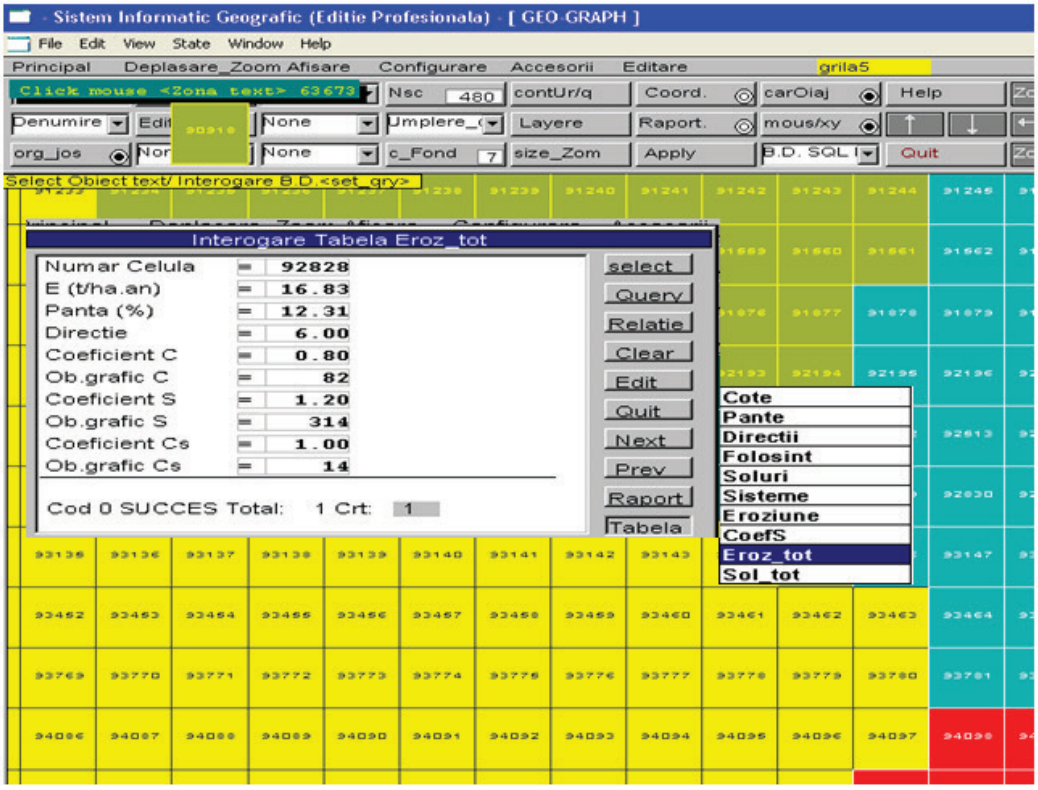


Figure 14. Answer of the SQL interrogation on the information layer of purposes in Antoheşti water catchment; List of interrogation selection possibilities

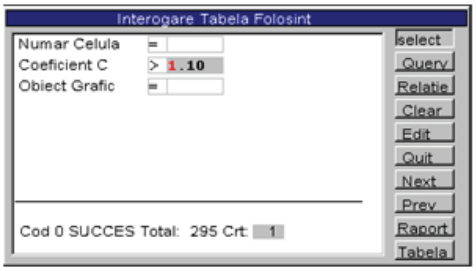


Figure 15. Example of interrogation based on SQL keys

The answer of the interrogation brings in the center of the screen the first cell that meets the requirement, as well as the interrogated table. The lower part of the interrogation shows the total number of cells which meet the interrogation requirements, and the fields are filled-in with the values of the first cell which was identified in the list (Figure 16).
The answer consists of 295 cells, which represent 295 x 25 x25 (m^2) = 18.4375 ha.

By clicking the "Next" button, the entire list is displayed, both graphically and alphanumerically.
Within the GIS application, the system was designed so as to enable the user to generate their own criteria by means of the SQL language, by clicking the "Edit" button or operating changes in the window, through the selected interrogation controls (Figure 17).
The interrogation is performed by means of SQL controls, and does not require the existence of the key in the database (as in the case of the previous interrogation). It should also be mentioned that the Client / Server databases do not use interrogation keys, but only SQL controls.
The following example shows a criterion-based interrogation by means of editing an own SQL control. The interrogation has two requirements, namely: it is intended to identify the area of the water catchment occupied by plough land (which means C > 0.8) and no protective anti-erosional systems apply (C_s=1.0).

