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# HIDROTEHNICĂ

## S U M A R

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# STUDY ON THE DISTRIBUTION OF SOIL HUMIDITY DEPENDING ON SOIL AGGREGATES STABILITY FROM THE BREAZU STUDY AREA

BY

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Received: June 16, 2014
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**Abstract.** This study is focused on highlighting the relationship between soil humidity and soil aggregates stability existing in the study area Breazu. For this study were used several laboratory methods applied at international level for each soil property. Soil moisture was used the vials oven drying method and to determine soil aggregates stability was applied the soil aggregates diving method using the Eijkelkamp Wet Seiving Apparatus.

**Keywords:** hydrostability of soil aggregates and soil humidity.

## 1. Introduction

Worldwide soil has represented, representing and will represent primordial source of supply of the population with food without which we could not exist (Stătescu & Pavel, 2011). So how much more seriously approach the problems by the excess or deficiency of moisture is the impact solving key of this soil propertie variation.

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Soil moisture representing the basic trait of soil which in case of absence can lead to serious damage to development support of plants (I.C.P.A., 1980).

According to classical literature the soil humidity is one of the most important characteristics of the soil because by it depends the majority of of the soil hydraulic properties and beyond. In our study we will discuss the relationship between the soil moisture and soil aggregates stability of soil fragments that contribute to the soil formation of a certain area (Filipov & Lupaşcu, 2003).

## 2. Materials and Methods

From Breazu area (Fig. 1 *a*) were extracted a series of disturbed samples shown in Fig. 1 *b*) one for each depth (0,...,20 cm, 20,...,40 cm, 40,...,60 cm and 60,...,80 cm ).

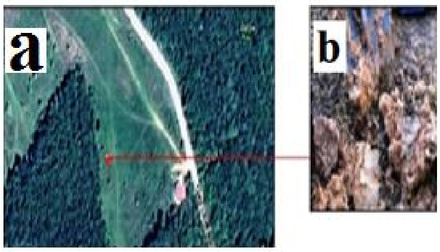


Fig. 1 – Presentation of the location study: *a* – zone of sampling soil; *b* – samples harvested.

Determination of soil humidity was achieved using drying oven soil dried soil vials method by weighing (Fig. 2 *a*, *b*, *c*) their input before and after introduction to drying machine. After the humidity, soil aggregates stability analysis was performed by the Wet Seiving method (Fig. 2 *d*).

This analysis was implemented using the Eijkelkamp Wet Seiving Apparatus.

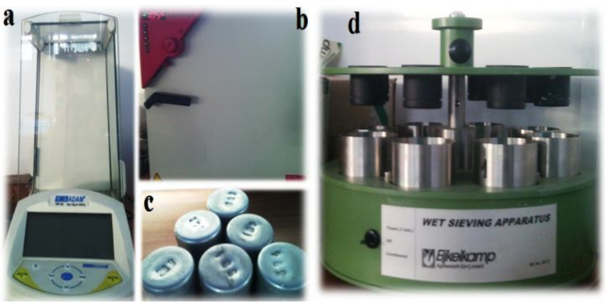


Fig. 2 – The tools used in research: *a*, *b* and *c* – equipment used to analyze the soil humidity; *d* – equipment used to analyze soil aggregates stability - Eijkelkamp Wet Seiving Apparatus.

Soil humidity is calculated with eq. 1 (Dumitru, 2009):

$$W_g = \frac{b-c}{c-a}, \tag{1}$$

where: $W_g$ is the humidity, [%]; $a$ – mass of empty vial, [g]; $b$ – mass of vial with wet soil, [g]; $c$ – mass of vial with dry soil, [g].

In the case of the soil aggregates stability was taken into account the material scraped from the 4 g of soil analyzed result after drying expressed in percentages

## 3. Results and Discussions

In Table 1 are presents the results obtained after applying the research methods of the soil humidity and the soil aggregates stability for Breazu study area.

**Table 1**

*Soil humidity and soil aggregates stability for Breazu site*

| Sample, [cm] | *W*, [%] | $S_a$. S., [%] |
|---|---|---|
| B 0-20 | 25.41 | 45.65 |
| B 20-40 | 20.36 | 6.27 |
| B 40-60 | 19.35 | 33.17 |
| B 60-80 | 21.78 | 28.47 |

As can be seen in Fig. 3 In the case the soil taken from the first depth we can reveal the relationship between soil moisture and stability of aggregates that can be presented by a proportional variation of both characteristics considered.

Thus with the humidity increasing increased the amount of material gnawed from the soil aggregates analyzed which means that this ground is among the weakest in terms of stability of aggregates argumented by the presence of a less clay content and more than siltt and sand that confer to soil particles a poorer cohesion.

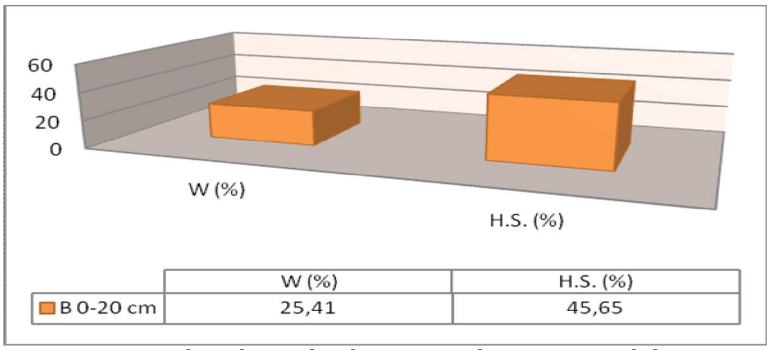


Fig. 3 – The relationship between soil aggregate stability and soil humidity for B 0-20 cm.

Compared to the previous case the situation shown in Fig. 4 is the total opposite and see that there is a decrease in soil aggregate stability percentages assigned in relation to an increase in soil humidity which means that B 20-40 cm soil is the most resistant (Table 1) and shows good stability argument percentage values smaller but higher clay content unevenly distributed over the entire soil profile (0,...,80 cm).

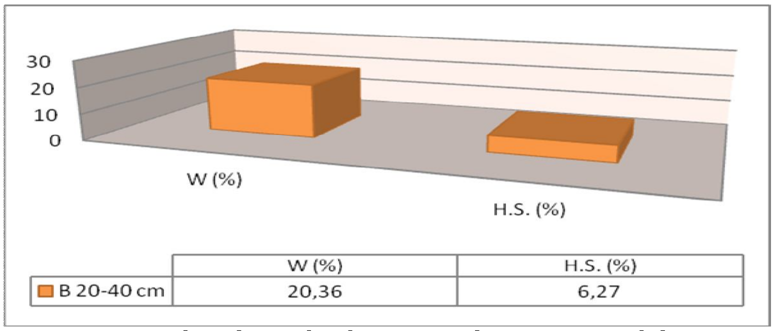


Fig. 4 – The relationship between soil aggregates stability and soil humidity for B 20-40 cm.

Soil collected from the 40,…,60 cm depth from the other soil samples remarked a much weaker soil aggregates stability a than 20,…,40 cm to a similary value of soil humidity to the previous case. This can be attributed to increased bulk density due to triggering soil compaction process and uneven settlement of soil particles aspect shown in Fig. 5.

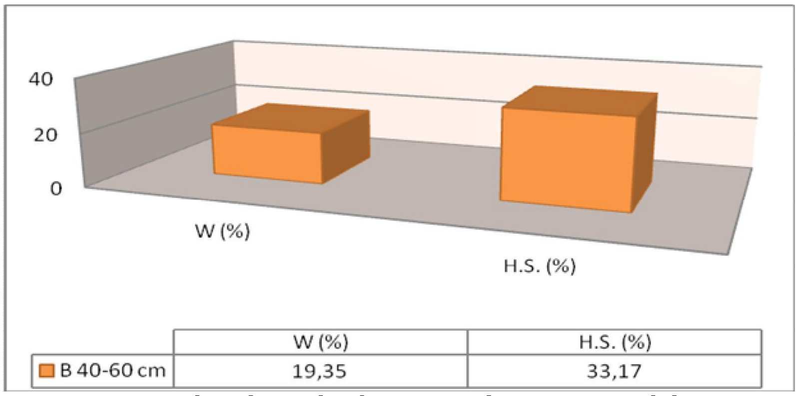


Fig. 5 – The relationship between soil aggregates stability and soil humidity for B 40-60 cm.

In the case of soil taken from the last depth (60,…,80 cm) the aggregate stability was higher than the humidity fact see in Fig. 6. But it should be noted that compared to other soils that presented a higher clay content and less silt and sand content which was noticed ever since in the sampling stage.

Even though this type of soil was richer in clay that no showed an increased stability in certain variations of hydrophysical properties.

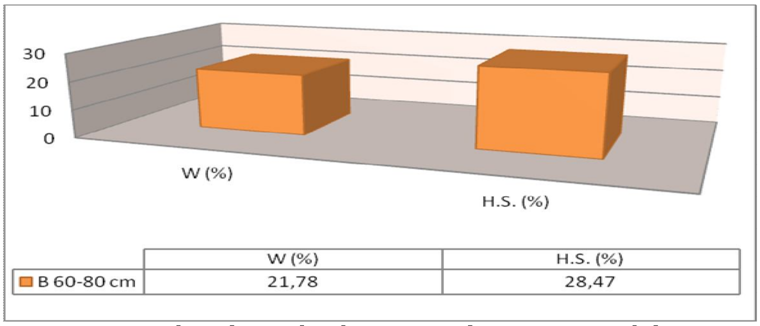


Fig. 6 – The relationship between soil aggregates stability and soil humidity for B 60-80 cm.

## 4. Conclusions

Making an overall analysis we can mention the following:

1º Soil from the analyzed site presented a series of situations which differed from one to another depth.

2º After the results interpretation came out that the unstable soil was at the ground surface that despite the presence of organic matter not showed an increased stability of aggregates to the action of humidity or in some cases percolating that section of water from rainfall or other chemical compounds compared to the soil at the next depth that had highest aggregates stability.

3º The relationship between humidity and aggregates stability is very important because it greatly influences soil hydraulic properties due to vertical detachment and cast off material that can opture the gaps present in the soil preventing in finally the access and water stored for plants.

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## STUDIU PRIVIND DISTRIBUȚIA UMIDITĂȚII SOLULUI ÎN FUNCȚIE DE STABILITATEA AGREGATELOR DE SOL DIN ZONA DE STUDIU BREAZU


(Rezumat)

Studiu de față este focusat pe evidențierea relației dintre umiditatea solului şi stabilitatea agregatelor de sol existente în zona de studiu Breazu. Pentru realizarea

acestui studiu s-au folosit o serie de metode de laborator aplicate la nivel internațional pentru fiecare proprietate a solului.

Pentru umiditatea solului s-a utilizat metoda uscării fiolelor la etuvă, iar pentru determinarea stabilității s-a aplicat metoda scufundări agregatelor de sol în apă cu ajutorul aparatului Eijkelkamp Wet Seiving Apparatus.

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# STUDY REGARDING THE EFFECTS UPON POPULATION HEALTH OF THE EVOLUTION OF RESIDUAL CHLORINE IN WATER DISTRIBUTION SYSTEMS

BY

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**Abstract.** Maintaining a sustainable physical infrastructure is a challenge due to the complexity of distribution systems.

Gaps in physical and hydraulic systems for water distribution may lead to the influx of contaminants through the pipe walls through cracks and through the intersection with risk areas. These external events can introduce sediment contamination, or may decrease concentrations of disinfectant in the distribution system, resulting in a degradation of water quality.

During 1991-2000, the residential area of Lunca Cetăţuii was the area where there were more episodes of acute diarrheal disease. The causes were the perpetuation of major unrepaired failures at the water supply mains and sanitary deficiencies of the resident population.

According to the experimental analysis, measurements were performed in a number of network nodes of the water distribution system in Lunca Cetăţuii using the program EPANET, and some of the data were taken from APAVITAL Iasi, using reports of water quality monitoring in different periods of time.

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After studying the monitoring report for 2009, a node was chosen in which it was monitored the monthly residual chlorine concentration. From this node there were extracted months with the lowest chlorine concentrations.

**Keywords:** residual chlorine; water distribution system; EPANET.

## 1. Introduction

Drinking water is water intended for human consumption and can be represented in the following forms: (Law no. 458/2002):

a) any type water in their natural state or after treatment, used for drinking, preparing food or for other domestic purposes, regardless of its origin and whether it is supplied through the distribution network, tank or distributed in bottles or in other containers;

b) any water used as a source in the food industry for the manufacturing, processing, preservation or marketing of products or substances intended for human consumption.

The quality of water distributed through centralized systems in areas with more than 5,000 inhabitants or with a distribution volume of 1,000 $m^3$/day is monitored according to Law. 458/2002 on drinking water quality. This law is the transposition of Directive 98/83 – Quality of water for human consumption, which regulates drinking water quality, aiming at protecting human health against any type of contamination effects.

Maintaining a sustainable physical infrastructure is a challenge due to the complexity of distribution systems. Moreover, it should be taken into consideration factors that vary from system to system, such as the network size distribution, the material and age of the pipes, the water pressure, the storage capacity and the retention time in the system.

Gaps in physical and hydraulic systems for water distribution may lead to the influx of contaminants through the pipe walls through cracks and through the intersection with risk areas. These external events can introduce sediment contamination, or may decrease concentrations of disinfectant in the distribution system, resulting in a degradation of water quality.

The equations governing water quality modeling are based on the principles of conservation of mass coupled with reaction kinetics (Mays, 2000; Clark, 2012; Bârsan, 2005).

The following phenomena that occur in the distribution system are represented in a typical water quality model:

a) advection transport in pipelines;

b) the mixture at the intersection nodes of pipes;

c) the mixture in the tanks;

d) reactions in water volume;

e) reactions at the pipe wall.

## 2. Experimental

The experimental base consists of the distribution system of drinking water that serves the town of Lunca Cetățuii, Ciurea village, Iaşi (Fig. 1). Public water supply in Ciurea is done for most of the villages from wells (of which 27 are public and 1,326 individual). Lunca Cetățuii and Hlincea localities are supplied through a centralized system with its own distribution network of drinking water. Water supply system of Ciurea village is considered an extension of the water distribution system of Iaşi.


Fig. 1 − Ciurea and Lunca Cetățuii location în Iaşi county.

The necessary water pressure supply is ensured by tanks located in Iaşi, respectively in CUG neighborhood and Miroslava. Water sources for Iasi are:

A. Source Timişeşti – surface water + groundwater – basin r. Moldova.

B. Source r. Prut – surface water – Prut basin.

Water is transformed into drinking water in treatment plants Timişeşti/ Săbăoani and Chirița, where it supports three corrections of free residual chlorine concentration at Şorogari, Aurora and CUG. For storage there are three tanks, one of 5,000 m$^3$ in Miroslava, one of 1,000 m$^3$ in CUG and a reservoir of 150 m$^3$ in Hlincea.

The actual lengths of water supply systems in Ciurea village are presented in Table 1.

During 1991–2000, the residential area of Lunca Cetățuii was the area where there were more episodes of acute diarrheal disease. The causes were the perpetuation of major unrepaired failures at the water supply mains and sanitary deficiencies of the resident population.

Comparing the number of cases of acute diarrheal disease reported for Iaşi with the ones identified by family doctors in Ciurea, we note that in 1991, 1995, 1997 and 2000 increased the number of cases, including the population from the residential area.

During 1991–2000, the residential area of Lunca Cetățuii was the area where there were more episodes of acute diarrheal disease. The causes were the perpetuation of major unrepaired failures at the water supply mains and sanitary deficiencies of the resident population.

**Table 1**

*The Parameters of the Water Distribution System in Ciurea, Lunca Cetățuii and Hlincea Villages*

| Locality | Material | Diameter, [mm] | Length, [ml] | Type of supply |
|---|---|---|---|---|
| Lunca Cetățuii | PEHD | 160 | 128.2 | Gravitational |
| | | 110 | 928.5 | |
| | | 90 | 354.1 | |
| | | 75 | 66.2 | |
| | | 63 | 156.8 | |
| | | 32 | 37.7 | |
| | TOTAL PEHD | | 1,671.50 | |
| | OL | 250 | 87.9 | |
| | | 200 | 1,418.9 | |
| | | 150 | 28.4 | |
| | | 100 | 309.7 | |
| | TOTAL OL | | 1,844.90 | |
| | PREMO | 400 | 809.6 | |
| | TOTAL PREMO | | 809.6 | |
| Total water supply system Lunca Cetățuii | | | 4,326.00 | |
| Hlincea | PEHD, PN 4 | 110 | 1,227.00 | Gravitational |
| | PEHD, PN 4 | 90 | 596.7 | |
| | PEHD, PN 4 | 75 | 2,164.0 | |
| Total water supply system Hlincea | | | 3,987.7 | |
| Total water supply system Ciurea – Lunca Cetățuii and Hlincea | | | 8,313.70 | |

During 1991–2000, the residential area of Lunca Cetățuii was the area where there were more episodes of acute diarrheal disease. The causes were the perpetuation of major unrepaired failures at the water supply mains and sanitary deficiencies of the resident population.

Comparing the number of cases of acute diarrheal disease reported for Iaşi with the ones identified by family doctors in Ciurea, we note that in 1991, 1995, 1997 and 2000 increased the number of cases, including the population from the residential area.

The research analyzed epidemic episodes in 1995, 1997 and 2000, correlating the number of reported cases of acute diarrheal disease with the results of water samples – chemical and bacteriological examinations.

In september 1995 there were a total of 189 cases of acute diarrheal disease discovered at residents of blocks of Lunca Cetatuii. Water samples collected from 8 blocks (57, 58, 60, 61, 62, 77, 78, 90) showed lack of free residual chlorine and coliform presence. There have also been detected a total number of germs and even fecal coliforms, indicating massive contamination of the drinking water network.

It was noted that in may 1995 in blocks 57, 58, 60, 61 water chemical examination indicated no residual chlorine and failure repairs to the water system led to outbreaks in september.

