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S U M A R

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Section
HYDROTECHNICS

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Pp.

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CONSIDERATIONS OF WATER DISINFECTING PROCESSES

BY

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Abstract. This paper is about current problems, such as the disinfection of tap water through the degrading of water sources' quality. The current methods of disinfection used in Romania have some problems in treating the water that is being distributed to the population. This situation involves the utilization of new or alternative technologies of disinfection. The new technologies of water disinfection, either physical of chemical, must be analyzed and compared technically and economically. Some technologies can be applied to small systems of water supply, or can complete the classic methods of disinfection. In this paper, water disinfection through UV radiations is being presented as an additional solution to chlorine gas disinfection. The studies contain some comparative data, which allow the utilization of modern water disinfection techniques.

Keywords: drinking water; chlorine; UV; technology; installation.

1. Introduction

Drinking water, which is destined for human consumption, is any kind of water, in natural state or after being treated, used for drinking, for cooking or other purposes. The drinking water which is collected from natural sources is being treated and distributed through an under pressure pipeline network. The

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main subject of the disinfection of water, which is meant for human consumption, is turbidity elimination, pathogen and physical contaminators through the application of some specialized technologies. Water disinfection is necessary before it is being distributed to the consumers, because by the coagulation, flocculation and filtration processes, it isn't possible for all the pathogens to be eliminated.

Drinking water disinfection methods have evolved in time. The most common treating method is chlorine disinfection. Chlorine is a strong disinfectant and has the ability to stay remanence in the disinfection process. Lately, there have been imposed a series of modern technologies, especially the disinfection through UV radiations or ozone. Chlorine disinfections have a very developed technology, a good price and also the installations are periodically verified. Modern disinfection methods need a series of studies on the application technique and raising levels of performance of treatment facilities.

2. Materials and the Research Method

In order to assure the population's health, the water that is being distributed has to have a certain quality. The access to some quality drinking water is an essential condition for human health. The elimination of pathogen bacteria is achieved through disinfection technologies in the treating stations. Water disinfection is a physical, chemical or mixed process of water disinfection in order to destroy the ordinary microorganisms and the pathogenic ones.

The disinfection is the last step in the water treating process. The disinfection takes place in the decantation process, where the quantity of bacteria is being reduced by the sedimentation of solid matters in a suspension (Mănescu, 1994).The presence of water pollutants is determined by the water circulation path (of surface, underground) and human activities. Natural water can contain bacteria, viruses, parasites (from the water circulation path), human or animal manure, etc. Microbial induced diseased can be transmitted through water (waterborne diseases) and can cause epidemics among people and animals. Waterborne diseases have been discovered since last centuries, but the scientific explanation has been given by the microbiological researches done by Koch and Pasteur.

Bacteriological indicators are important for drinking water disinfection. The identification of normal or pathogenic bacteria is important parameters in the disinfection process. The most important indicators refer to:

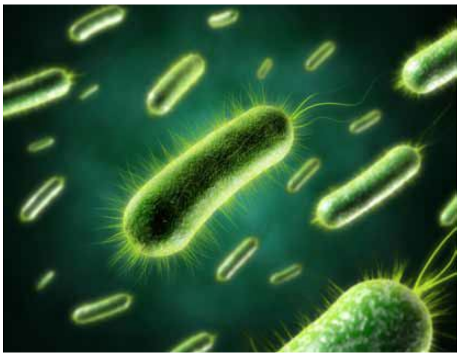
a) the total amount of bacteria which can develop at 37°C;

b) the amount of coliform bacteria;

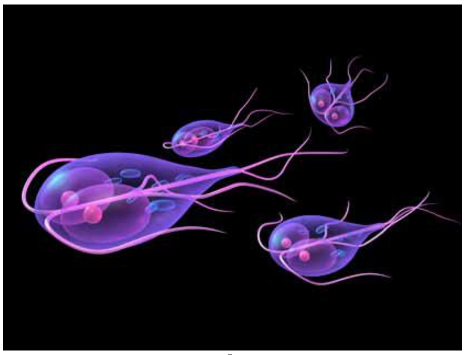
c) viruses;

d) parasites (Fig. 1).

The pathogenic bacteria which can cause waterborne diseases must be completely eliminated from the water that is meant for human or animal consumption.



a



b

Fig. 1 – Pathogen agents in natural water source:
a – E-coli (*Escherichia coli*); *b* – protozoon (*Cryptosporidium*).