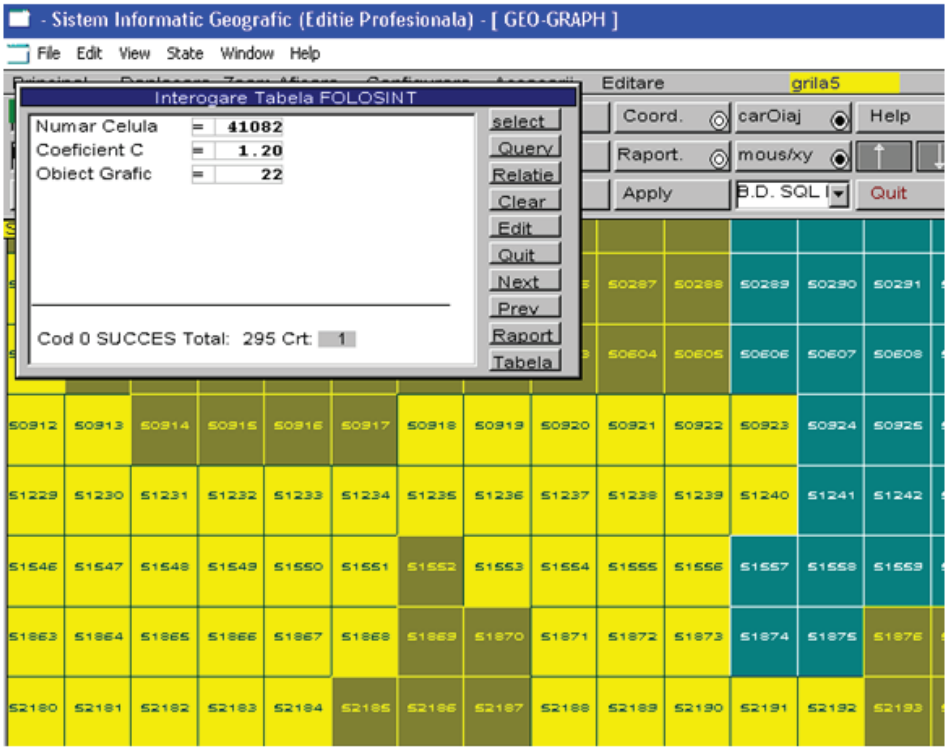


Figure 16. Criterion-based interrogation by means of SQL language; answer of the interrogation

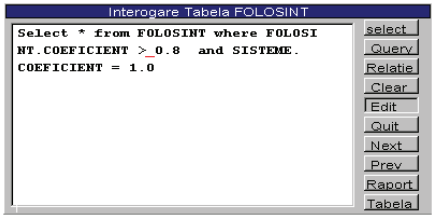


Figure 17. Syntax of the criterion-based interrogation SQL control

The answer of the interrogation in a graphic form is showed in Figure 18. All colors were deactivated and only the areas that met the interrogation requirements are highlighted.

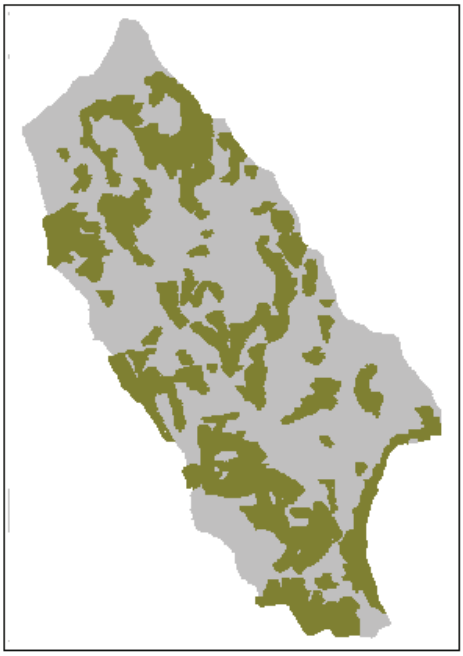


Figure 18. The answer of the interrogation in a graphic form

CONCLUSIONS

The implementation of the Geographic Information Systems (GIS) in the analysis of erosional processes for large areas ensures the possibility to perform a complex monitoring on the quality of versant soil and enables the timely performance of the most appropriate protection and preservation actions concerning the fertility thereof.

The use of GIS for the analysis of land degradation processes and for the forecast of the time progress thereof is possible for both the relatively small plots of certain holders, located more or less uniformly within a territory, as well as for larger areas, water catchments or regional and administrative units.

A major advantage of the GIS consists of the possibility to perform an interrogation on any uploaded information layer, the database being a relational one.

The possibility to conduct statistics based on the information obtained after processing such. If, for values of C, S, Cs coefficients, one could have determined with a certain approximation the related areas, directly from the site plans, in case of landscape parameters (gradient, flowing directions) and erosion, in case of the analyzed water catchments, this would not have been possible.

One should note the facilitation of the criteria analysis due to the existence of virtual tables within the project. The criteria analysis enables us to obtain information from different layers.

REFERENCES

Biali Gabriela, Cojocaru Paula, 2015. Database role in a GIS project for agricultural management on soils subject to erosion. Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, Vol. IV, Print ISSN 2285-6064, 154-157.

Biali Gabriela, Statescu Fl., 2013. Application of GIS technique in land evaluation for agricultural uses, Environmental Engineering and Management Journal, **11**, 821-828.

Motoc M., Tuhai A., 1998. A few issues on assessing soil erosion effects as well as anti-erosion measures and works. Soil Science Magazine, Tome.1.

Renard K.G., Foster G.R., 1996. Predict soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE), USDA – ARS, Agricultural Handbook, 703.

Statescu Fl., Zauca D.C., Pavel V.L., 2013. Soil structure and water-stable aggregates, Environmental Engineering and Management Journal, 12, 741-746.

Wischmeier W.H., Smith D.D., 1978. A universal soil loss equation to guide conservation from planning, Transactions of the 7th International Congress of Soil Science, Wisconsin, USA 7, 418-425