Between 15.07.–08.06.1997 there were diagnosed by doctors at the Infectious Diseases Hospital Iaşi a number of 86 cases of BDA in persons aged between five months and 70 years (Fig. 2). Affected people were living in 9 blocks, the higher number being recorded in blocks 64, 63 and 60, supplied from the same water main, located at the end of the network.

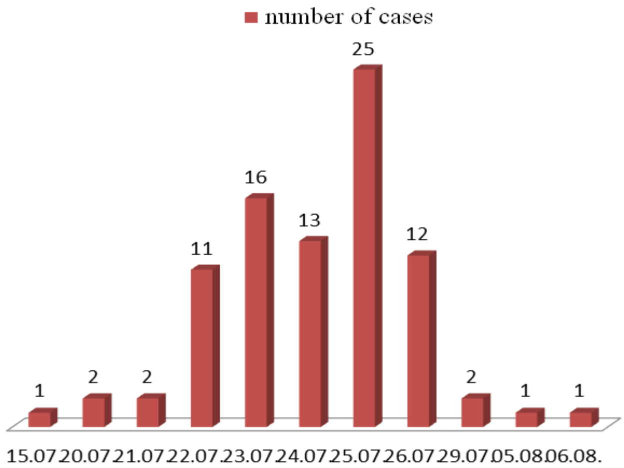



Fig. 2 − Daily distribution of BDA cases in July 1997, Lunca Cetăţuii.

Analyzing the data shown in Fig. 3 it results that most cases were recorded in block 64. In this block it was noted the absence of residual chlorine in most measurements.

Poor quality of drinking water supplied to buildings where there have been illnesses has been confirmed since february 1997 as a result of the samples analyzed by the public health authority. Bacteriological examinations indicated the presence of spore forms and an increased number of germs.

Since June, water samples (39 samples) from blocks 56, 58, 63, 64, 77, 89, 90 and the storage tank had unsatisfactory results both chemically - no residual chlorine and also a massive bacterial load - coliforms, faecal streptococci, germs.

This research imposed the directions on water quality parameters and in particular the presence of residual chlorine.

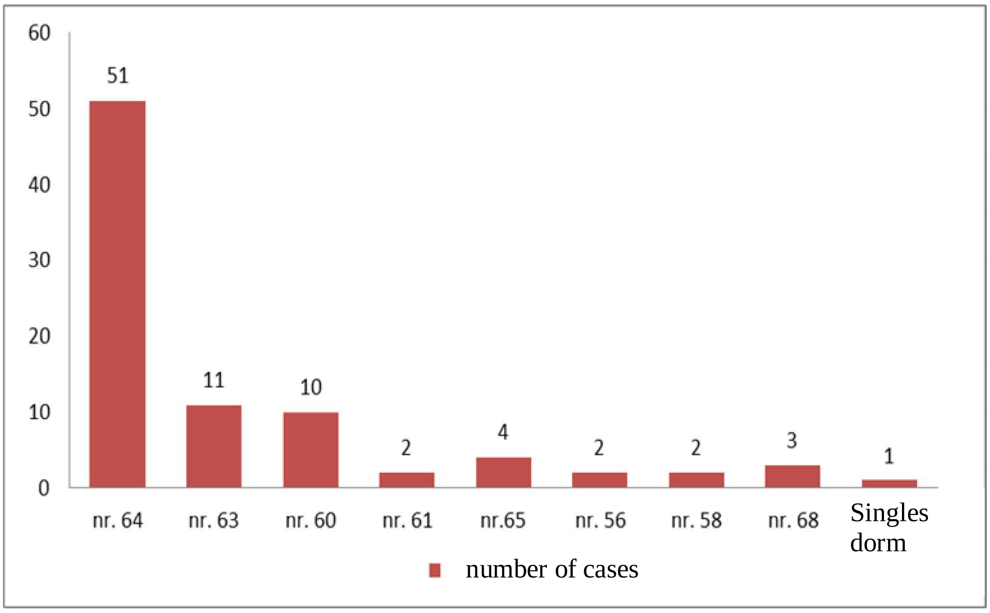



Fig. 3 – BDA cases distribution taking into consideration the residence, may 2000, Lunca Cetățuii.

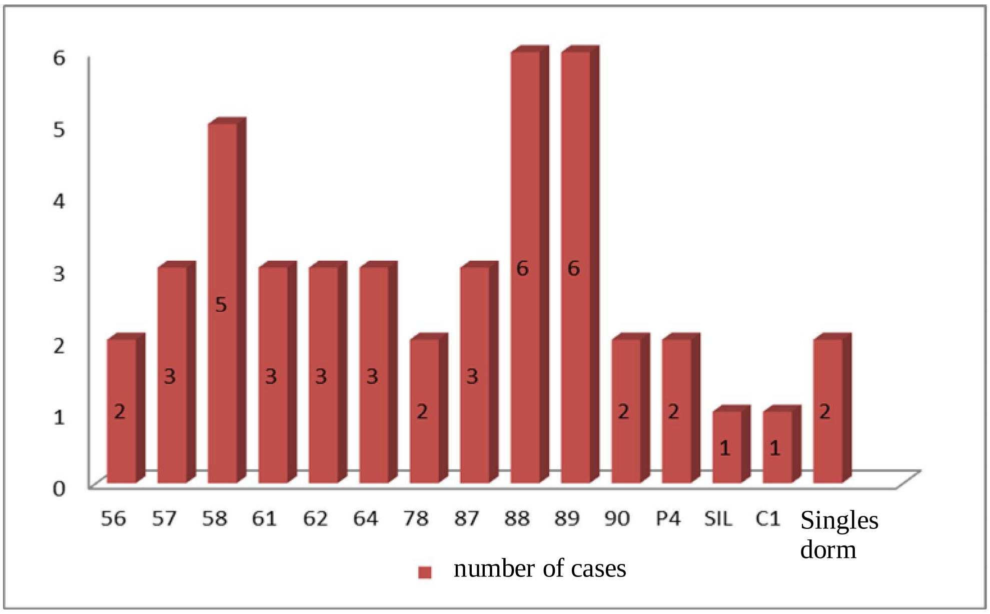



Fig. 4 – Daily distribution of BDA cases in 2000, Lunca Cetățuii.

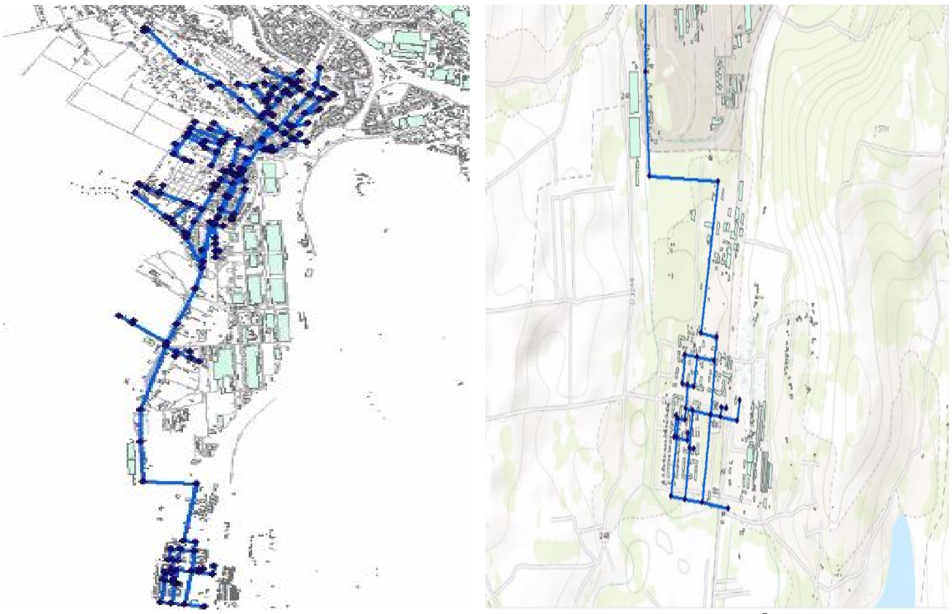
During 17.05.-05.06.2000 there were a total of 44 cases of acute diarrheal disease in people aged 6 months to 64 years (Fig. 3).

It is noted that prior to the epidemic episode in may 2000 there have been four failures in the water supply system - in the block 58 (in 11.05., 18.05., 19.05. and 22.05.2000) and 29.05.2000 at the block 57 (Fig. 4). This required the interruption of the drinking water supply for repairing the affected mains.

They were collected 25 drinking water samples from all blocks where sick people lived, noting at the bacteriological exam the presence of an increased number of germ from blocks 58, 78, 89 and coliforms from block 58.

## 3. Results and Discussions

According to the experimental analysis (Figs. 5 and 6), measurements were performed in a number of network nodes using the program EPANET, and some of the data were taken from APAVITAL Iasi, using reports of water quality monitoring in different periods of time. After studying the monitoring report for 2009, a node was chosen (Fig. 7) in which it was monitored the monthly residual chlorine concentration. From this node there were extracted months with the lowest chlorine concentrations (Fig. 8).



*a* *b*

Fig. 5 − Analysis model for Lunca Cetăţuii: *a* – calculation scheme for Iaşi – Lunca Cetăţuii; *b* – detail regarding water distribution system.

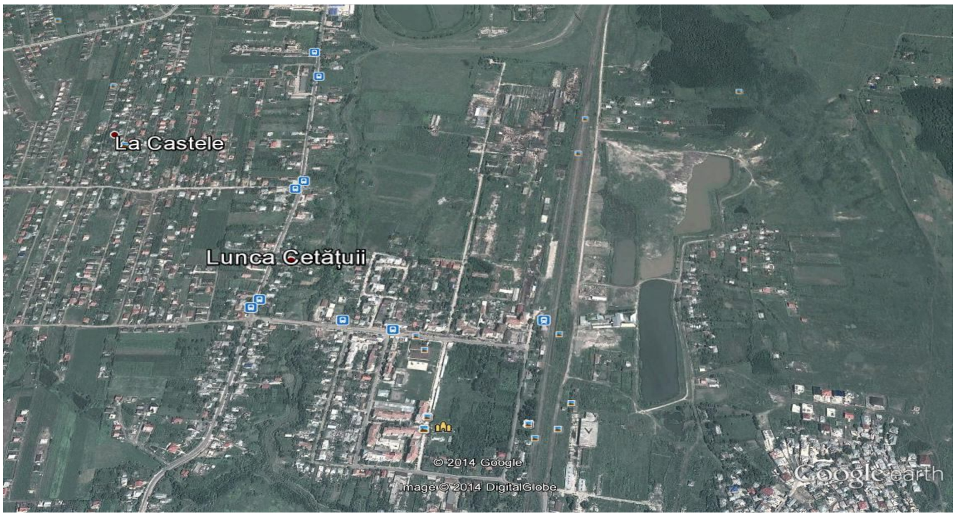



Fig. 6 − Analysis model for Lunca Cetățuii: Google Earth image of Lunca Cetățuii.

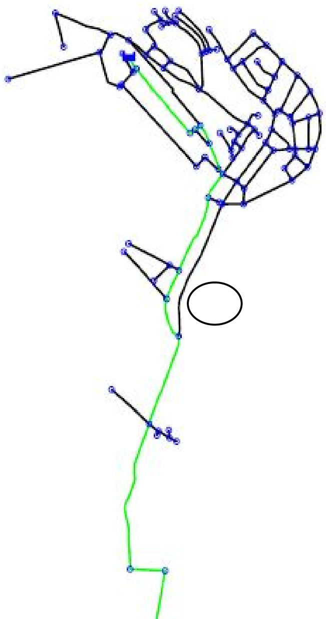
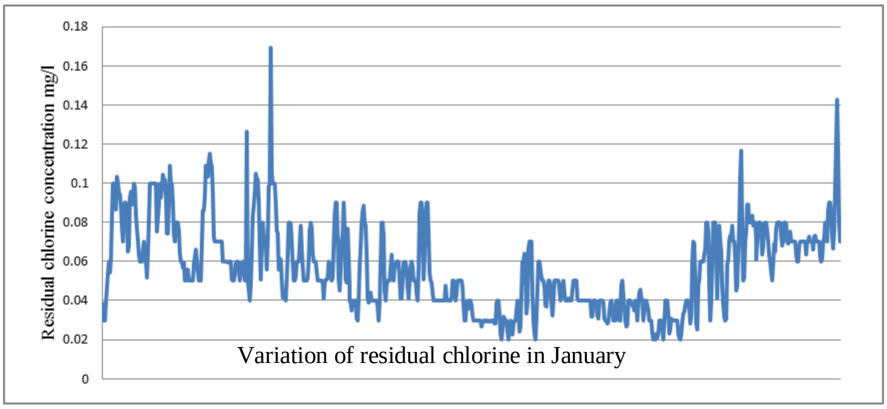


Fig. 7 – Analysis scheme with showing of the chosen node for monitorization from APAVITAL report.

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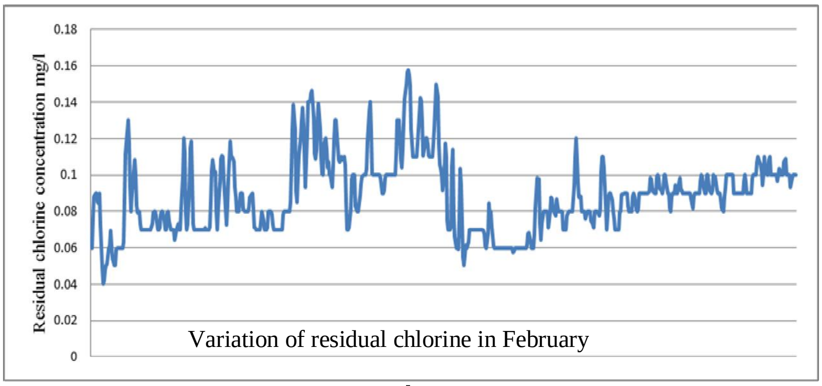


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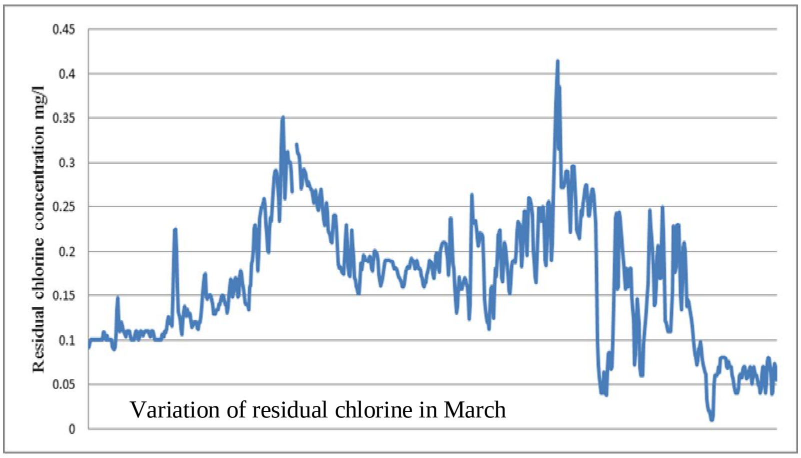


*c*

Fig. 8 – The most unfavourable months extracted from APAVITAL report: *a* – january 2009; *b* – february 2009; *c* – march 2009.

The study of the evolution of the concentration of disinfectant, mainly residual chlorine evolution in distribution of drinking water system is particularly complex due to the influence of the pipes material, the hydraulic parameters of intrusions from outside, the length of transport, etc., situation which involves a special research method and a detailed database.

## 4. Conclusions

Based on the performed research, there is required a hydraulic simulation analysis of the evolution of residual chlorine in the supply and distribution system of Lunca Cetatuii, analysis performed for the current state (in which the recorded values of 0.05,...,0.01 mg/l are under the permissible limit). A possible solution to solve the existing case is to create a prechlorination station by injecting residual chlorine into a well established node. This concentration of disinfectant is required to return to normal levels of chlorine residual in each node of the water distribution system for the chosen locality.

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* * * Directiva 98/83/EC – Calitatea apei destinată consumului uman.

* * * Law 458/2002 M.O. no. 552/29 July 2002 – Legea privind calitatea apei potabile.

* * * Legea 311/28.06.2004 – Legea pentru modificarea şi completarea Legii nr. 458/ 2002 privind calitatea apei potabile.



STUDIU PRIVIND EFECTELE ASUPRA SĂNATĂȚII POPULAȚIEI A EVOLUȚIEI CLORULUI REZIDUAL ÎN SISTEMELE DE DISTRIBUȚIE A APEI

(Rezumat)

Menținerea unei infrastructuri fizice durabile reprezintă o provocare din cauza complexității sistemelor de distribuție.

Breşe în integritatea fizică şi hidraulică a sistemelor de distribuție a apei poate conduce la afluxul de contaminanți prin pereții conductelor, prin fisuri și prin intersecția cu zone de risc. Aceste evenimente externe pot introduce contaminanți, care prin sedimentare, pot scădea concentrațiile de dezinfectant în sistemul de distribuție, având ca rezultat o degradare a calității apei.

În timpul 1991-2000, zona rezidentiala Lunca Cetăţuii a fost zona în care au existat mai multe episoade de boală diareică acută. Cauzele au fost perpetuarea unor defecţiuni neremediate majore la reţeaua de alimentare cu apă şi deficienţe sanitare ale populaţiei rezidente.

Conform analizei experimentale, măsurătorile au fost efectuate într-un număr de noduri de reţea ale sistemului de distribuţie a apei din Lunca Cetăţuii, folosind programul EPANRT, iar unele dintre date au fost preluate de la APAVITAL Iaşi, folosind rapoarte de monitorizare a calităţii apei în diferite perioade de timp. După studierea raportului de monitorizare pentru anul 2009, un nod a fost ales în care a fost monitorizată concentraţia de clor rezidual lunar. Din acest nod au fost extrase luni cu cele mai mici concentraţii de clor.