The disinfection can be done through multiple technological processes:

– redox processes by using strong oxidant agents (disinfection agents);

– filtration processes / ultrafiltration which separates the bacteria from the water by using filters (slow filtration with sand and coal, membrane and capillary processes etc.);

– filtration processes combined with biological processes etc.

The ideal disinfectant for the drinking water must meet the following requirements:

– it has to have a germicide effect on all water pathogens;

– there mustn't be any toxic compounds in the treated water after using it;

– it has to be precise, easy to use and cheap;

– it has to meet all the conditions and regulations.

Disinfection can be done with physical or chemical disinfection. Ideally, disinfectants must have a residual effect, meaning that it has to remain active in the water and also after the disinfection. A disinfectant should prevent the development of pathogenic microorganisms in the water pipes after the disinfection, avoiding this way the contamination of water.

Physical disinfection can be done with the following: UV radiations, electronic radiations, gamma radiations, ultrasounds, heat, etc. Chemical disinfection can be done with the following: chlorine, sodium hypochlorite, chlorine dioxide, chloramines, hydrogen peroxide, bromine, ionizing copper/silver, ozone, etc. Chemical disinfection of the drinking water with chlorine has been used for more than a century. The most used chemical disinfecting agents are chlorine and its derivatives (ClO_2, NH_2Cl, NaOCl). Lately, ozone has been used quite often. Treating water with UV radiations is the most used method out of all the physical ones. From the point of view of the effectiveness of disinfectants for destroying micro-organisms in a proportion of 99.99%, it is found that this decreases in the following order:

$$O_3 > Cl_2 > Br_2 > ClO_2 > I_2 > Ag^{2+} > \text{cloramine} > KMnO_4 > H_2O_2.$$

3. Comparative Analysis of Methods of Disinfection

3.1. Chemical Disinfection Methods – Disinfection with Chlorine

Chlorine is the most used disinfectant in treating drinking water. Chlorine can be used and controlled in relatively easy conditions. Chlorine disinfection has remanence and also the cost of purchase is acceptable. The germicide effect on the bacteria and viruses can be done by breaking the chemical bounds from its molecules, which can be done after a hydrolysis reaction. The disinfection process has maximum effectiveness when the pH of water is between 5.50,…,7.50. The dosing of chlorine gas in the water treating process can be done keeping in mind that the dose should have a higher value so there remains a residual dose of chlorine in the water. This will assure the remanence of the process. The necessary dose of chlorine is between 0.20,…,0.40 mg/l. In some situations, the concentration of chlorine in the water increases, so the dose of residual chlorine can be assured.

Chlorination is the most used process of disinfection. This can be done though the direct contact between chlorine (or its derivatives) and the water (Table 1). By its position in the treating scheme, there can be distinguished the following options: prechlorination, the main chlorination and chlorination as after – disinfection. The residual chlorine reacts with the organic matter in the water and it forms a series of chemical toxic compounds, called byproducts of disinfection (PSD or DBP – disinfection by – products). The most- known and most toxic byproducts are the trihalomethanes (THM) and the haloacetic acids (HAA).

Table 1

The Chlorine Disinfection Period for Water Filled with Pathogenic Microorganisms (dose of chlorine: 1.0 mg/l, pH = 7.5, T = 2.5°C)

Microorganism	Disinfection time
E. Coli Bacteria 0157 H7	<1 minute
Hepatitis A Virus	Aprox. 16 minutes
Giardia	Aprox. 45 minutes
Cryptosporidium	Aprox.9600 minutes (6.7 days)

The advantages of chlorine disinfection are:

1º low cost of acquisition and operation;
2º effectiveness on the majority of microorganisms;
3º short to moderate period of contact;
4º remanence in the transport system;
5º high and accessible application technology (Fig. 2).

a *b*

Fig. 2 – The chlorine gas disinfecting installation from the water treating station Chiriţa Iaşi: *a* – the room with the liquid chlorine tanks: *b* – the hydro ejector device that introduces the disinfectant in the treated drinking water.

The disadvantages of chlorine disinfection are:

a) danger when the operating rules of the dosing installation are not followed; chlorine is highly volatile and inflammable, so there must be special conditions of transport, storage and manipulation;

b) the formation of DBP, with mutagenic and carcinogenic effects; if the level of DBP is too high, the treating system has to be changed in order to lower the formation of byproducts.

c) ineffectiveness against Giardia and Cryptosporidium protozoa;

d) can cause unpleasant smell and taste in water.

There is a way to lower the level of THM, that being the relocation of the chlorination process after sedimentation and coagulation and before the filtration. Changing this process leads to an increase in the exploitation costs by excessive use and the use of the carbon activated filters. The pre-ozonation, which is used in the oxidation process of the organic matter before the sand filters and the carbon activated filters, can be also used to extend the life of the carbon filters, this way the prices get somewhat lower.

In the disinfection process, there can be used other products of chlorine, but not on the same level as chlorine gas. A product that’s been used in the last 20 years is the chlorine dioxide. Chlorine dioxide is a much more efficient disinfectant than chlorine gas, reducing the byproducts by the oxidation of the THM precursors. This generation must be done in situ, because it’s an unstable compound (it can explode in the air in concentration higher than 10%). The chlorine dioxide is produced in aqueous solution and must be used for only a short while after that. Chlorine dioxide must be protected from the sun rays, which leads to its decomposition. Chlorine dioxide is produced in the chemical reaction between sodium hypochlorite and chlorine gas, but other processes can be used that don’t require chlorine gas (hydrochloric acid, sodium chlorite etc.).

Chlorine gas disinfection is the main type of disinfection that is currently used in Romania. The drinking water treating stations feature take-over and dosing installments and also installations that introduce chlorine gas in the hydraulic path. The whole technological process is automatic.

Fig. 3 – The dosage installation of the chlorine dioxide from the water treating station Chirița Iași.

A few of the water treating stations use chlorine dioxide to increase the disinfection process and also for the process of treating the drinking water (Fig. 3). The advantages of chlorine dioxide disinfection are:

– chlorine dioxide disinfection creates low levels of THM and doesn't produce HAA;

– the modern systems don't require chlorine gas transportation and also they prevent the chlorites and chlorates discharge;

– higher efficiency in eliminating the microorganisms, compared to chlorine or chloramines, but it's not as effective as chlorine gas.

The disadvantages of chlorine dioxide disinfection are:

a) producing chlorine dioxide in the chemical reaction between chlorine gas and hypochlorite requires an excess of compounds to optimize the process; if the process is not carefully controlled, it can lead to a high concentration of chlorine in the treated water and the resulting of toxic byproducts (chlorites, chlorates);

b) the *in situ* production requires special conditions in the means of transport and chlorine gas manipulation;

c) chlorine dioxide is an explosive gas and requires special manipulation conditions and rules;

d) daily monitoring of the chlorites and chlorine dioxide;

e) high cost of equipments;

f) high level of knowledge for the operators.

3.2. Disinfecting through Physical Methods – Disinfection Through UV Light

The ultraviolet (UV) light is a part of the electromagnetic radiation determined by a low wavelength of the visible spectrum and X radiation. The UV spectrum is between 100,...,400 nm and is invisible for the human eye.

The absorbing spectra of the UV light by microorganisms are between 200,...,254 nm, the second value representing the maximum (Fig. 4). Nucleic acids (DNA and RNA) absorb the UV light, which leads to the inhibition of the microorganism reproduction capacity.

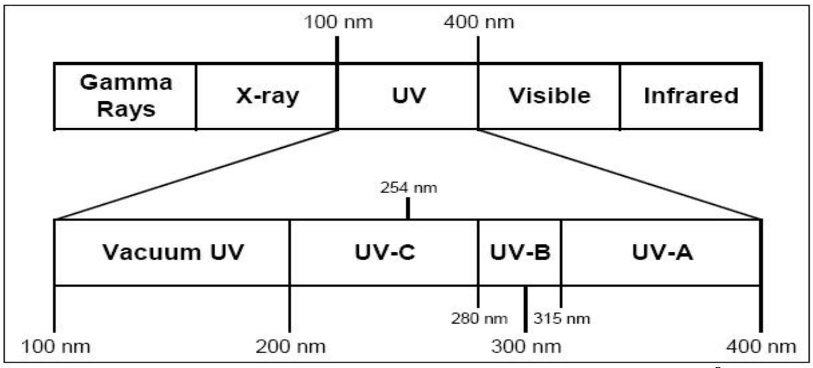
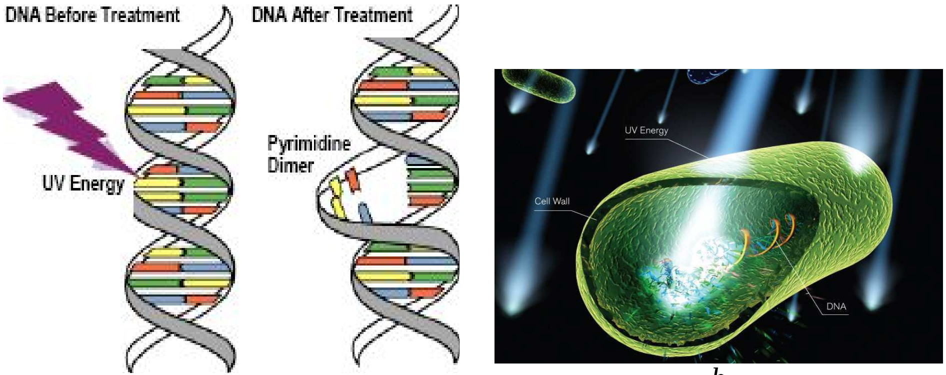