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# EVOLUTION ANALYSE ON THE SPECIFIC VALUES OF CERTAIN PROPERTIES OF SOILS IN THE AREA RĂDUCĂNENI, JUD. IAŞI

BY

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**Abstract.** The study of evolution of soils should be done in close conjunction with the dynamics of natural factors and land use. Răducăneni catchment soils were investigated by using maps. The research had the objective of quantifying the changes recorded by the physical and chemical properties of soils identified, caused by the action of physical factors and anthropogenic. To do this, it was analyzed the evolution of the main physical and chemical properties of soils for the period 1962-2010.

**Keywords:** soil mapping; physical and chemical properties; soil horizon.

## 1. Introduction

Soil is subject to continuous development. Studying the evolution of soils should be done in close correlation with the dynamics of natural factors and the use of the land. It can be done in different ways.

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The progress made in the field of soil science (national and international level), determined the development, in 1979, by I.C.P.A. (Central Institute of soil) of a new classification system. This system presents superior taxonomic units (class, type and subtype) and inferior (variety, family and species), being called the Romanian System of Soil Classification (SRCS). For the identification of taxonomic soil units are being used diagnostic horizons and diagnostic characters (pedogenetical horizons and group of characteristics used to define a taxonomic units). 10 classes were established and 39 soil types, indicating horizons and diagnostic characteristics for all types of soil. At the sub-type base level, this classification sets 233 sub-types, giving a total of 470 combined basic sub-types. It was developed at national level the Romanian soil map.

By 519 Order from August 8, 2003, the ministry of Agriculture, Forestry, Water and Environment approved the Romanian System of Soil Taxonomy.

Until now, soils from the Răducăneni hydrographic basin were investigated using mapping, conducted in 1962 and 1990. As genetic soil types, on studied territory, in 1962, were identified brown forest soils and brown forest weak podzolite soils. In addition to local patterns, we can find on a smaller area carbonated leached chernoziom.

Time interaction of natural and anthropic factors in the micro-climate of this area, led to the formation of several soil types (Table 1).

In 1962, were identified within the area of Răducăneni 6 soil types with the following percentage of the investigated area (4,159.30 ha): 27,13% brown forest soils, 26.62% complex soils, 15.80% colluvial and alluvial, 13.35% chernozioms, 13.83% waterlogged soils and 3.27% landslide.

**Table 1**

*Soil Types and Their Percentage in the Mapped Area*

| No. | Type | 1962* | | 1990** | |
|---|---|---|---|---|---|
| | | A [ha] | % from A | A [ha] | % from A |
| 1 | Brown typical clay illuviated soils | 1,128.8 | 27.13 | 636.1 | 9.14 |
| 2 | Chernozioms | 555.0 | 13.35 | 1,464.1 | 21.04 |
| 3 | Waterlogged soils | 575.4 | 13.83 | 544.2 | 7.82 |
| 4 | Alluvial soils | 657.0 | 15.80 | 1,234.4 | 20.97 |
| 5 | Depth erosion | 135.9 | 3.27 | 513.4 | 7.38 |
| 6 | Soil complex | 1,107.2 | 26.62 | 1,188.2 | 17.0 |
| 7 | Gray cambic soil | – | – | 39.2 | 6.23 |
| 8 | Rendzina | – | – | 13.5 | 0.19 |
| 9 | Pseudorendzina | – | – | 11.0 | 0.16 |
| 10 | Brown typical clay soil | – | – | 636.1 | 9.14 |
| 11 | Protosol | – | – | 239.8 | 3.49 |
| 12 | Sloppy soils | – | – | 453.0 | 6.51 |
| | TOTAL studied area | 4,159.3 | 100.00 | 6,962.0 | 100.00 |

*soil classification was made after geographical and genetical classification

** soil classification was made after S.R.C.S., I.C.P.A. 1980

Within this 6 soil types identified in 1962, were established 12 groups of soils which include a total of 31 soil units (US), listed in the soil map of the territory.

In 1990, according to the SRCS classification were identified soils from the following classes: molisoils, clay soils, hydromorphic soils, undeveloped soils and complex soils, being determined 57 soil units, 6 complexes and a form of depth erosion.

## 2. Experimental

### 2.1. Materials and Methods

After field research conducted in the 2009-2010 years and the existing cartographic materials, the cadastral map of Răducăneni hydrographic basin was made (Fig.1). The names of the soil types identified in 1962 were equated in SRCS names (1990) and then in SRTS (2010), resulting data from Table 2.

**Table 2**

*Soil Classes and Their Percentage in the Răducăneni-Iaşi Area*

| | Soil classes | | | 1962* | | 1990 | | 2010 | |
|---|---|---|---|---|---|---|---|---|---|
| | SRCS | SRTS | Symb. | A, [ha] | % from A | A, [ha] | % from A | A, [ha] | % from A |
| 1 | Clay-alluvial soils | Luvisoils | LUV | 1379.7 | 33.17 | 930.50 | 13.37 | 900.2 | 13.59 |
| 2 | molisoils | cernosoil | CER | 664.5 | 15.98 | 2205.15 | 31.67 | 1996.8 | 30.14 |
| 3 | hydromorphic soils | Hidrisoils | HID | 657.5 | 15.81 | 991.50 | 14.24 | 945.1 | 14.27 |
| 4 | undeveloped soils | Protisoils | PRO | 723.5 | 17.39 | 1251.80 | 17.98 | 1141.3 | 17.23 |
| 5 | undeveloped soils | Antrisoils | ANT | 734.1 | 17.65 | 1583.05 | 22.74 | 1640.6 | 24.77 |
| | TOTAL studied area | – | – | 4159.3 | 100.0 | 6962.0 | 100.0 | 6624.0 | 100.0 |

* The names of the soil types identified in 1962 were equated in SRCS names and then in SRTS

Field researches were made in the main profiles (representative) for each class of soil, but also from the secondary profiles and samples were taken with the help of soil sensor.

After the establishment of classes and soil types, it was possible to make the soil map of Răducăneni area (Fig. 2).

Data collected in the field (sheets describing soil profiles, analytical data) were the primary materials absolutely necessary to make the final maps and were ranked in data store. Mapping and specific maps were made with GIS technologies.

Researches aimed the quantification of changes to the physical and chemical properties of identified soils, caused by the action of physical and anthropic factors in the area. For this, it was analyzed the evolution of main physical and chemical properties of soils in the period 1962-2010. Working methodology was based both on the use of information material mapping from 1962 and 1990 as well as carrying out laboratory test in 2010. The laboratory analyzes were performed by adhering to specific technical standards.

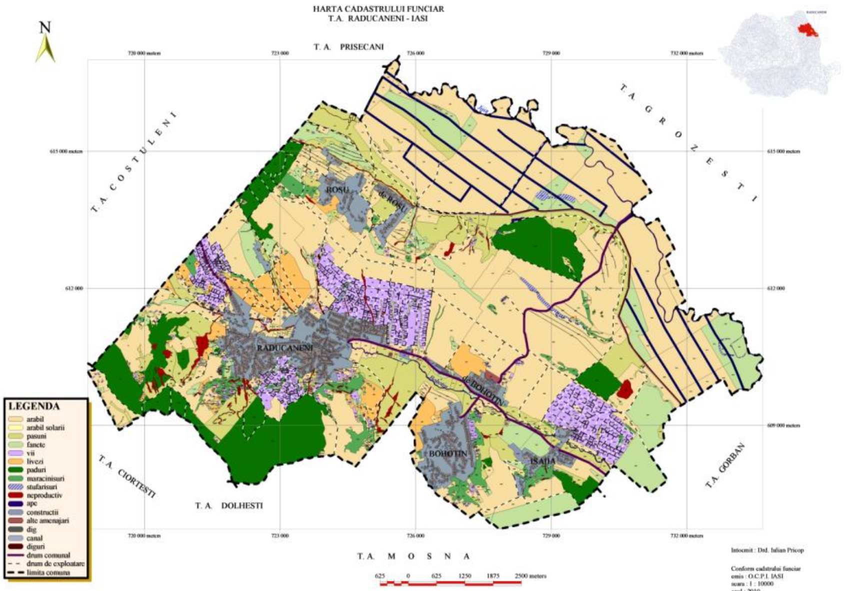


Fig. 1 – Cadastral map of studied area.

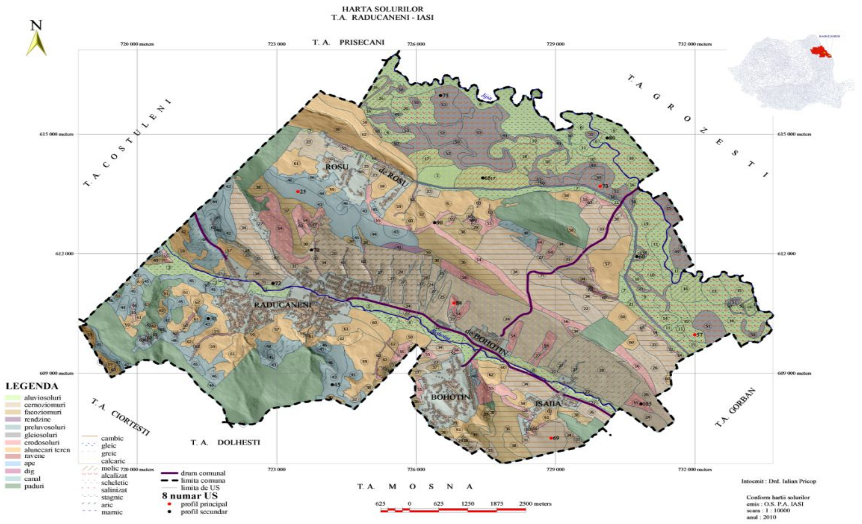


Fig. 2 – Soil map from Răducăneni area (2010).

## 3. Results and Discussions

### 3.1. Evolution Analysis of Physical Properties

3.1.1. *Texture*

Quantitative relationships between soil particles of various sizes vary from one soil to another, from one horizon to another, and define soil texture. So, on the main soil types from the studied area (Tables 3,…,7), particle size are uneven on horizons and soil types. Because of that, the aero-hydric regime is different from one soil to another and greatly influences fertility.

**Table 3**
*Grain Size Distribution of Protisoils*

| Horizon | sand (0.2–0.02) | | | dust (0.02–0.002) | | | clay (< 0.002) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 |
| Atsc | 42.20 | 36.8 | 15.2 | 20.35 | 27.1 | 23.3 | 37.40 | 36.1 | 61.5 |
| Am | 56.45 | 43.2 | 16.4 | 17.10 | 22.5 | 19.9 | 26.45 | 34.3 | 63.7 |
| AGosc | 56.95 | 45.8 | 15.9 | 16.80 | 22.6 | 18.3 | 26.30 | 31.6 | 65.8 |
| Cgosc | 43.85 | 46.7 | 16.3 | 17.20 | 23.0 | 17.5 | 38.95 | 30.3 | 66.2 |
| CGrsc | – | 32.2 | 13.2 | – | 29.0 | 22.3 | – | 38.8 | 64.5 |

**Table 4**
*Grain Size Distribution of Cernisoils*

| Horizon | sand (0.2–0.02) | | | dust (0.02–0.002) | | | clay (< 0.002) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 |
| Am | 47.45 | 48.50 | 38.2 | 24.00 | 21.00 | 28.0 | 26.45 | 40.20 | 33.8 |
| AB | 47.55 | 50.80 | 41.1 | 23.70 | 22.00 | 27.0 | 28.75 | 37.90 | 31.9 |
| Bv1 | 47.40 | 47.20 | 37.1 | 24.20 | 25.70 | 28.3 | 28.00 | 38.40 | 34.6 |
| Bv2 | – | 49.90 | 35.2 | – | 24.60 | 31.9 | – | 36.50 | 32.9 |
| BR | – | – | 36.8 | – | – | 27.5 | – | – | 35.7 |

**Table 5**
*Grain Size Distribution of Luvisoils*

| Horizon | sand (0.2–0.02) | | | dust (0.02–0.002) | | | clay (< 0.002) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 |
| Ao | 45.90 | 40.9 | 40.1 | 25.25 | 28.8 | 24.9 | 28.85 | 30.3 | 35.0 |
| Ao | 43.10 | 40.3 | 37.8 | 26.05 | 28.7 | 25.0 | 30.85 | 31.0 | 37.2 |
| AB | 43.85 | 38.4 | 35.5 | 22.95 | 27.9 | 21.6 | 33.20 | 33.7 | 42.9 |
| Bt1 | – | 41.8 | 36.8 | – | 23.5 | 22.9 | – | 34.7 | 40.3 |
| Bt2 | – | 45.4 | 34.8 | – | 21.9 | 26.8 | – | 32.7 | 38.4 |

**Table 6**

*Grain Size Distribution of Hidrisoils*

| Horizon | sand (0.2–0.02) | | | dust (0.02–0.002) | | | clay (< 0.002) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 |
| Am | 20.80 | 15.9 | 6.9 | 19.55 | 28.0 | 9.9 | 59.65 | 56.1 | 70.5 |
| AGrsc | 17.75 | 19.9 | 10.1 | 16.40 | 22.9 | 14.9 | 65.85 | 57.2 | 83.2 |
| Grsc | 18.55 | 13.0 | 4.7 | 17.70 | 22.3 | 23.0 | 61.05 | 64.2 | 75.0 |

**Table 7**

*Grain Size Distribution of Antrisoils*

| Horizon | Coarse sand (2.0–0.2) | | sand (0.2–0.02) | | | dust (0.02–0.002) | | | clay (< 0.002) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1962 | 1990 | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 | 1962 | 1990 | 2010 |
| Ac | 12.82 | - | 41.68 | 43.20 | 34.8 | 21.90 | 27.75 | 24.1 | 23.60 | 29.00 | 41.1 |
| ACk | 15.02 | 6.49 | 48.19 | 54.26 | 34.9 | 13.40 | 18.90 | 21.6 | 23.15 | 20.35 | 43.5 |
| Ck | 13.25 | 4.56 | 43.60 | 60.99 | 35.1 | 17.50 | 15.45 | 20.1 | 25.65 | 19.00 | 44.8 |
| Cca1 | 9.30 | – | 45.50 | – | 42.1 | 22.70 | – | 25.2 | 22.50 | – | 42.7 |
| Cca2 | – | – | – | – | 56.2 | – | – | 29.4 | – | – | 40.4 |

Based on data from both, field and laboratory, on the size distribution in the first 2 horizons, was drawn the soil texture map of the studied territory (Fig. 3):

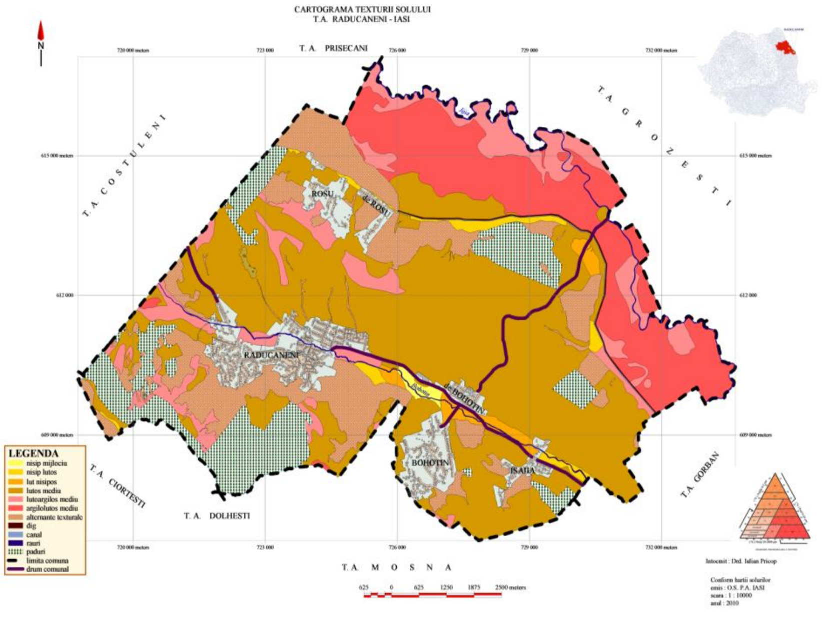


Fig. 3 – Soil texture map.

In Fig. 4, it can be seen that the loamy soil texture have the largest share in this basin, 47.92% of the 6,624 ha.

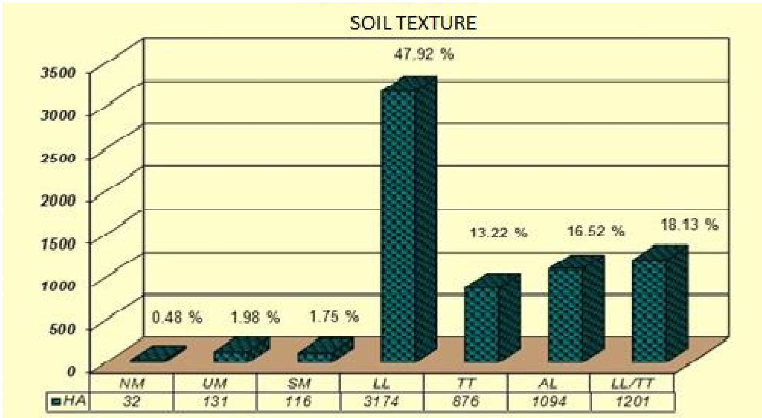


Fig. 4 – Textural classes in the studied area.

3.1.2. *Soil compaction*

Through compaction water circulation and aeration is reduced. Indicators for assessing soil compaction are: bulk density (Da), total porosity of soil (Pt), the minimum required total porosity (Ptmn), aeration porosity (Pa), the degree of compaction (GT), the resistance to penetration, plowed resistance. The evolution of soil compaction from the study area is evidenced in data presented in Tables 8,…,12.