Fig. 4 – The defining scheme of the UV spectrum (1 nm = 10^{-9} m).

The discovery of the mercury vapor lamp (1901) allowed the use of UV light as a disinfectant. The disinfecting effect of the UV light is considered to be the result of the formation of HO and HO_2 radicals. The bactericidal effect takes place in the DNA and RNA by altering the reproduction of bacteria (Fig. 5). UV radiation is generated by applying a voltage across a gas mixture, which leads to a discharge of photons. The emitted radiations from the discharge of photons depend on the chemical composition of the gas and also on the power level of the lamp. Most of the UV tubes used for water treating use a gas mix which incorporates mercury steam. Mercury vapor lamps emit germicidal wavelengths.

The main factors that influence the UV light disinfecting process are the intensity of the radiation, the emission yield, the emission temperature, the voltage, the transmitting yield, the reflection of light at 254 nm.

The projection of UV reactors relies on the Bunsen – Roscoe equation, which states the fact that the level of UV disinfection is directly proportional with the irradiation dose. The geometrical shape, the swirl of the water stream and the hydrodynamic of the installation are important in the UV light disinfection process. The radiation is emitted by a mercury lamp which is made out of quartz or glass.



a *b*

Fig. 5 – The action method of the UV light on the DNA: *a* – the degrading scheme of the DNA; *b* – the inactivation of the pathogen cell.

The advantage of the UV disinfection process is that it doesn't produce byproducts. In some situations, a chlorine post – disinfecting step is necessary. This allows the presence of a residual disinfectant in the water transport system. The main disadvantage is the high cost of the machinery and the UV lights.

The disinfecting installations eliminate 99.99% of viruses, bacteria, algae and fungus (especially Giardia Lamlia and Cryptosporidium) from the treated water. The disinfected water is bacteriological safe and can be consumed or it can be used in special technologies.

The efficiency of the UV reactors depend on the water's chemical composition, which has to be sterilized: total hardness < 6 ^{o}G, iron < 0.3 mg/l, hydrogen sulfide < 0.05 mg/l, solid suspensions <10 mg/l, turbidity <1 NTU, manganese < 0.5 mg/l.

UV light disinfection can be used in spaces that are closed and under pressure (pipes, Fig. 6 *a*) or open spaces (channels, pools, Fig. 6 *b*).

The advantages of the disinfection through the UV radiations are:

a) short exposure;

b) doesn't produce byproducts;

c) doesn't change the smell and taste of water;

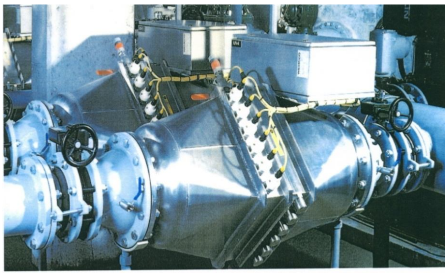
d) ensures a complete destruction of the microorganisms, including the resistant protozoa.

The disadvantages of using the UV light disinfection are:

a) it doesn't remanence;

b) the efficiency of the process depends on the turbidity level and the matters that are dissolved in the water;

c) the disinfection equipments have a large structural complexity;
d) the operators need prior training.


a


b

Fig. 6 – The action method of the UV light on the DNA: *a* – the degrading scheme of the DNA; *b* – the inactivation of the pathogen cell.

Disinfection through UV light is efficient again protozoa cysts, bacteria and viruses. The UV light doesn't kill the microorganisms, but damages the structure of the DNA and RNA, preventing the reproduction of the microorganisms. When a microorganism can't reproduce it also can't infect anymore.

4. Comparative Analysis of the Studied Disinfection Methods

The comparative analysis considered the following criteria:
i) the applicability of the disinfecting method in the current stage of technical development;
ii) the cost of the investment and the exploitation of the disinfecting installations;
iii) efficiency on the degradation and destruction of pathogens;
iv) influence on the operating staff from the water treating stations.

The disinfection domains that use chlorine and UV light coalesce, which shows that they can cooperate (Fig. 7). The comparative analysis between the applicability criteria is shown in Table 2. The comparative analysis between costs is shown in Table 3.

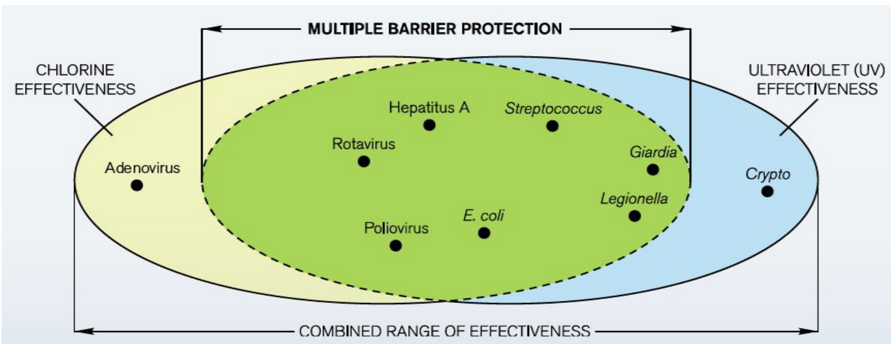


Fig. 7 – Disinfecting domains of chlorine and UV light.

Disinfection through UV radiations is feasible only for those systems that do not require surface water. Small doses cannot efficiently inactivate all viruses, spores and cysts. Organisms can sometimes repair the destructive effects of UV radiations through a “repair mechanism”, known as photoreactivation, or in the absence of light know as “repair in the dark”.

Studies have shown that ozone is the most efficient and most effective disinfecting agent (minimal dose for maximum efficiency). But ozone disinfection is the most expensive one and also has a high risk in exploitation.

Table 2

Optimal Concentration of the Disinfectant Agents in Order to Inactivate the Microorganisms

Disinfecting agent	Chlorine	CLO_2	Cloramine	UV (253,7 NM)
Microorganisms	C·t mg·min/L	C·t mg·min/L	C·t mg·min/L	L·t mW·s/cm^2
E coli	0.034–0.05	0.4–0.75	95–180	6.0
Bacillus S	–	–	–	16.0
Polio 1	1.1–2.5	0.2–6.7	770–3,740	48.0
Rotavirus	0.01–0.05	0.2–2.1	3,810–6,480	–
Phage f2	0.08-0.18	–	–	–
Giardia lamblia	47–150	–	–	–
Giardia muris	30–630	7.2–18.5	1,400	–
Cryptosporidium	7,200	–	–	–

A comparative analysis was made for the two most used methods in Romania. In the current stage there have been imposed some severe standards for the secondary oxidation compounds, in which case the chemical disinfection processes are not satisfactory. In this context some new processes are required, which can contribute to an efficient elimination of chemical substances and pathogens from surface waters.

Table 2

Comparative Analysis between the Studied Methods

CRITERIA	UV	Chlorine	Chlorine dioxide	Chloramine
DBP	No	Yes	Yes	Yes
Bacteria elimination	Yes	Yes	Yes	Yes
Virus elimination	Yes	Yes	Yes	Yes
Taste and smell correction	No	No	No	No

An important role is played by the physical method of disinfection (through UV radiation) and combining it with the oxidation processes. Comparing it to other water disinfecting systems, UV light disinfection has more advantages, taking into consideration the costs, the workforce and also the need for qualified technical personnel who can operate the machinery. UV light disinfection is ecological, it is viable on the long term, it follows the technical rules and does not produce mutagen and cancerous byproducts.