**Table 8**
*The Degree of Compaction for Protisoils*

| Horizon | 1962 | | 1990 | | 2010 | |
|---|---|---|---|---|---|---|
| | Name | Code | Name | Code | Name | Code |
| Atsc | moderate compacted | mc | loose | af | low compacted | sc |
| Am | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |
| AGosc | highly compacted | fc | moderate compacted | mc | highly compacted | fc |

**Table 9**
*The Degree of Compaction for Cernisoils*

| Horizon | 1962 | | 1990 | | 2010 | |
|---|---|---|---|---|---|---|
| | Name | Code | Name | Code | Name | Code |
| Am | loose | af | loose | af | loose | af |
| AB | loose | af | loose | af | loose | af |
| Bv1 | moderate compacted | mc | low compacted | sc | low compacted | sc |
| BR | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |

**Table 10**

*The Degree of Compaction for Luvisoils*

| Horizon | 1962 | | 1990 | | 2010 | |
|---|---|---|---|---|---|---|
| | Name | Code | Name | Code | Name | Code |
| Ao | loose | af | loose | af | loose | af |
| Ao | moderate compacted | mc | moderate compacted | mc | low compacted | sc |
| AB | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |
| Bt1 | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |
| Bt2 | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |

**Table 11**

*The Degree of Compaction for Hidrisoils*

| Horizon | 1962 | | 1990 | | 2010 | |
|---|---|---|---|---|---|---|
| | Name | Code | Name | Code | Name | Code |
| Am | moderate compacted | mc | highly compacted | fa | low compacted | sc |
| AGrsc | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |
| Grsc1 | moderate compacted | mc | highly compacted | fc | highly compacted | fc |
| Grsc2 | highly compacted | fc | highly compacted | fc | highly compacted | fc |

**Table 12**

*The Degree of Compaction for Antrisoils*

| Horizon | 1962 | | 1990 | | 2010 | |
|---|---|---|---|---|---|---|
| | Name | Code | Name | Code | Name | Code |
| Ac | loose | af | moderate compacted | mc | low compacted | sc |
| ACk | moderate compacted | mc | moderate compacted | mc | moderate compacted | mc |
| Ck | moderate compacted | mc | moderate compacted | mc | Moderate compacted | mc |
| Cca1 | highly compacted | fc | highly compacted | fc | highly compacted | fc |

In the studied area, it wasn’t identified a manifestation of a process of soils compaction, natural or artificial. The evolution of soil compaction degree was determined by tillage carried out.

## 3.2. Evolution Analysis of Chemical Properties

3.2.1. *Humus content*

Research on humus content was made on samples taken from all soil types from studied area. We followed both current specific values (2010) and their evolution over the period 1962-2010. Table 13 presents the analysis on cernisoils.

**Table 13**
*Humus Content in Cernisoils*

| Horizon | 1962 | | | 1990 | | | 2010 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name | % | Code | Name | % | Code | Name | % | Code |
| Am | small | 2.58 | 03 | medium | 3.07 | 04 | medium | 3.63 | 04 |
| AB | small | 2.13 | 03 | small | 2.50 | 03 | medium | 3.54 | 04 |
| Bv1 | small | 1.59 | 03 | small | 2.15 | 03 | small | 1.97 | 03 |

Based on the results obtained on the determination in humus content in all soils types from Răducăneni territory was drawn the map of availability of soil organic matter (Fig. 5).

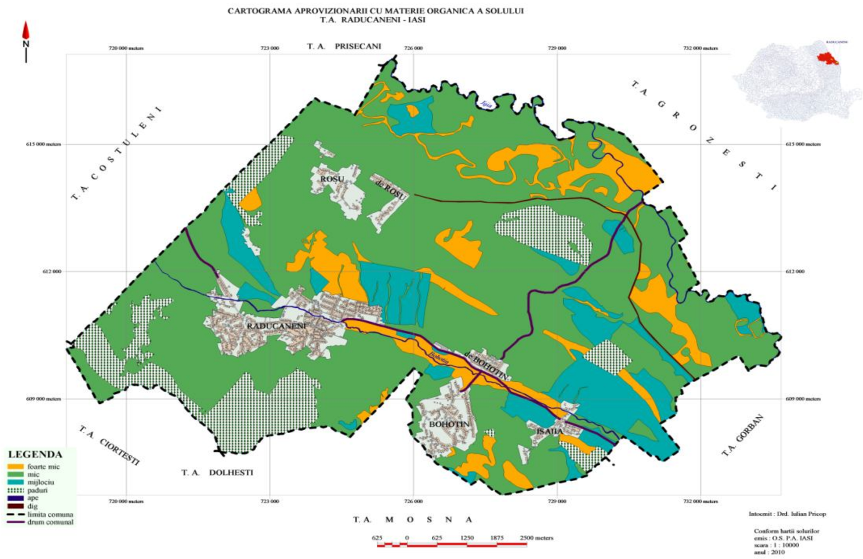


Fig. 5 – Availability of soil organic matter on Răducăneni territory

This map reveals as dominant in the studied area, the class of small humus content.

3.2.2. *Soil reaction*

Detailed studies have shown that from the total area of 6,624 ha, examined in 2010, only 1,424 ha (21,5%) have a neutral pH. The largest soil surface in this basin has alkaline pH (3,933 ha = 59.37%), which together with slightly acid soils (1,076 ha = 16.24%) occupy 75.61% of the area under study. Soils with moderate acidity represents 2.89% from which 2.07% are soils with moderate alkaline reaction and 0.82% soils with moderate acid reaction (54 ha).

**Table 14**
*Cernisoils Reaction*

| Horizon | 1962 | | | 1990 | | | 2010 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Name | pH | Code | Name | pH | Code | Name | pH | Code |
| Am | low acid | 6.60 | 6.6 | neutral | 7.0 | 7.0 | neutral | 6.94 | 7.0 |
| AB | low acid | 6.80 | 6.6 | neutral | 7.0 | 7.0 | neutral | 7.04 | 7.0 |
| Bv1 | neutral | 7.05 | 7.0 | neutral | 7.0 | 7.0 | slightly alkaline | 7.57 | 7.5 |
| Bv2 | - | - | - | - | 8.1 | 8.1 | slightly alkaline | 7.47 | 7.5 |
| BR | - | - | - | - | - | - | slightly alkaline | 8.02 | 8.1 |

Soil reaction classes, depending on the pH of the water suspension (1:2.5), were determined on the results from laboratory analysis. Processing these results, allow us to prepare soils reaction maps from Răducăneni area (Fig. 6).

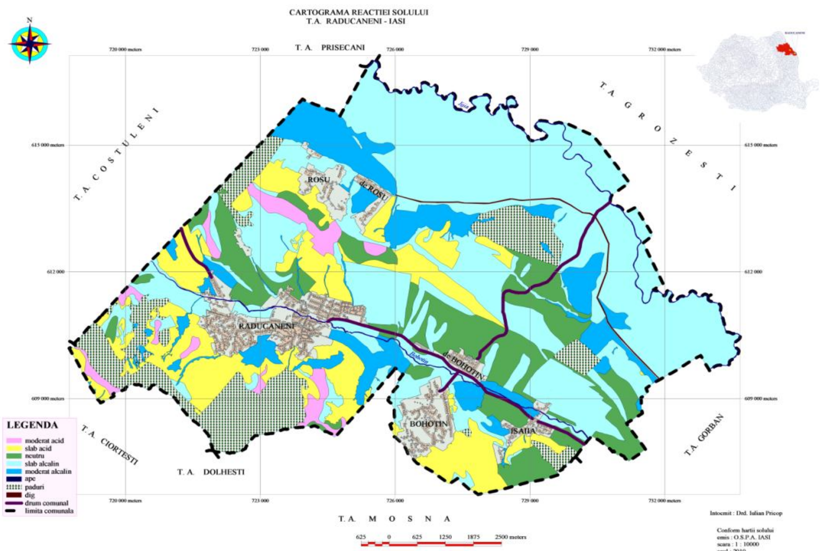


Fig. 6 – Soil reaction map from Răducăneni territory.

3.2.3. *Carbonates content*

Soil carbonates content (%) from Răducăneni territory is very different. The research results revealed the following:

a) *protisoils*: in 1962, the carbonates content from first horizon (5.64%) decreased to second horizon (3.15%). In 1990, the phenomenon is reversed, increasing from the first to the fourth horizon, from 1.5% to 11.4%. It should be noted that the profiles executed in 2010 were not found any carbonates;

b) *cernisoils*: analyzes showed that in 1962 they didn't contain any carbonates. In 1990 is showed a rate of 5.04% on the last horizon, and in 2010, in fifth horizon 1.19%;

c) *luvisoils*: it was identified the present of carbonates only in 1962 at 142 cm depth;

d) *hidrosoils*: in 1962, 1.2% carbonates on third horizon, increasing in 1990 on first three horizons (5.85%,…,8.35%) and in 2010 from 6.46% (first horizon) to 7.48% (second one). The evolution of carbonates content in hidrisoils during 1962,…,2010 revealed a decrease from second horizon to first one. This evolution process is attributed to carbonation and re carbonation processes;

e) *antrisoils*: in 1962, on 2 and 3 horizon were found carbonates and in 1990 and 2010 all horizon contain carbonates between 2.84% and 16.7%, respectively between 2.39% and 23.4%.

## 4. Conclusions

Soil quality knowledge presents a practical importance in that it is a basic component of fertility. Soil quality is an easily changeable appropriation being influenced by many factors. Soil quality analysis based on knowledge of the properties of all physical, chemical and biological weapons in close connection with the natural and anthropogenic factors operating in the area under study.

Răducăneni basin soil, from the point of view of quality has been maintained at the same level during the period of research. There were processes that lead to significant changes on the physical-chemical properties of soils.

To protect the quality of soils in the area under study, it is recommended to strictly respect the principles of sustainable management continuous monitoring of the development of physical and chemical properties and biological and operational intervention, through appropriate measures, when potential triggering degradation processes conditions are identified.

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## ANALIZA EVOLUȚIEI VALORILOR SPECIFICE ALE UNOR PROPRIETĂȚI ALE SOLURILOR DIN ZONA RĂDUCĂNENI, JUD. IAŞI

(Rezumat)

Studiul evoluției solurilor trebuie făcut în strânsă corelație cu dinamica factorilor naturali si a modului de utilizare a terenului. Solurile din bazinul hidrografic Răducăneni au fost cercetate cu ajutorul cartărilor. Cercetările efectuate au avut ca obiectiv cuantificarea modificărilor înregistrate de proprietățile fizice şi chimice ale solurilor identificate, determinate de acțiunea factorilor fizici şi antropici din zonă. Pentru aceasta, a fost analizată evoluția principalelor proprietăți fizice şi chimice ale solurilor, în perioada 1962–2010.

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# CONSIDERATIONS ON WATER MOVEMENT OF THE HEAD RACE WITH THE FREE LEVEL

BY

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**Abstract.** The paper presents test data regarding the hydraulic regime of the Strunga hydrotechnical gallery, located on the Timişeşti – Jassy head race. The gallery’s main purpose is to underpass, over a distance of 1,250 m, the Strunga hills. Over a period of 42 years the gallery functioned freely, fact that influenced its behavior in time, the stability of the hydraulic regime and the construction as a whole. At the moment the gallery is faced with a movement consisting of a sequence of gradually varied forms and rapidly varied forms. These movements have influenced the parameters of the flowing section leading to the appearance, development and conservation of the hydraulic erosion phenomena.

**Keywords:** gallery; hydrodynamic erosion; variable roughness; flows modelling.

## 1. Introduction

The supply systems are made up of constructions and installations Having the function to meet the requirements of consumers in population centres and industrial areas.

An important place in the functional system of water supply occupies the pipe ducts. They carry water from the source to the treatment plants, tanks-

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away or pumping stations. The head race achievement involves significant investments and special operating conditions. The operation of head race is continuous, and the interventions are limited in order not to disrupt the water supply to the system.

The phenomenon of water's flow can be head race:

a) flow with free head race gravitational level;

b) pressure flow (head race, pumping);

c) type mixed-flow (gravity + pump) in some situations.

Hydrodynamic regime parameters in certain situations can develop in water head race a destructive process continuously or variable in time. Multiple destructive actions to amend the parameters and functional you constructive and work together head race, lessens the mechanical resistances, jeopardizing the stability and decreases the safety in operation of construction. Most of the times, destructive effects remedy involves expensive and works which are carried out in extremely difficult conditions.

Water supply systems in the urban environment of Romania are, for the most part, current exploitation phase. Some water supply systems or some parts thereof lie in the third phase – the phase of aging, period characterized by increased wear, moral and physical. In this phase, the operation of water supply systems requires annual maintenance and repair expenses extremely high. At the same time, water supply systems conducted in the last 30…40 years no longer correspond to modern standards, which burden the relationship between manufacturer and user.

The head race water fall many times in phase III in the light of their age and the type of occupancy. At a certain time, the structural components of the water supply systems must be subject to the technical expertise for the evaluation of operation parameters and safety.

## 2. The Structural and Hydraulic Parameters of the Hydrotechnical Gallery

Water supply system of the city of Iaşi is connected to two sources:

a) a source of groundwater in the Verşeni area in Timişeşti and freatic layer of the Moldova River and river Neamțului;

b) a source from the surface through a capture on the Prut River.

From both sources goes to Iaşi municipality a number of pipe on a pipeline route varied as relief, geology, hydraulic parameters and mode of operation. Timişeşti source supply is achieved through two gravitational head race at the base who have been connected in recent years a number of secondary head race. The power source of the Prut River is achieved by pumping and use of five pipe ducts.

Gravitational pipe ducts in Timişeşti source has the following main features:

1. The first pipe was put into service in 1911…1913 and is made of cast iron, Dn 800 and Dn 600 on a length of about 144.0 miles until connecting with basic storage tanks of the municipality of Iaşi; head race operates almost 100 years.

2. The second pipe was put into operation in 1973 and comprises three sections.

a) the first section is made from two threads Dn 1000 PREMO on a length of 52 km;

b) the third section is achieved by a single thread Dn 1000 PREMO on last 52 km and linked to the tanks of the city;

c)between the two sections of head races is an integrated Gallery of engineering subcrossing of the Hill Strunga (drainage between Siret and Prut b.h. b.h., odds +285 m ... +290 m) which is basically the second section with a length of 1,324 m.

On their route to Iaşi, head race from source Timişeşti crosses Moldova River and then Siret River. The first pipe avoids subtraversarea Hill Strunga by using a route detour road.

In the last period were new sources of groundwater that complements on the primary. Flow rates are injected into the second pipe on the route (the home of the gallery).

The analyses carried out and technical surveys developed allow the statement of conclusions and observations concerning the structural and functional condition of head race from source as fallwos:

- head races Timişeşti-works continuously on large amount of years (the first in 1911-1913, and the second in 1973);

-potting geotechnical environment influenced while physico-mechanical parameters of cut-and-pipeline; resulted in a decrease of mechanical resistance;

-in the last period flow rates have been increased on the pipe for water supply and consumers, Iaşi County, and neighboring ones;

The gallery takes two gravitational flow transported pipes (PREMO Dn 1000) (Fig. 1) supplied in Timişeşti source and transfer them transport pressure

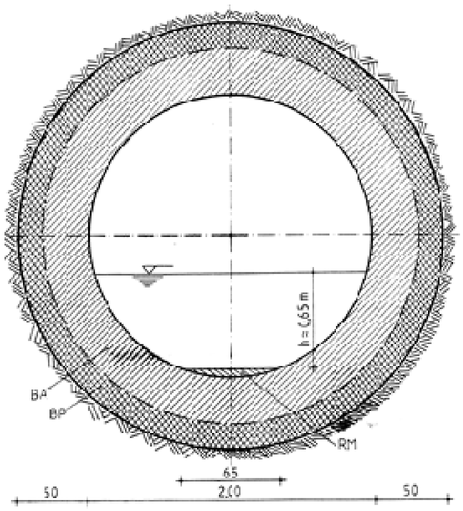


Fig.1. – The hydraulic analysis scheme.

pipeline (Dn 1000) connected to the city's compensation tanks. Gallery supply is achieved through a load, with rectangular section and depth of 6.0 m downstream, the flow into a well, where the level is adjusted by a jetty for putting under pressure of the gallery.

The length of the Gallery is of 1,324 m and the slope of the average value of 1.14 0/00. According to the longitudinal profile, the first half of the length, the slope is flood bed 1.0 0/00. On the last length of the Gallery, the slope is flood bed 1.28 0/00 (Luca & Hobjilă, 2000).

At the present stage, the Horn Gallery is operated in a flow with free level to allow carriage of flow rates increased over time.

## 3. The Result of the Study and Research

Research were conducted within the flow section (Fig. 2), as the Gallery has highlighted significant changes in the roughness of the wall. Centre, with influence over the way of distribution on the perimeter of the roughness. Flow with free level caused a flood bed processing by hydrodynamic erosion phenomenon. The roughness was clearly differentiated on the perimeter, with the formation of four dimensional characteristic areas. The hearth Gallery was modeled under the action of water currents, with the formation of cavities in the concrete mass and creation of big roughness influencing the process flow.

Fig. 2 – View of the flow section of the Strunga hydrotechnical gallery.

On the lower third of the perimeter of the flow section, but descendant, the effects of hydrodynamic erosion phenomenon. It continually shapes the roughness of the wall in the area of contact with water.

Analysis of the phenomenon of flow was achieved by simulating various functional situations possible to appear in the head race achieved in the form of Gallery. The analysis was carried out for movements in permanent and non-permanent flow regime. The analysis was done in the following situations:

a) the hydraulic analysis on the whole length of the Gallery;

b) hydraulic analysis on the first section of the Gallery;

c) hydraulic analysis on the second section of the Gallery;

d) hydraulic analysis on the third section of the gallery.

The deal Strunga Gallery was achieved from the hostel to the output according to the data obtained after the first simulation. In the simulation of flow phenomenon was used a spreadsheet program specializing on the flow in the pipeline with mixed sections (lines + curves). The analysis was conducted for a gap of variable flow rates and especially for situations to increase over time. Strunga Gallery was reviewed in terms of actual behaviour at the action flow carry and the response of the structure of the combined action of the resistance forces of the location. All at once, it was analysed the behavior of the Gallery to increase flow transport.

The Gallery has been analysed from the inside, along the entire length, for highlighting structural and functional status. Based on the data of land and interpreted with the help of simulation models for the analysis of hydraulic and mechanical behavior of the Gallery from the combined action of the action groups of the location.

Verify the current mode revealed hydraulic operation of the gallery in the current process of exploitation. This mode of operation is indistinguishable from those provided for in the project execution of the head race. It provided for a functioning under pressure performed by weir mounted in the home. Through this mode of operation would have been stopped the infiltrations from outside the gallery.

The roughness of the flow section is variable and shows the following values (Fig. 3):

a) on the bottom of the Gallery the roughness coefficients have approximating to average values $n$ = 0.013 ... 0.018 and maximum input area 0.018…0.022;

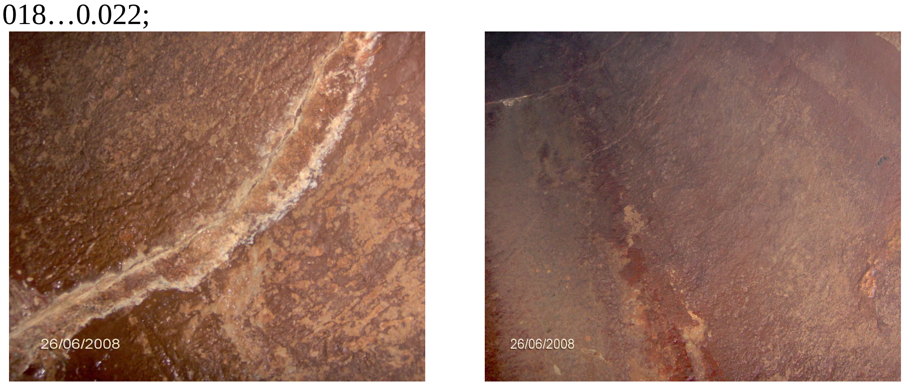


Fig. 3 – View of the flow section with various roughness.

b) on the sidewalls, where constantly in contact with the water, the approximate by values are $n$ = 0.015...0.019, depending on the position in the section over the gallery.

Longitudinal slope of the Gallery does not correspond with the longitudinal profile; the gallery presents a discontinuous gradient, due to (probably) cut-and-run technology, with values positive and negative values and maintenance of a water layer with heights of (20 .. 40) cm.

Visualization of flow in the section expert highlighted the fact that the gallery works being partially full. Water depth marked on the wall of the Gallery to an average annual flow has a value of 0.62...0.75 m, and the weighted average of 0.65 m and according to the review. From the point of view of the weir, the section of the Gallery is a section control and according to the observations in the field, the depth is variable, depending on the flow transport.

Analyses have shown that the flow in the modified section of the Gallery consists of a succession of uneven movements gradually varied and rapidly varied. The type of motion affects differently the functional condition and hydrodynamic stability of perimeter and watering of the gallery itself.

Theoretical and experimental, hydraulic analysis, (Fig. 4) performed inside the flow section and by simulating various possible situations in the process of exploitation, the increase in cross-flow perspective, show the emergence of phenomena of hydraulic instabilities in operation. Increase flow transported of the head race Timişeşti-Iaşi may cause intensification of erosion processes in the hydrodynamic input and a well functioning on the first section of the gallery.

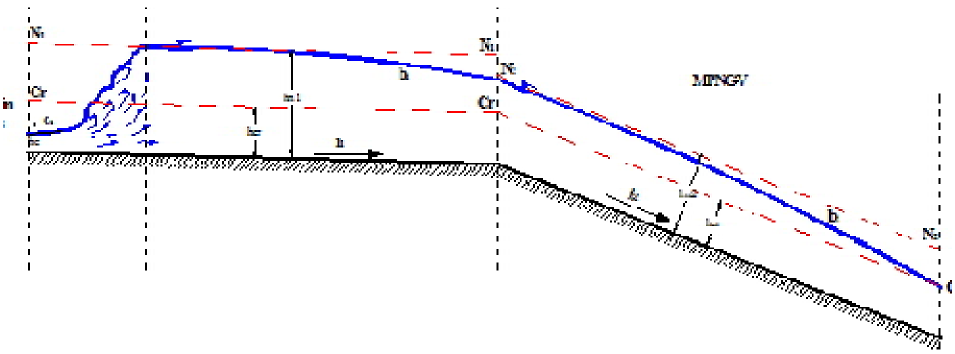

Fig. 4 – The water movement in the gallery Strunga hydrotechnical gallery.

Hydraulic results estimate that on the entry the process of hydrodynamic erosion due to high speed of water (6 to 9 m/s) is intensified. At the same time, damage to the flood bed can cause the phenomenon of cavitation on the first 10…30 m of input section.

This phenomenon combined with dynamic erosion can accelerate the process of degradation of the flood bed gallery in this area, observed by and to viewing the sections of flow.

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Researches have highlighted a continuous exchange of water between the gallery and the potting medium, through a process of infiltration – exfiltration. The water quality of the rock massif (likely sulphur mineral water) determines a chemical erosion of the materials of construction of the gallery. Worst-case situation from the point of view of the weir is recorded on the first section of the Gallery (about 60,...,110 m). According to the investigations into the gallery and data obtained through simulation, it follows that a distance of 20…95 m after the entrance in the Gallery, the water current plays in a supercritical state of motion. This fact is demonstrated by the flow section, where you record a hydrodynamic erosion is recorded and, with a heavy transport of material of various sizes.

Velocities recorded in this zone are values of 4.9 ... 9.2 m/s in the input section, depending on the value of depth control. In the final section of the supercritical state, moving speeds reach 1.70,...,1.790 m/s values. Still, supercritical movement goes a hydraulic jump in a slow motion, and that position is marked at different distances through the phenomenon of sedimentary silt.

## 4. Conclusions

Research has revealed the infiltration phenomena and exfiltration of engineering, with influence on potential mechanical behavior of construction in cooperation with the potting medium, leading to following conclusions:

1. Influence of hydraulic regime change by forming under the action of external and internal factors, the gallery presents engineering crazing, developed mainly on the transverse direction and having different values on its length of the Gallery.

2. Constructive Structure of its input and output part presents the degradation of flood bed and walls, with highlighting of transverse cracks through which produces a continuous process of infiltration.

3. In the area of connection of different structures of execution of the Gallery (reinforced monolithic concrete and composite wall), and in particular in the vicinity of exit are well developed cracks perimeter borders, which is a risk factor for the stability of the construction of water projects.

4. Flow Gallery section presents a phenomenon of hydrodynamic erosion variable on the length, more intensified on the input and less active on central and final sections.

5. The flow in the Gallery consists of a succession of uneven movements gradually variable and rapidly varied influences differently the functional condition and hydrodynamic stability.

6. The presence of differentiated regimes of flow is highlighted areas of erosion, as well as those filing positioned on the length of the Gallery.

7. The current operating mode of the Gallery can influence the quality of water transported water infiltration thanks sulfurous potting in the massive gallery through the cracks and surface water within the well.

Interpretation of data from the review allows the following general conclusions.

8. The head races of water is in a continuous operation on the great periods of time which determines the appearance of a destructive phenomena in hydraulic terms.

9. Hydraulic regime of the head racer is changed on the whole or on some structural elements for objective reasons but also subjective. The changes are determined by the functional parameters increase (debit) over time.

10. In the case study analysed it was found that after an operation for about 40 years, the Gallery has presented of specific hydrodynamic erosion the structural parameters of the head race.

11. The phenomenon of flow with free gallery level consists of a succession of uneven movements gradually variable and rapidly varieable influences differently the functional condition and hydrodynamic stability of perimeter and watering of the building itself.

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# CONSIDERAŢII PRIVIND MIŞCAREA APEI ÎN ADUCŢIUNILE CU NIVEL LIBER

(Rezumat)

Sunt prezentate date privind regimul hidraulic al galeriei hidrotehnice Strunga, situat pe aducţiunea Timişeşti - Iaşi. Scopul principal al galeriei este de a subtraversa, pe o distanţă de 1.250 m, dealurile Strunga. Pe o perioadă de 42 de ani, galeria a funcţionat cu nivel liber, fapt ce a influenţat comportamentul său în timp, stabilitatea regimului hidraulic şi construcţia în ansamblu. În acest moment galeria se confruntă cu o mişcare care constă dintr-o secvenţă de forme treptat variate şi forme rapid variate. Aceste mişcări au influenţat parametrii secţiunii de curgere care au dus la apariţia, dezvoltarea şi conservarea fenomenelor de eroziune hidraulică.

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# RESTORATION OF WATER COURSES

BY

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**Abstract.** In recent decades, in our country, water courses were significantly altered both in terms of geomorphology (geometry, sublayers, etc.) and geodynamic point of view. Each type of anthropical intervention produced a variety of morpho-ecological alterations and disruptions, depending on the type of the affected water flow, the length of the sector on which these works have been made, their age and spread. The morphological characteristics of water courses and ecological status are indicators of the functioning of aquatic environments. Thus, restoration of water courses is a priority for the Water Framework Directive, whose main objective is to achieve a "good status" of surface waters.

The paper presents the main types of anthropical interventions on water courses and the morpho-ecological alterations produced, underlying general principles of restoration for each type of hydromorphological pressure.

**Keywords:** ecological restoration; ecological reconstruction; water courses.

## 1. Introduction

From the analysis in river basin management plans, in our country in the year 2010 from a total of 3.399 water courses, 1.241 water courses are at risk of failing to meet environmental targets in 2015 . Of these, approximately

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half have significant hydromorphological alterations. Therefore, an essential part of the Management Plan is the program of measures, from which the most important steps are represented by restoration/reconstruction of water courses.

## 2. Basic Principles and Concepts of Water Courses Restoration/Reconstruction. Definitions.

The specialists in the “restoration” of damaged ecosystems in general, and the aquatic ones, in particular, have adopted the concept of *effective ecological restoration* with more than 25 years ago. Therefore, most of the "restoration" projects of water courses (lotic and lentic) have as defined aim the ecological restoration. Following the principles of ecological economy and sustainable development, the strategies and plans of management must target the conservation and restoration/reconstruction of water resources (adaptive potential, capacity of self-support and self-development ).

*Ecological restoration* represents a process that helps to restore an ecosystem that has been degraded, damaged or destroyed, a process of recovery and management of ecological integrity of an ecosystem. It is an organized activity that initiates or accelerates the recovery of the ecosystem considering its health (functional processes), integrity (species and communities of organisms) and sustainability (stress ressistance, adaptability). The goal of ecological restoration is to re-establish the functions of a degraded ecosystem and to maintain the biodiversity and health values of the restored ecosystems. A restored ecosystem should be a self-sustainable one so that biodiversity can continue to mature through natural processes and to respond in the long term to environmental changes.

*Ecological reconstruction* represents a "process of rebuilding of a new type of ecosystem after the destruction and/or other ecological regression of another one" (Godeanu, 1998). The new structure consists of some parts of the old ecosystem (climate and soil elements), but the biological component is different from the previous one, the attention being more on functionality than on ecological restoration of previously existing structures. In the case of ecological reconstruction the new ecosystem is a semiartifical one.

Referring stricly to the restoration of a water course, ecological reconstruction comprises of a set of activities (biological, chemical, etc.) which aim to improve water quality (reduce pollutants and increase the level of dissolved oxygen) . Furthermore, it targets to restore the water flow and sedimentation process, riverbed geometry, biodiversity, etc.

Ecological restoration includes a wide range of activities that vary depending on the degree of degradation of the ecosystem and the desired objectives. These activities can be: pressure/alteration sources removal, stabilization of banks, restoration of the riparian zones and wetlands, etc.

Nationally and internationally there are many different approaches to the concept of ecological restoration:

a) *Natural regeneration* is a ecological recovery process, whose development occurs without human intervention if it occurs in normal, natural conditions of recovery of the structures and functions affected by natural or anthropical causes. This process takes at least 2-3 years, but the effective recovery lasts mostly more than 20 years.

b) *Ecological restoration* is the process of recreation of an ecosystem after an ecological regression. This type of recovery aims to bring the structures and ecosystem functions to the original state that they previously possessed. (Godeanu, 1998). Environmental restoration is a highly complex process that involves the rehabilitation of previous structures and mainly of the biodiversity of the ecological system in question. This represents the recovery from a disturbed or totally altered state to a previous one, natural or anthropically modified.

c) *Ecological reconstruction* is "the process of rebuilding of a new type of ecosystem after the destruction and / or other ecological regression of another one" (Godeanu, 1998). In the new structure there are some elements of the old ecosystem , but the biological component is largely different from the previous one, the focus being more oriented on ecological functionality rather than on ecological restoration of previously existing structures.

d) *Ecological remediation* is a process of "healing" ecological systems seriously affected by natural or anthropical impacts using physical, chemical and biological methods (Godeanu, 1998). The purpose is to improve the ecological status of the water course, taking into consideration that its similarity to the initial state is not a mandatory issue.

e) *Ecological construction* is the process of creating artificial ecosystems within the human habitat which are made either to increase human comfort or for intensive food production. Its purpose is to be self-sustainable or not to require permanent maintenance works (Godeanu, 1998).

## 3. General Concepts Regarding the Restoration of Water Courses. Performance Levels of Restoration

According to the specialized literature, there were defined three categories of actions that have as objective the preservation and restoration of good morphological and ecological functioning of a water course:

1º *Preservation – in the case when the morpho-ecological functioning is still good (category P)*. In most cases it involves protection and management measures of lands that are threatened by latent anthropical pressure.

2º *Limitation of potential (future) malfunctions – in the case morpho-ecological functioning is spoiled but still correct (category L)*. There are no restoration operations needed, but it is important to apply some actions in order to block the ongoing malfunctions, such as: bottom thresholds for stabilizing an early deepening of the thalweg, space for mobility to avoid the deepening of the currently moderated thalweg, better management of water quality, etc.

3º *Restoration - in case of environmental/ water degradation (category R)*. Under Category R, there are three levels of restoration objectives (performance levels of restoration works):

a) ***Level R1***: restoring a section of the hydrosystem, mostly the one containing fish, in the case a real operation of functional restructuring can not be achieved. This issue concerns the establishment of structures for hydrological and habitat diversification : deflector, thresholds of reduced height, etc. This level of performance does not require a large land requirement and can be set up in the actual minor riverbed.It can be applied to urban areas where restrictions relating land are important.

b) ***Level R2***: performance level of restoration higher than level R1 . It is aimed the improving of all aquatic and riparian compartments: solid transport, aquatic habitat, riparian vegetation. This level requires a larger land requirement (from 2 to 10 times the natural width of the minor riverbed).

c) ***Level R3***: level R2 + concerns the ensuring of the right space for mobility and functionality. This level of performance, the most ambitious one, involves the completion of the process of functional restoration of the hydrosystem. The necessary land requirement in order for this level of performance to be effective is at least 10 times the width of the minor riverbed before restoration.

## 4. Preliminary Evaluation Criteria of the Presumable Efficiency of a Restoration Project

Although there are no precise rules about the custom parameters characterizing the structure and functions of ecosystems' water courses, it is estimated that they are associated with the following parameters:

a) hydrological regime;
b) size of the water course;
c) erosion and sedimentation;
d) the flooding area / riparian vegetation;
e) channel processes;
f) water quality;
g) aquatic and riparian species and related habitats.

Based on an extensive documentation from international technical literature, it is proposed a preliminary methodology that allows to evaluate, in a brief but rapid manner, the presumable efficiency of an ecological restoration project.

This efficiency is measured by determining the probable effectiveness score. The principle demonstrated by studies and restoration projects completed to date is the following: the result achieved after a restoration process is better if the water course is more active (more "powerful"), its banks are easier to erode and the solid intake is greater.

Thus the evaluation of the probable effectiveness score of the restoration is based on five variables as follows:

a) hydraulic capacity of the water course;
b) potential erosion of the banks;
c) potential solid intakes;
d) available land requirement of the section proposed for restoration;
e) water quality

### 4.1. Hydraulic Capacity of Water Courses

The evolution of aquatic habitats in flowing waters depends almost exclusively on the dynamics and morphology of the water course. By changing the sedimentologic and hydraulic conditions, the natural dynamics of the water course is disrupted. In natural conditions, water courses establish a balance between the sediment load and the fluid flow necessary for their transportation.

Dynamic equilibrium theory assumes that rivers adjust continously their dependent variables as a result of natural or artificial fluctuations of their independent variables. Consequently, on a water course in dynamic equilibrium are always ongoing processes of erosion or deposition, meanders migration to downstream or modification of the riverbed level.

The existence of these phenomena proves the vitality of the water course, in a constant search for balance.

Every water course disposes of a fairly wide range of variables in order to shape their own morphology. Among these variables the most important for the morphodynamic evolution of a water course are the following (Diaconu, 1999):

a) hydrographic basin geology that determine the nature of the available river deposits;

b) the usage of the land that conditions the potential intake of alluvial material;

c) hydrological regime, especially the floods (independent variable $Q$);

d) hydraulic slope of the flow $J$;

e) cohesion of the riverbed material which depends upon its sedimentology;

f) cohesion of the banks which depends on the nature sedimentology and on the plant coverage.

The regenerative capacity of the system depends on the balance between the potential energy and the cohesion of the constituent material of which the riverbed and banks are made of.

From a scientific standpoint, over the years, it has been proven that the ability to adjust/adapt a water course to various restoration processes was largely the result of its specific capacity (Brookes, 1988; Wasson, 1998) . The hydraulic capacity corresponds essentially to the result of the multiplication of two elements : slope and water flow. It characterizes the dynamic potential of the water course. Similar to this concept, in Romanian literature can be found the notion of "potential energy per unit length of the water course" (Diaconu, 1999).

Hydraulic capacity of a water course ($P$) can be calculated using the formula: $P = \gamma QJ$ watt/m, where $\gamma$ is the specific weight of water (9.810 N/m), $Q$ is the filling flow [cm/s], $J$ is the hydraulic gradient. Specific capacity is obtained by dividing the hydraulic capacity ($P$) by the width of the minor riverbed corresponding to the filling flow. It is expressed in [w/m$^2$]. The results obtained by Brookes permit the identification of different specific capacity thresholds, which are represented in Fig. 1.