UV radiation has been demonstrated to be efficient against pathogen organisms, including the ones responsible for cholera, polio, typhoid fever, hepatitis and other bacterial, viral and parasitic diseases. By using UV light (alone, or combined with hydrogen peroxide), the chemical contaminants (such as pesticides, industrial and pharmaceutical solvents), are destroyed.

5. Conclusions

1. The disinfecting methods that use chlorine and its derivates are viable solutions for the human communities with short economical resources.

2. Chlorine disinfection is currently the most used method for the sterilization of water against pathogens. Has the advantage of remanence to the hydraulic system of water transport.

3. The UV disinfecting method is extremely efficient for inactivating pathogens, but is not remanence to the transport and distribution system of drinking water.

4. Chlorine and UV light disinfection have different costs of investment, medium for chlorine and high for UV light, which influences the applicability in society.

5. UV light disinfecting method does not produce byproducts.

6. UV light disinfecting method is a physical process, which eliminates the necessity of generation, managing, transporting or storing toxic or dangerous substances or corrosive chemical substances.

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CONSIDERAȚII PRIVIND PROCESUL DE DEZINFECȚIE AL APEI POTABILE

(Rezumat)

Lucrarea tratează probleme actuale privind dezinfecția apei potabile prin prisma degradării calității surselor de apă. Metodele de dezinfecție utilizate în România prezintă probleme negative în tratarea apei distribuită populației. Această situație impune utilizarea de tehnologii noi sau alternative de dezinfecție. Tehnologiile noi de dezinfecție a apei, de tip fizic şi chimic, trebuie analizate comparativ din punct de vedere tehnic şi economic. Unele tehnologii de dezinfecție pot fi aplicate la sisteme mici de alimentare cu apă, sau pot completa metodele clasice de dezinfecție. În lucrare se prezintă dezinfecția cu radiații UV, ca o soluție de completare a dezinfecției cu clor gazos. Studiile şi cercetările efectuate prezintă o serie de date comparative, care permit utilizarea tehnologiilor moderne de dezinfecție a apei.

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MONITORING AND CONTROLLING THE OPERATIONAL AND ENERGY-RELATED PARAMETERS FROM THE BOLDEŞTI RE-PUMPING STATION WITHIN THE „BOLDEŞTI – COTNARI” WATER SUPPLY SYSTEM

BY

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Abstract. This article presents the monitoring and controlling system of operational and energy-related parameters from the Boldeşti re-pumping station within the „Boldeşti – Cotnari” water supply system. Being included in the scope of works for the refurbishment of the re-pumping station, the implementing of this system brings multiple benefits: optimization of pumps power consumptions, providing a preventive maintenance, performing of technical analysis and diagnoses and scheduling of operational periods outside peak periods of power grid load curves.

Key words: pumping station; monitoring and control; process parameters; static frequency converters.

1. Introduction

The rehabilitation and the modernization of water supply systems, in order to ensure their adequate capacity of satisfying the current and the future

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demands of water consumers and also their best energy and economic parameters, with the best available technology, can be achieved through their computerization (Toma, 2012).

The pumping stations are main items within water systems that supply the large urban communities, being operated in numerous sectors: source water catchment, water conveying (when terrain configuration is not suitable for gravity flowing), in water plants (in all process stages such as sludge draining from clarifiers, filter backwashing) and, finally, for providing the normal supply pressure inside water networks (Dobre, 2006).

According to the US Energy Department the water electric pumps in America are consuming around 25% of the entire power amount that is produced (U.S. Department of Energy, 1998). According to Almeida, the situation is nearly the same in the European Union, where 22% of power consumption appears in water pumps (Fig. 1) (Almeida *et. al*, 2003).

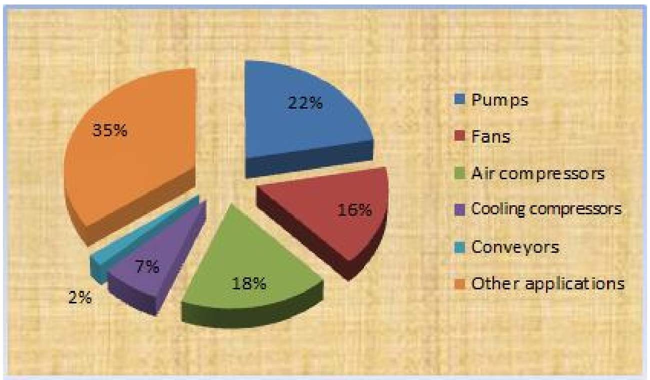

Fig. 1 − EU: Estimated distribution of power consumption.