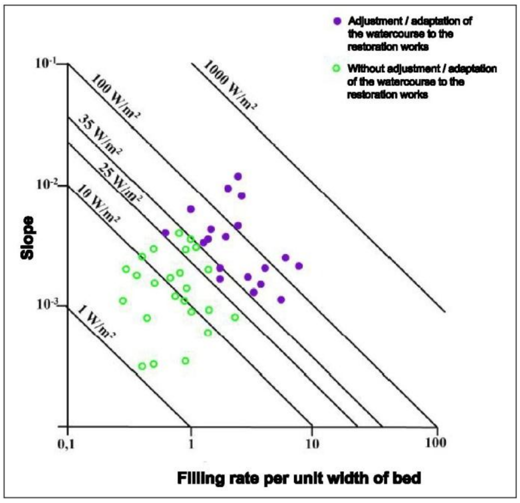


Fig. 1 – Specific capacity of a water course (after Brookes 1988, Wasson 1998).

A "major" threshold appears at about 35 W/m, value from which the natural capacity of harnessed water courses (regulations, etc) allows them to readjust/recalibrate from the morphological point of view and to find, step by step, a geometry more similar to the natural one. A "minor" threshold is visible at about 25 W/m. Other values of river capacities do not allow the identification of additional thresholds.

#### 4.2. Erosion of Banks

Yet unpublished studies of French researchers concluded that there is a link between the level of 25,...,35 W/m² and the characteristics of banks , especially related to their erosion capacity. Thus, water courses, whose hydraulic capacity is rated at 10,...,15 W/m (low capacity) may have a relatively important geodynamic activity if their banks are slightly or not cohesive and if they get a certain amount of upstream coarse sediments, which by submission – on one bank of the water course – activate the erosion processes on the opposite bank. As far as „stronger" water courses are concerned (40,...,50 W/m), flowing in beds made up of cohesive sediments (silty sands, clays), they will probably be less active, especially if the solid contributions coming from upstream are in a relatively small amount.

A simple approach is to define erosion classes (grades) depending on the appearance of the banks (Fig. 2).

No erosion

Poor erosion

Average erosion

Significant erosion

Fig. 2 – Examples of different degrees of bank erosion.

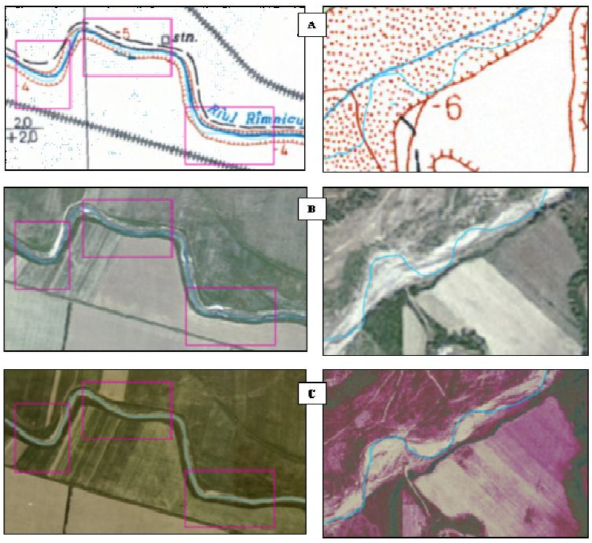


Fig. 3 – A – 1:25000 topographic map; B – satellite images 2.5 m resolution; C – orthophotoplan 0.5 m resolution.

Another way to evaluate bank erosion is the comparison of maps made at different points in time. The national available maps, that can be considered for this analysis, are the following (Fig. 3):

a) 1:25,000 topographic maps, 1955 DTM edition and 1980 DTM edition;

b) SPOT Satellite Images, resolution 2.5 m – made in 2004-2006;

c) orthophotoplanes, resolution 0.5 m, made in 2007.

In order to identify sectors subjected to erosion and to map the areas of interest, particularly useful are the topographic maps made at scales of 1/10,000, 1/25,000.

### 4.3. Solid Contributions

Besides activating the lateral erosion, upstream coarse sediments intake is extremely important in terms of riverbed sedimentary deposits formation.

For evaluating solid contributions on a water course, the available information in Romania are the following:

a) Zoning of the average specific flow of sediments in suspension [t/ha.year] (Diaconu, 1971) (Fig. 4).

b) Multiannual specific average flow of sediments in suspension [t/ha.year]; in this case measurements regarding the flow of sediments in suspension are available at hydrometric stations. These measurements are synthesized in daily average sheets and processed as graphs of correlation $R = f(Q)$ . It is specified that at some hydrometric stations, measurements of the riverbed sediments are performed.

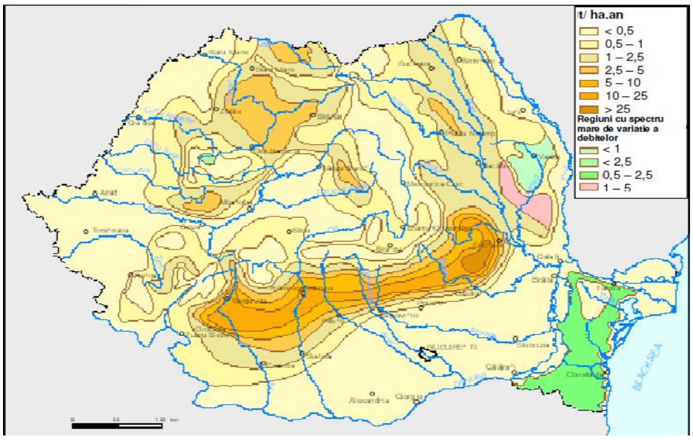


Fig. 4 – Areas of sediments flow in specific average suspensions [t/ha.year] (Diaconu, 1971).

It is said that the flow of sediments in suspension quantitatively reflects the alluvial transit on the river segment and the flow of hauled sediments (added to the one conveyed in suspension) reflects the total amount of transported sediments.

Another approach is based on the analysis of the aerophotogrammes available in Romania (for medium and large rivers) and SPOT satellite images (with plane resolution of 2.5 m). Based upon these ,sedimentary deposits (alluvial benches) visible on the orthophotoplanes can be mapped in a simple manner (as a point). Afterwards the result can be presented as a synthetic map that can allow the highlighting of water courses according to the density of areas with sedimentary deposits (proposed criterion: no. Of sedimentary deposits/water course km). This approach is used also by the French National Geographic Institute („BD Orttho") – Fig. 5.

Fig. 5 – Examples of localization and mapping of visible sedimentary banks.

The disadvantages of using this method to precisely reflect the solid transport in a water course are the following:

a) high flows at the moment of the sattelite image capturing can mask the presence of alluvial deposits;

b) presence of riparian vegetation at the moment of the sattelite image capturing can cover the water course.

c) the backwater area generated by thresholds or dams, can mask existing deposits by flooding.

#### 4.4. Land Requirement for the Proposed Restoration Section

Land requirement for the proposed restoration section is evaluated according to the socio-political context of the restoration project. It is analysed whether the set up limitation to the actual riverbed is mandatory or if the alluvial expansion space can be multiplyed (1 to 10 times the riverbed width(B)).

#### 4.5. Water Quality

Water quality must be evaluated in accordance with the current legislation. Order 161/2006 for approving the norms concerning the classification of surface water quality is used in order to determine the ecological status of water courses. According to part. (1), water courses are classified based on biological quality, hydromorphological, chemical and physico-chemical elements, in five states: very good (I), good (II), moderate (III), poor (IV) and bad (V).

4.5.1. *The Main Hydromorphological Alterations and Associated Morpho-Ecological Disruptions*

In our country, in recent decades, water courses were significantly altered both in terms of geomorphology (geometry, substrate, etc.) and geodynamic point of view. Each type of anthropical intervention produced in time a variety of morpho-ecological alterations and disruptions, depending on the type of the affected water flow, the length of the sector on which these works have been made, their age and extent.

The main types of anthropical interventions on water courses, based on which the general principles of restoration are proposed (for each type of hydromorphological pressure), are the following :

a) correction of water courses (cutting of crooks, meanders);

b) regularization of water courses beds (corrections and recalibration of beds);

c) removal of riparian vegetation;

d) protection / consolidation of banks;

e) implementation of dams;

f) execution of thresholds and transversal works on water courses;

g) removal of gravel from water courses' beds.

## 5. Conclusion

The human being became over the years a dominant and undisputed force of the world through his intelligence and his capacity of constructing and also of modifying continuously the environment. However, it must not be neglected that he will permanently be dependent of the natural environment as a user of the natural resources. This fact makes him direcly responsible for their adequate management.

Taking into consideration the importantance of maintaining or bringing in a good condition the state of water courses, it is mandatory to give the proper attention to the ecological processes of river restoration.

The reconstruction, rehabilitation and restoration of aquatic ecosystems require detailed research for every type of water course, with respect to the concept of integrated management of water courses.

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## RESTAURAREA CURSURILOR DE APĂ

(Rezumat)

În țara noastră, în ultimile decenii, cursurile de apă au fost semnificativ alterate atât din punct de vedere geomorfologic (geometrie, substrat, etc.), cât şi din punct de vedere geodinamic.

Fiecare tip de intervenție antropică a produs în timp o mare varietate de alterări şi disfunctionalități morfo-ecologice, în funcție de tipul cursului de apă afectat, lungimea sectorului pe care s-au realizat respectivele lucrări, vechimea şi amploarea acestora.

Caracteristicile morfologice ale cursurilor de apă şi starea ecologică reprezintă indicatori ai stării de funcționare a mediilor acvatice. Astfel, restaurarea cursurilor de apă este o prioritate a Directivei Cadru privind apa, a cărui principal obiectiv este de a obține o "stare bună" a apelor de suprafață.

Lucrarea prezintă principalele tipuri de intervenții antropice asupra cursurilor de apă şi disfunctionalitățile morfo-ecologice produse, care stau la baza principiilor generale de restaurare, pentru fiecare tip de presiune hidromorfologică, în funcție de obiectivul de restaurare propus.

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# METHODS OF SPATIALIZATION OF SOIL POLLUTION PUNCTUAL PARAMETERS

BY

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**Abstract.** This paper sets out the main interpolation methods used for the spatialization of punctual parameters in order to develop a soil numerical model (MNT). This model will represent an information layer used in a Geographic Information System (GIS). The paper also contains considerations on the use of these methods in the study of soil pollution processes.

**Keywords:** interpolation; spatial; parameters.

## 1. Introduction

The soil pollution phenomena are of spatial nature and are characterized by an obvious variability of the specific parameter values (e.g., the concentration). Due to the fact that for the evaluation of these we perform actions in order to take soil samples by means of a limited number of profiles randomly distributed in the region, after the laboratory test we can only obtain punctual information.

Based on the limited number of profiles and samples, respectively, it is only possible to approximately characterize the condition of the soil degradation for the entire impaired territory, and it is difficult to develop, in due time, the

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best intervention actions. This inconvenient has improved a little in order to serve as a Numerical Land Model (MNT) which is based on the spatial interpolation technique.

The MNT represents a database in the form of an IT file where the data is organized in a matrix, and each value represents a numerical characteristic of a geographic point or unit. In the strict sense, a soil numerical model refers to the numerical representation of the spatial distribution of a feature on a topographic surface (Chaloz, 1992). In this context it can be called: Spatial variation model of a phenomenon.

Depending on whether the points whose soil parameters (for instance) are known are evenly or unevenly ordered in space, we can talk about the mesh model or the irregular model (*e.g.*, triangular). In case of the mesh model, the points coincide with the intersection of a regular mesh. Starting from the source data, the concentrations of various pollutants (in our applications) representing the MNT generally result by means of an interpolation.

The MNT is about to become one the most used “layer” of information in a numerical SIG, an excellent explanatory way for very numerous phenomena.

## 2. Methods of Interpolation

The interpolation methods used for the development of MNT can be classified into two major categories: *global* methods and *local* methods.

The methods of *global interpolation* consist of establishing continuous mathematical functions (polynomial functions, Fourier series etc.) adjusting all the known measuring points. The interpolation function is defined based on the tridimensional coordinates of the test points (Burrough & McDonnel,1998). Considering the case of representation of a topographic surface by means of a second degree polynomial function ($f$), such function is defined by the formula below, where $C$ represents the concentration of a polluting element found in a soil profile, $x$ and $y$ are the coordinates of the points, and $q$ the coefficients of the polynomial:

$$C = f(x,y) = q_0 + q_1x + q_2y + q_3xy + q_4x^2 + q_5y^2. \quad (1)$$

Each test point generates an observation formula. The number of this formula should be n, namely equal with the one of the test points. Taking into consideration the fact that the number of equations is higher than the number of unknown parameters ($q_i$), the principle of least squares can apply.

The global methods can be used in order to analyze the spatial trends of pollution phenomena, but rarely for an interpolation during the construction of a grid. They have the major flaw of not passing necessarily through the test points. For these reason, often one can notice obvious differences from the actual value in the immediate vicinity of a test point. In fact, these are smoothing functions (Zeiler, 2002). They express a trend of the surface. That is why these have been called “trend surface”. The *local interpolation* methods are used more often than the previous ones because generally they generate more realistic estimates. Depending on the complexity degree, they authorize the entry, in the *form of weight*, of information concerning the reviewed phenomenon and of statistics for the estimate of the potential error margin during the interpolation (acc. to Kriging).

According to the principle thereof, these methods estimate the “value” of each point of the mesh network by means of the test points located in the vicinity thereof. The elements defined for such transformations are: the location of the mesh points – called *knots* of the mesh -, the concept of vicinity and the influence on the “weight of the neighboring points” (Collet, 1989). The main methods of interpolation based on this weighting concept are the method of the closest neighbor, the method of the weighted running mean, the Kriging method, the triangulation method and the B-spline method.

• **The method of the closest neighbor** is the simplest one and consists of assigning to an unknown point the value (*e.g.*, the concentration of a polluting element) of the closest test point (weighting equal with 1). This method requires a high density of measuring devices in order to avoid the effect of scales entered in the model.

• **The method of weighted averages,** more adjusted for the interpolation of MNT, is a simple and common numerical technique. This considers the concentration value of a polluting element at a certain point as the linear combination of the test concentrations at other surrounding points, weighted by the reverse distance between the latter and the position where the interpolation will take place.

According to the principle of weighted averages, the attribute value of the phenomenon (dependent variable) of an unknown point, $C_i$ (the concentration, in this case), for the regular grid type MNT of this point representing each knot, is determined based on the attribute values at the control point $j$ ($C_j$) according to the next formula, where $x$ and $y$ represent the coordinates, $p$ the weight and n the retained test points (independent variables):

$$C_i = \frac{\sum_{j=1}^{j=n} p_j C_j}{\sum_{j=1}^{j=n} p_j}; \quad p_j = \left[\sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2}\right]^k. \quad (2)$$

The exponent k depends mainly on the type of concentration variation in the region; a value of $k = 2$ provides reasonable results.

The grid is established in two stages. The first calculates the rectangular coordinates of the grid knots, and the second, by means of interpolation, the estimated value of the parameter (concentration of the polluting element) at this point (acc. to Fig. 1).

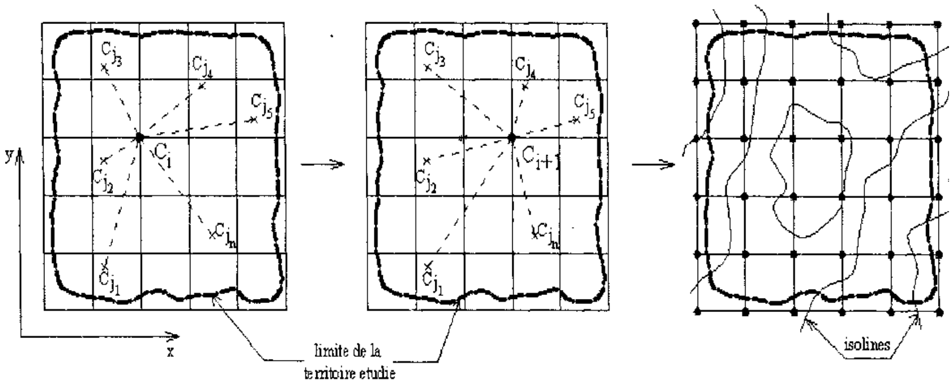


Fig. 1 – Interpolation according to the method of weighted averages.

The first operation is strictly geometrical and shows no difficulty; the two spaces fully overlap. On the contrary, the second is much more delicate. What size of window should we use? How many test points? What weight should be assign? In case the distribution of the test points is not uniform around the points to be estimated, certain authors propose the division of the window into quadrants or octants, with an identical number of points.
The method of weighted averages provides viable results in most cases [Burrough, 1986], however cannot provide values higher or lower than the values of the test points.

- **The Kriging method** uses a concept of statistical weighting in order to mitigate the estimation error. The weight to be assigned to the test points and the best size of the window within which the points are analyzed, are defined by means of the autocorrelation function (or variogram) established previously by means of interpolation. The distribution of the test points is taken into consideration by means of a system of matrix equations, expressing the relations connecting these points together and with the interpolation point. The resolution of this system provides the coefficients which enable us to calculate the interpolation as well as the corresponding error estimates.

The kriging represents an efficient solution, but the viability of this estimate is variable and mainly depends on the precision of the autocorrelation function (Burrough, 1998, Popovici & Biali, 2000). Nowadays, numerous software programs running on the PC (Surfer, UNIRAS etc.) contain kriging modules.

- **The triangulation method** (TIN – Triangulated Irregular Network).

The selection of an interpolation method also depends on the structure of adopted data. In a MNT based on a regular grid, the method of weighted averages is generally used. With respect to the MNT based on TIN, the support points are connected together by means of a triangular mesh network (Fig.2).

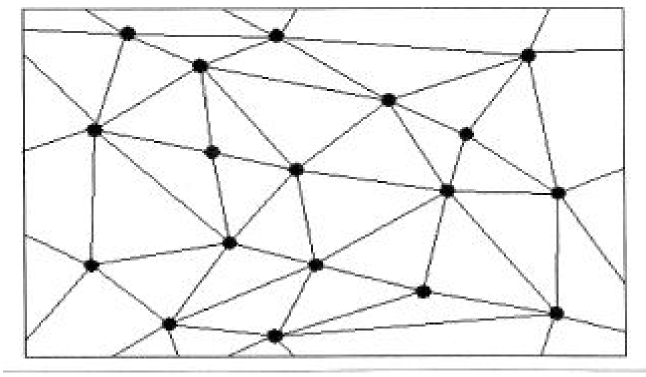

Fig. 2 – Example TIN - Triangulated Irregular Network.

The variation of the parameter along the values of the triangles is supposed to be linear. By connecting the points of equal values we can draw lines of isovalues. Many software programs based on vector type data operate according to the TIN principle (*e.g.*, ARC/INFO).

• **The B-spline method** enables a local adjustment with a poor polynomial order (the 3rd degree is currently used) and only refers to a limited number of test points; the adjusting polynomials are calculated step by step by moving a window which generally incorporates four test points. That way, the interpolation is performed at a relatively high speed.

## 3. Conclusions.

In this work we set out the most common procedures of interpolation existing in the currently available SIG software programs.

The polygons of Thissen - Voronoi are well known in hydrology for the establishment of spatial distribution of the recorded rainfall, but strictly speaking, this is not a method of interpolation, because it has certain serious limitations. This model has a qualitative value and is appropriate for rough approximations in the absence of more elaborated methods.

This work highlights the importance of selecting the interpolation methods and the role of IT systems in the environment projects.

The implementation of a MNT in a SIG/GIS type project enables the licensed establishments to perform an integrated ecological monitoring, foundations based on parameters and indexes with spatial and time distribution provided in "real time", the information framework required for the strategy related to overcoming the negative consequences of pollution on the soil quality, for developing forecasts and for exercising the efficient control on the actions for the ecological rehabilitation of the analyzed region.

This approach requires the development and management, by means of an electronic control unit, of two databases: one of spatial/graphic type (the topographic layout in numerical/digital format over the analyzed region) and an attribute/descriptive type database, which surrounds the alphanumerical type data of each polluting element, the sources etc.).

By knowing this data, the number of soil profiles on the land, the rectangular coordinates of these profiles and, for instance, the concentration degree for all polluting elements, by means of a specific software program, of SIG/GIS type, we have the opportunity to establish and expose other characteristics of the pollution, such as: the maximum, minimum, average values, the reliability notes, the segmentation of the region in different classes, the graphic layout based on frequency etc. These databases can be updated at all times.

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METODE DE SPAŢIALIZARE A PARAMETRILOR PUNCTUALI DE POLUARE A SOLURILOR

(Rezumat)

Sunt prezentate principalele metode de interpolare utilizate pentru spaţializarea parametrilor punctuali, în scopul de a dezvolta un model numeric de teren (MNT). Acest model va reprezenta un strat de informaţii utilizat într-un sistem de informaţii geografice (GIS). Lucrarea conţine de asemenea consideraţii cu privire la utilizarea acestor metode în studiul proceselor de poluare a solului.

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# RESEARCH REGARDING THE DETERMINATION OF WATER QUALITY PARAMETERS AND LAND USE OF MOLDOVA RIVER

BY

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**Abstract.** The paper presents studies regarding the surface water quality monitoring in the basin of the Siret River. Water samples used in the study were taken from the river in three monitoring sections: Baia, Fundul Moldovei and Gura Humorului. For these samples were determined a number of parameters of surface water quality: the content of chlorides, calcium and magnesium. The monitoring data has found the following: water quality of River Moldova surpassed the maximum permissible values for indicators of calcium and magnesium, resulting a decreased water quality in 2006. Moldova River water quality in 2007 was influenced by the presence of indicators magnesium and calcium, which had exceeded the allowed river water quality in 2008 too, even in these conditions Moldova registered a positive evolution in terms of water quality compared to previous years.

**Keywords:** quality parameters; water quality; sources of pollution; GIS; land use.

## 1. Introduction

Siret River Basin is located in the East-Northeast region, with an area of 42,890 km$^2$, which, in Fig. 1, represent 18% of total area of Romania.

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The average altitude of the basin is 515 m and average slope is 0.5 ‰. In Siret River Basin were coded 1013 streams, representing a total network of 15,157 km long river which represent 19.2% of the total network length encoded in the country.

The main rivers are the Siret River and its tributaries that collect all the water on the Eastern side of the Carpathians rivers namely Suceava, Moldova, Bistrița, Trotuş, Putna, Ramnicu Sărat and Buzău River (Giurma *et al.*, 2001).

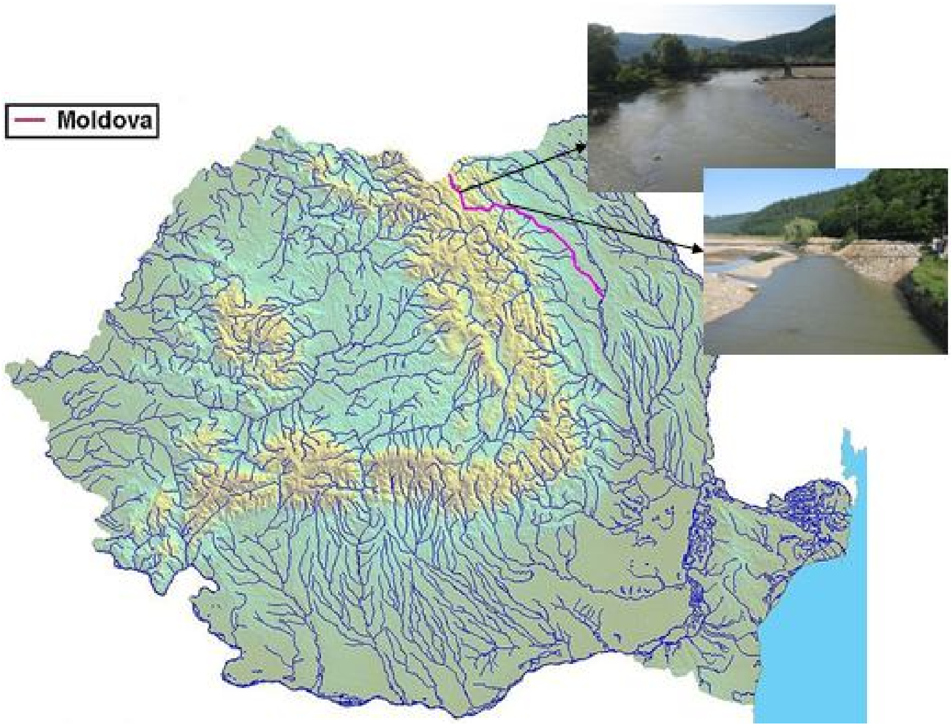


Fig. 1 – Moldova River Basin the boundaries of river.

Moldova River flows over a length of 237 km NW - SE and crosses the territory of three counties: Suceava, Iaşi and Neamț. From its 150 km length is located in Suceava County, where river basin Moldova occupies over 35% of total area of the county.

Through Suceava County, the river passes through areas with more pronounced slope (Pojorâta, Prisaca) and areas where the slope drops to less than 3 m/km. Through Iaşi County, Moldova River flows over a length of 30 km, with an average flow of 31.1 $m^3/s$.

Moldova River increases water runoff and silt along its flow so that the averages annual (multi-values) are: 3.75 m/s at Fundu Moldovei, 7.56 m/s at Prisaca Dornei, 18.1 $m^3/s$ and Gura Humorului, 35.5 cm/s at Tupilați and the same value in Roman.

## 2. Material and Methods

### 2.1. Study Area and Land Use Data

The main sources of river pollution in Moldova can be ranked according to: the impact on the pollutant toxicity evacuated in receiver, potential or actual danger they pose to downstream users, the amount limits set for evacuated contaminants .

Depending on the development of mining activities, water quality and river tributaries of Moldova was variably affected. In recent years a number of mines have closed, but insufficiently treated mine water effects are not completely eliminated.

Mining is an important environmental risk factor. Mining and processing useful mineral substances, mainly in the mountainous area have lead to increased anthropic landscape modification. Tens of meters of deep excavations resulted in tailings deposits, waste dumps, tailings ponds .

In the upper basin of Moldova River there were two large mining: Fundu Moldovei and Leşu Ursului who were exploiting manganese, zinc and copper.

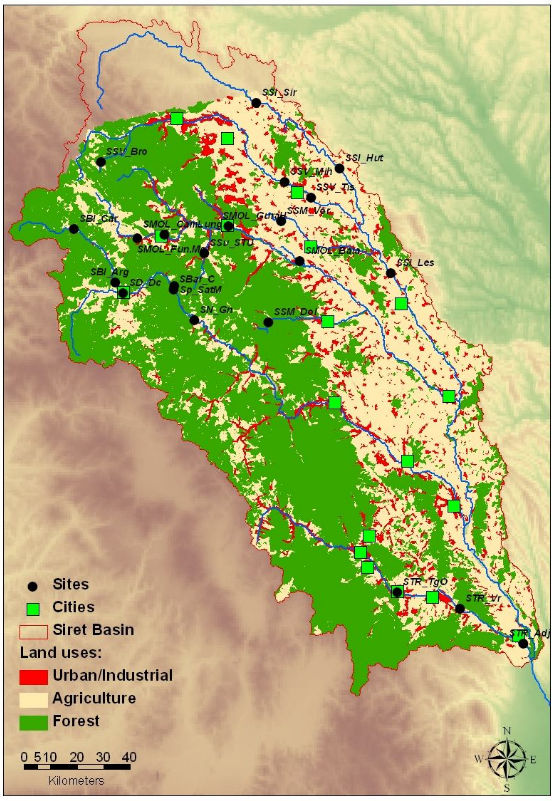


Fig. 2 – Study area of Moldova River basin; the boundaries of river and land use.

Depending on the development of mining activities, water quality affluent Moldova and its river was variably affected.

In what follows, we analyze data base of 22 sites in the Siret River Basine and 3 sites in the Moldova River (Fig. 2) using a newly developed GIS (Geographical Information System).

The main sources of pollution in the catchment area (Table 1) have influenced the state of its river water quality. The highest pollution input was recorded in the Moldova Basin coming the tow tributaries (Gura Humorului and Baia) due at least partly to the collection of urban wastes from the metropolitan of Suceava.. Mean values of Ca, N-NH4, RF, Na due to extensive urban use and accidental pollution.

**Table 1**

*Description of Total Drainage Area of Upstream Sub Catchment (DA)*

| Section Moldova River | Urban % | Mines % | Agriculture % | Forest % | Water % |
|---|---|---|---|---|---|
| SMOL_Baia | 40.18 | 0.00 | 59.82 | 0.00 | 0.00 |
| SMOL_CamLung | 75.34 | 0.00 | 5.1 | 19.56 | 0.00 |
| SMOL_Fun Mol | 32.64 | 0.00 | 37.88 | 29.48 | 0.00 |
| SMOL_GuraHum | 57.87 | 0.00 | 0.00 | 35.79 | 6.34 |

The development of GIS tools has allowed more sophisticated questions to be asked about how community composition in a stream is related to its physical setting at a variety of scales (McDonnell, 2000). In this context, attention has often been focused on whether conditions in the catchment have been strongly modified by human influence, (agriculture, forestry, mining, industry) or are largely natural (Basnyat *et al*., 2000; Manel *et al*., 2000; Prosser *et al*., 2001).

In the process of pollution, rivers in a watershed play a major role in assimilating or carrying off municipal and industrial waste water and runoff from agricultural land (Alexander *et al*., 2000; Singh *et al*., 2005). Thus, it is imperative to prevent and control river pollution. Spatial and temporal variations in water chemistry and the locations of the most significant contributors to pollution in a river basin must be clearly identified; this usually requires a monitoring program that will provide a representative and reliable estimation of the quality of surface waters (Alexander *et al*., 2000; Simeonov *et al*., 2003).

Identification of the point source and non-point source pollution in a watershed with complex river network is an environmental conundrum. Different multivariate approaches offer powerful means of understanding a large environmental datasets and the physical-chemical status of study systems (Simeonov *et al*., 2003; Singh *et al*., 2005; Zhou *et al*., 2007).

Land use percentage composition for each site was quantified with four different spatial scales. Total upstream drainage are for each location was delineated based on data and images form the USGS HydroSHEDS and

BioFresh data portal - Biodiversity of Freshwater Ecosystems, http://data.freshwaterbiodiversity.eu/shapefiles.html and http://hydrosheds.cr.usgs.gov.

### 2.2. Physical Chemical and Sstatistical Analyses

The pollution loads of urban point source are non-point sources. It indicates that the amount of Ca, from urban point sources is about 57% of the total (Fig. 3). So, point sources are overwhelmingly and should represent the priority for control and abatement. Non-point pollution sources should also be paid adequate attention.

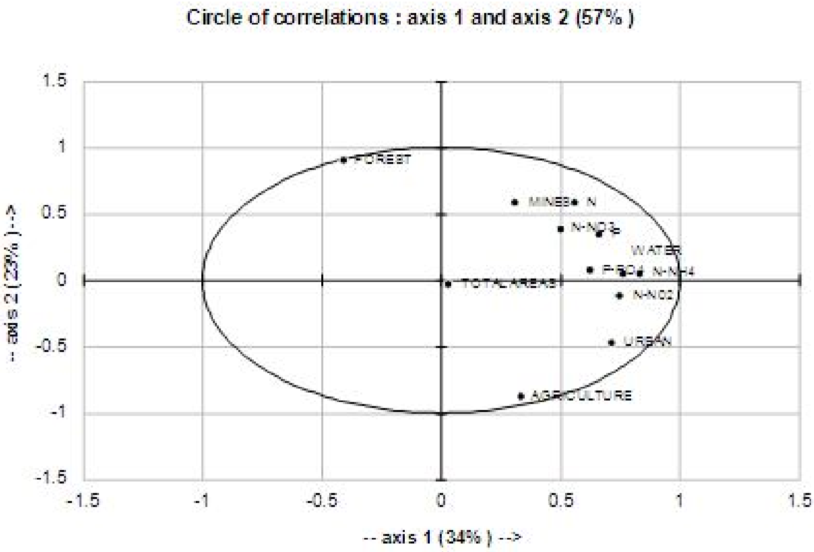


Fig. 3 – Correlation of non-point pollution sources of river and land use.

According to the characteristics of their special distribution, the pollution sources are classified as point sources, non-point sources and internal sources discharged into rivers and lakes.

**Table 2**
*Correlation and PCA Analysis with Coefficient Type Sperman's*

| Moldova River (basin) | Urban (basin) | Agriculture (basin) | Forest (basin) | DA (basin) | Cl | Ca |
|---|---|---|---|---|---|---|
| Urban (basin) | 1 | 0.5720 | –0.7064 | 0.2772 | 0.7391 | 0.5404 |
| Agriculture (basin) | 0.5720 | 1 | –0.9774 | –0.0435 | 0.1925 | 0.2445 |
| Forest (basin) | –0.7064 | –0.9774 | 1 | –0.0073 | –0.3123 | –0.3055 |
| DA (basin) | 0.2772 | –0.0435 | –0.0073 | 1 | 0.1372 | 0.1316 |
| Cl | 0.7391 | 0.1925 | –0.3123 | 0.1372 | 1 | 0.6556 |
| Ca | 0.5404 | 0.2445 | –0.3055 | 0.1316 | 0.6556 | 1 |

The urban point pollution sources are the principal sources, the non-point pollution sources take the second place, and the internal pollution sources are less significant. So waste water treatment plants in cities and towns along the main route should be built as soon as possible to ensure the water quality in Water Framework Directive (WFD) (2000/60/CE).

The main sources of river pollution in Moldova can be ranked according to: the impact on the pollutant toxicity evacuated in receiver, potential or actual danger they pose to downstream users, the amount limits set for evacuated contaminants.

The purpose of the Moldova River water quality monitoring was to determine the concentrations of: chlorine, calcium and magnesium ions in the period 2006-2008.

River Moldova water quality monitoring in the section Fundu Moldovei, in 2006, was on integrated part of the state „very good", but Gura Humorului monitoring sections and Baia, where calcium and magnesium indicators led to decreased water quality, was integrated in state as „ good" .

From the viewpoint of the chlorine content of analysed water, it proves that the maximum amount of chlorine indicator registered in the Moldova River, in 2006, was 16.2 µg/L (Fig.4).

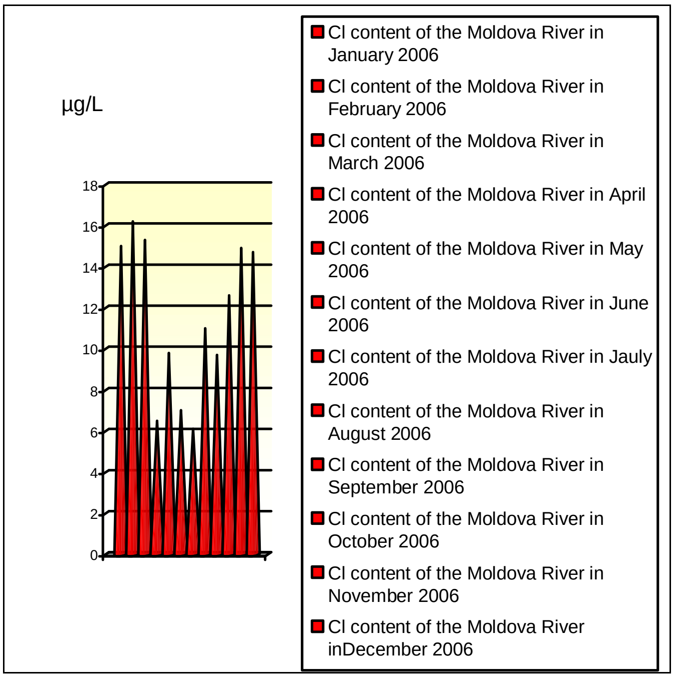


Fig.4 – Variation of Cl ion concentration of Moldova River (2006).