Given this, and the important value of the equipment, there is a need to implement a monitoring and control system for all operational and energy parameters involved in the functioning of the pumping stations.

2. General Description of the „Boldeşti–Cotnari" Water Supply System

The Cotnari commune (Iaşi County) is located in an area that features a difficult relief, and where stable water resources are scarce (for its inhabitants and also for its developed wine industry). Hence, the community had to be supplied from relatively remote sources, located around the Siret River. Nowadays, by means of the Blăgeşti main water pipeline (that was once serving a catchment abandoned since 1990) the Boldeşti water source is exploited (a creek that supplies a high quality water, at a relatively stable flowrate that reaches cca. 18...25 l/s (Fig. 2) (Toma *et al.*, 2010).

The main water pipeline conveys water from a level of 280 mSL (meters Sea Level) – inside the suction basin at level of 200 mSL – in the Cotnari tanks level, after the crossing of the Pascania Hill, on which is located - at the route's highest spot (407 mSL) – the Todiresti 500 m^3 tank, and passing afterwards through the Stroesti slope breaking and distribution system, located at level 360 mSL. Water is conveyed all along this route by means of two pumping plants: the Izvor-Boldeşti pumping station and the Boldesti re-pumping station (RPS). The Boldeşti RPS – Todireşti tank water conveying system includes the Boldeşti RPS and a Dn 300 pipeline, reaching a length of 4,300 m, which supplies the 500 m^3 Todireşti tank. The Dn 300 steel pipeline supplies water to the Todiresti village via a branch connecting pipe. This connecting pipe is located at approximately 2,000 m away from the Boldeşti RPS and ensures the supply of a 15 m^3 buffer tank, belonging to the Todireşti pumping station. The Todireşti PS is pumping water towards a 450 m^3 water tank, located on a dominating hill, allowing the gravity water distribution towards the commune (Toma *et al.*, 2010).

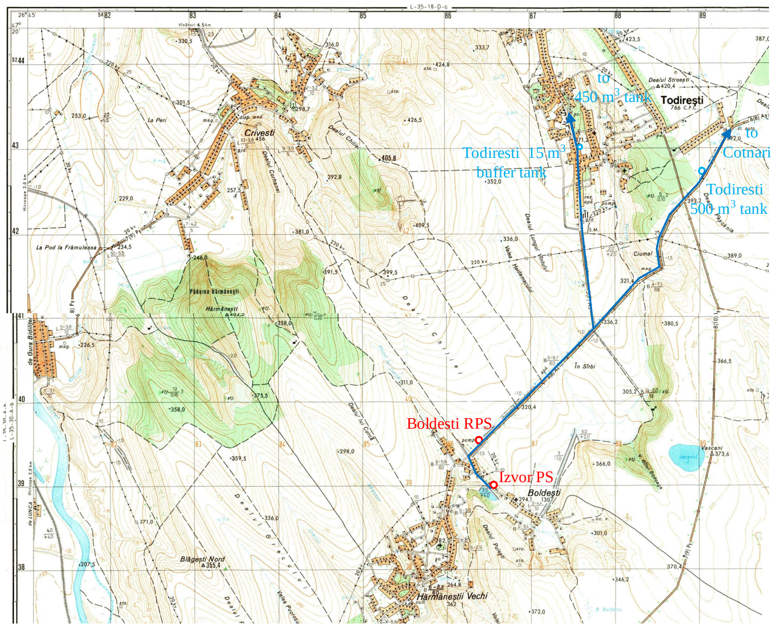

Fig. 2 – The „PS Izvor-RPS Boldesti-Todiresti tank" main water pipeline system.

The physical state of the water pipeline differs according to its various sectors. The pipeline can be considered as satisfactory on the „Izvor Boldeşti PS – Boldeşti RPS", and, to a large extent, on the „Boldeşti-Todireşti" sector. Problems appear on high gradient slope sectors, in the areas where the land has poor stability (downstreams the Stroeşti distribution system and on the slopes of

Cotnari commune). The most affected are the sections made out of asbestos cement pipes (Toma *et al.*, 2010) .

Fig. 3 shows the Boldeşti RPS diagram.