Concentration of calcium ions in the waters taken for monitoring river water quality of Moldova in 2006, reached the maximum value of 99.7 µg/L (Fig. 5).

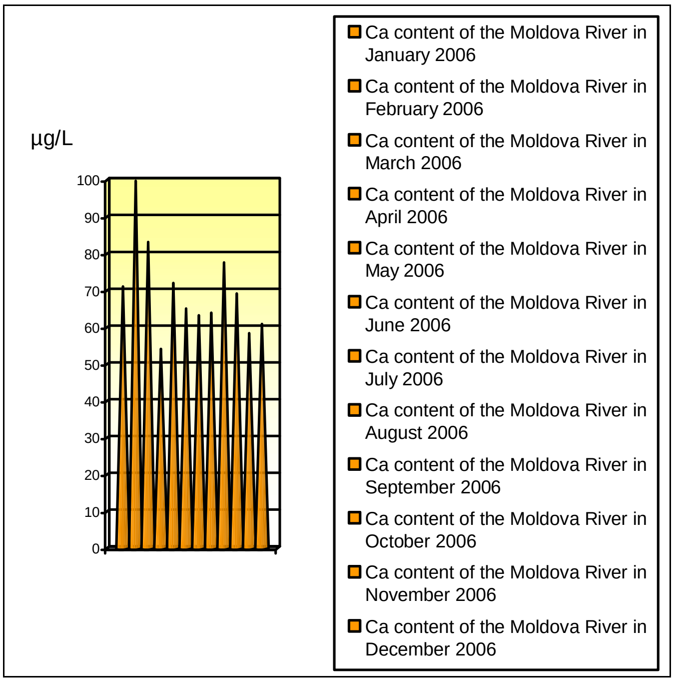


Fig. 5 – Variation of Ca ion concentration of Moldova River (2006).

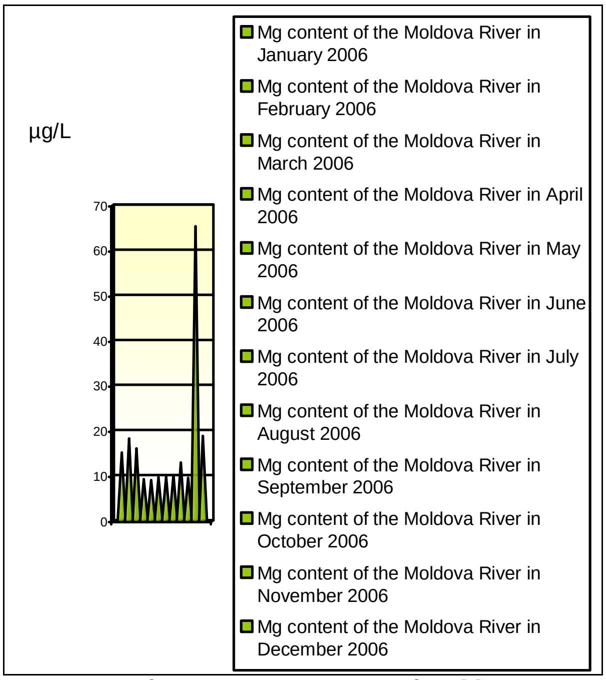


Fig. 6 – Variation of Mg ion concentration of Moldova River (2006).

The concentration of magnesium ions in the waters taken for monitoring section of Moldova River in 2006, reached a maximum of 65.4 µg/l (Fig. 6).

Moldova River water quality monitorized in the section Fundu Moldovei in 2007 are within the state as „very good" in the monitoring section.

From the viewpoint of the chlorine content of water analyzed, it proves that the maximum amount of chlorine indicator registered in the Moldova River in 2007 was 17.5 µg/l (Fig.7).

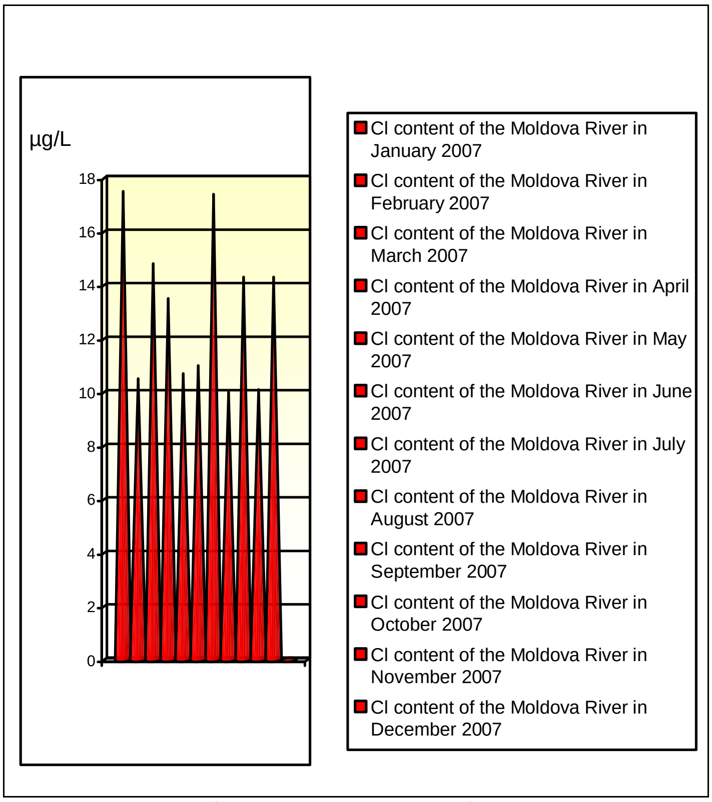


Fig. 7 – Variation of Cl ion concentration of Moldova River (2007).

The monitoring section Gura Humorului may be characterizad as having records a state of „good" due to the presence of magnesium indicator.

In monitoring section Baia were found calcium indicators, due to which, the section got the quality state „ good".

Considering the data presented so far we conclude that the river quality has improved since 2006.

Concentration of calcium ions in the waters taken for monitoring river water quality of Moldova in 2007, reached the maximum value of 79.5 µg/L (Fig. 8).

The concentration of magnesium ions in the water taken for monitoring river section of Moldova in 2007, reached a maximum of 61.7 µg/L (Fig. 9).

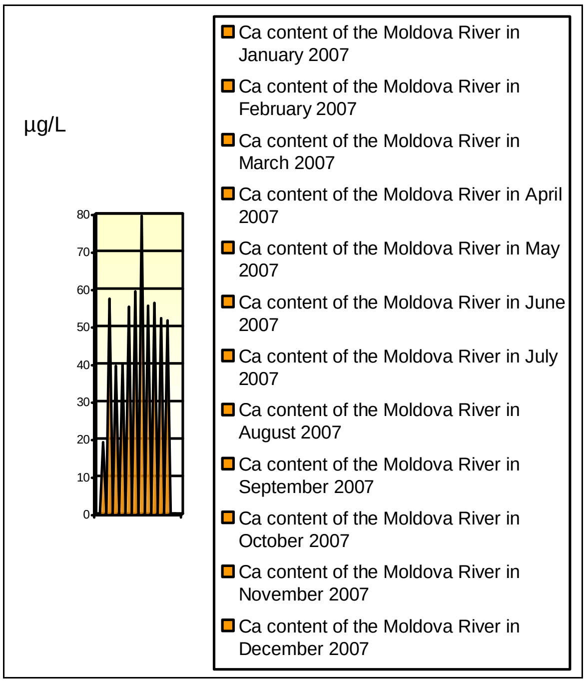


Fig. 8 – Variation of Ca ion concentration of Moldova River (2007).

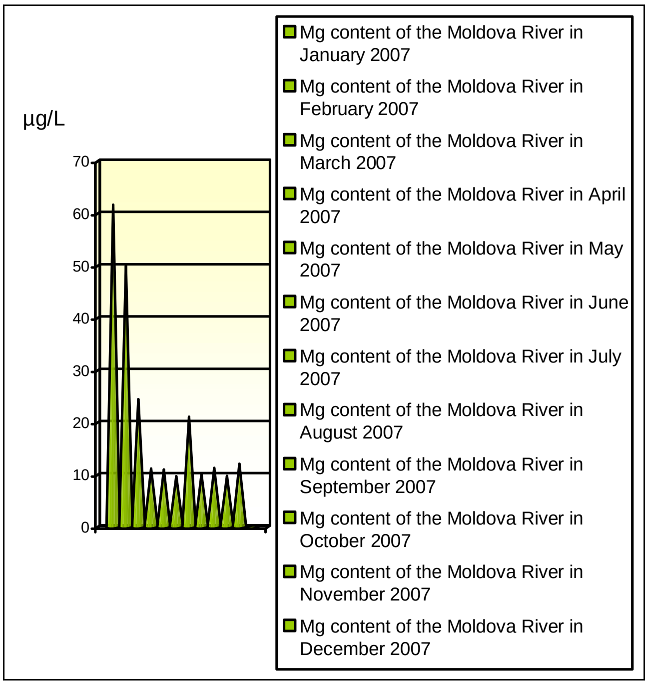


Fig. 9 – Variation of Mg ion concentration of Moldova River (2007).

Moldova River water quality in 2008, in Fundu Moldovei and Baia monitoring sections were recorded to the state of „very good”.

Under Gura Humorului monitoring the presence of calcium indicator record as a state of "good" water.

In 2008 Moldova River water has recorded a positive development in terms of water quality, with respect to the previous years.

From the view point of the chlorine content of water analysed, it proves that the maximum amount of chlorine indicator registered in the Moldova River in 2008 is 32.6 µg/L (Fig. 10).

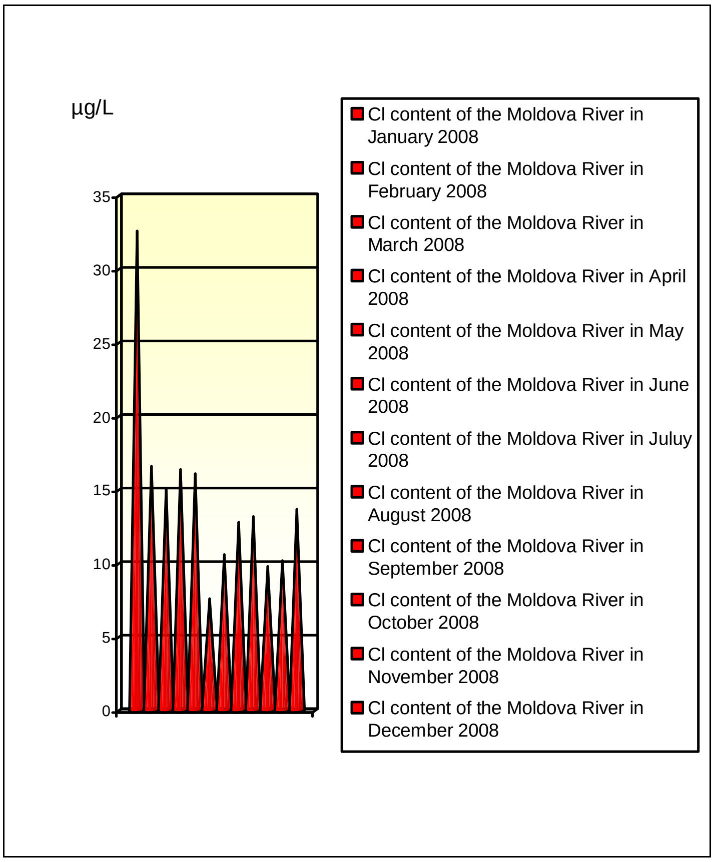


Fig. 10 – Variation of Cl ion concentration of Moldova River (2008).

In terms of calcium content of the water analysed, it results that the maximum amount of chlorine indicator registered in the Moldova River in 2008 was 87.9 µg/L (Fig. 11).

In terms of magnesium content of water analyzed, it was obtained that the maximum amount of chlorine indicator registered in the Moldova River in 2008 was 39.1 µg/L (Fig. 12).

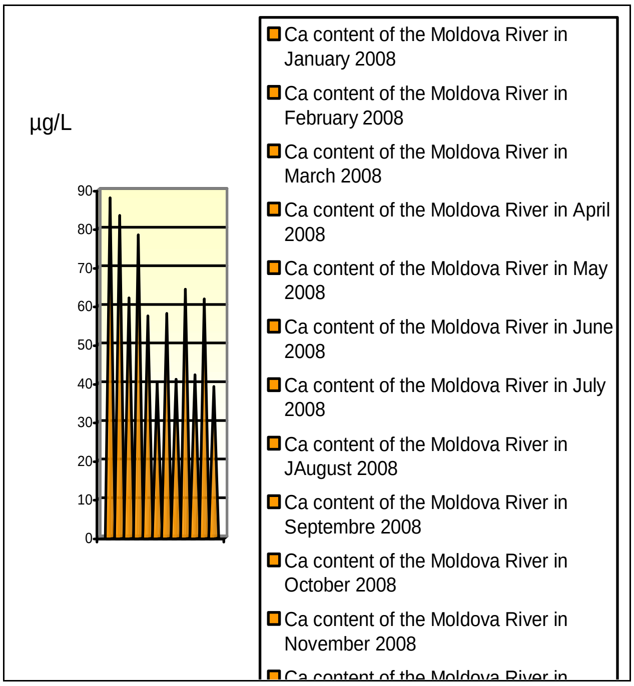


Fig. 11 – Variation of Ca ion concentration of Moldova River (2008).

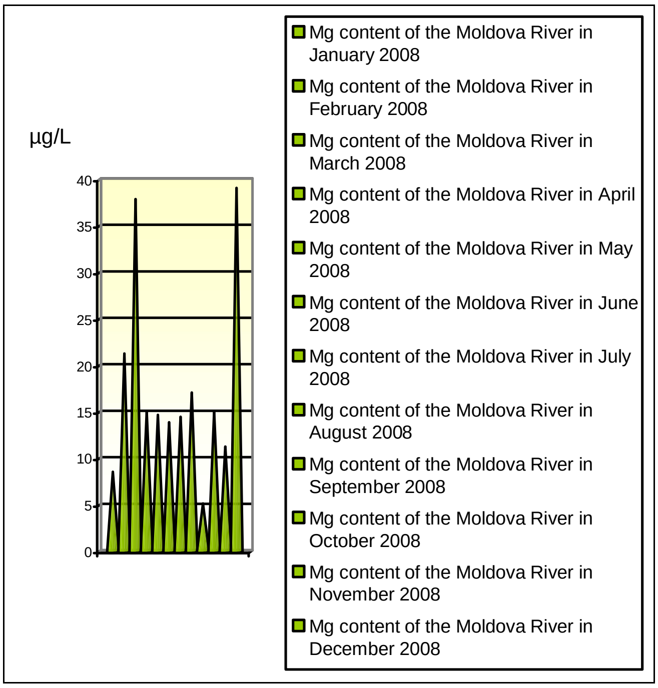


Fig. 12 – Variation of Mg ion concentration of Moldova River (2008).

## 3. Conclusions

Moldova River has a good water quality in the monitoring section Gura Humorului, scattered exceedances were recorded for calcium indicator.

The quality of the Moldova River monitoring section wates Fundu Moldovei, in 2006, was integrated a part of the state „very good”, but in monitoring sections Gura Humorului and Baia, calcium and magnesium indicators led to decreased water quality to the state of „good”.

The monitoring section Gura Humorului records a state of „good” due to the presence of magnesium indicator and the indicator section monitoring Baia because calcium was integrated at the state of „good”. Following such monitoring data the Moldova River water quality has improved since 2006.

Moldova River water quality in 2008 on Fundu Moldovei and Baia section of monitoring were integrated in the state as"very good".

The monitoring section Gura Humorului records a state of „good” due to the presence of magnesium indicator. The monitoring section Baia, was integrated in the state of „good” because of calcium indicator. Under Gura Humorului monitoring the presence of calcium indicator record as a state of „good” water.

In 2008 Moldova River water quality has registered a positive development in terms of water quality with respect to the previous years. The only thing to mention is that in certain situations, there is little value exceeded for the calcium indicator, water moving from a state of „very good” to state „ good”.

The central objective of the Water Framework Directive (Directive 2000/60/EC) is to achieve „good status” for all water bodies, both the surface and those of groundwater, except for the heavily modified artificial water bodies, which defines „good ecological potential”.

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## CERCETĂRI PRIVIND DETERMINAREA PARAMETRILOR DE CALITATE A APEI RÂULUI MOLDOVA

(Rezumat)

Apa reprezintă un element important pentru existenţa vieţii. Poluarea apei reprezintă, după definiţia generală, modificarea în mod direct sau indirect a compoziţiei normale a calităţii acesteia, ca urmare a activităţii umane, într-o astfel de măsură, încât afectează toate celelalte folosinţe la care apa ar putea servi în starea sa naturală. În lucrare se prezintă rezultatele privind monitorizarea calităţii apelor de suprafaţă din bazinul hidrografic Siret. Probele de apă utilizate în studiu au fost prelevate de pe cursul râului Moldova din trei secţiuni de monitorizare din localităţile Baia, Fundul Moldovei şi Gura Humorului. Pentru aceste probe au fost determinaţi o serie de parametri de calitate a apei de suprafaţă: conţinutul de cloruri, calciu şi magneziu. În urma monitorizării s-au stabilit următoarele concluzii: calitatea apei râului Moldova a prezentat depăşiri ale valorilor maxim admise pentru indicatorii de calciu si magneziu, ducând la scăderea calităţii apei în anul 2006, calitatea apei râului Moldova în 2007 a fost influenţată de prezenţa indicatorilor de magneziu şi calciu care au depăşit valorile admise, în anul 2008 calitatea apei râului Moldova a înregistrat o evoluţie pozitivă din punct de vedere al calităţii apei faţă de anii anteriori 2006 şi 2007.