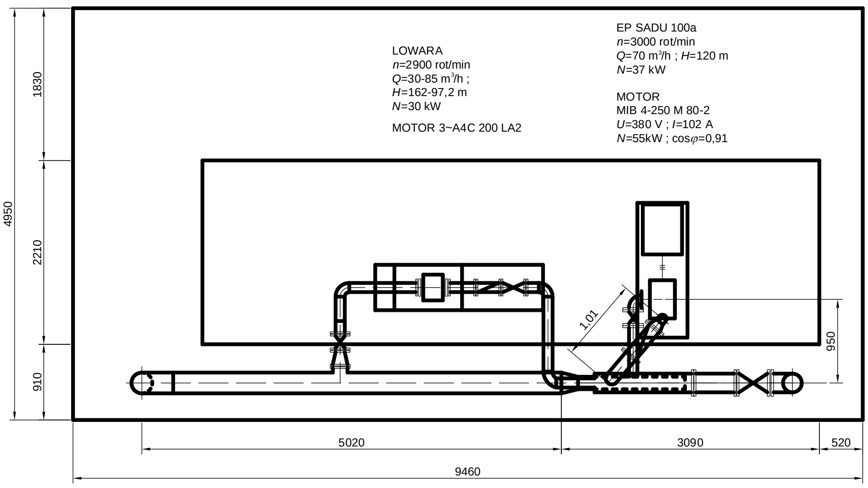

Fig. 3 − Boldeşti repumping station – diagram.

3. The Boldeşti RPS (Re-Pumping Station): the Monitoring and Control System

3.1. General Description

The need for a monitoring and control system for the Boldeşti RPS is justified by the large amounts of consumed power and the high value of the equipment.

The positive effects of implementing a monitoring system at this pumping station are (Alexandrescu, 2003):

- optimization of operational maneuvers;
- decreasing the frequency and severity of malfunctions;
- decreasing of time required for repairs;
- the possibility to perform a preventive maintenance.

In parallel with an optimal use of the new pumps (with low specific energy consumption and high reliability), there is the possibility to implemenet an unitary operation complex electronic protection systems that can ensure the motors safety as regards the following issues:

- heavy starting regimes;
- certain defects with unexpected development.

The monitoring and control system for the Boldeşti RPS will feature a hierarchical management structure on three levels (Toma *et al.*, 2010):

- the field level: plant fitted with automation devices;
- the local automation system: provided via PLCs;
- the local dispatcher level: medium capacity PC, connected to PLCs, having the role of local process graphic interface.

At Boldeşti RPS level, the equipment for which a monitoring and control system is to be implemented shall comprise:

- pumping groups;
- actuated valves;
- switching and protection devices;
- gauges for hydraulic parameters (flow, pressure);
- gauges for electrical parameters (voltage, current, power factor, active energy, reactive energy).

A sound control of Boldeşti RPS shall be carried out by processing information related to:

- the plant condition:
  - voltage presence/absence;
  - presence/absence of water on suction;
  - pumps on/off; - valve open/closed;
  - any improper operation regimes:
    - faulty insulation of electrical equipment;
    - motor overheating;
    - over/under voltage on power supply;
    - overcurrents and/or imbalance between phases;
    - incorrect phase sequences and/or absence of power in one or more phases (interrupted windings, faulty contactor etc.);
    - idle status;
    - heavy start up;
    - motor stalling;
    - pump not primed;
- water level in the 50 m^3 suction tank of Boldeşti RPS;
- water level in the discharge tanks (15 m^3 buffer tank in Todiresti commune and the tank from the Pascania-Todireşti hill);
- pump discharge pressure;
- pumped flow;
- volume of pumped water;
- power consumption,

and the start/stop control to pump units, respectively the opening/closing of certain valves.

3.2. The Boldeşti RPS: the Local Automation

The automation solution proposed for the Boldeşti RPS will use as field device a logical programmable automation device (PLC), based on industrial microcontrollers. This device will have logical autonomy and operational flexibility. Moreover, it has standard serial communication skills, being superior to any other automation solutions, based on other automation systems (by example, specialized complex relays).

The configuration of the Boldesti RPS automation system shall correspond to the functions that are to be provided by the PLC (Toma *et al.*, 2010):

- *protection of motors against electric failures*:
  - incorrect phase sequence (change of rotation direction);
  - no voltage on one phase (antibiphasical);
  - undervoltage;
  - voltage surge;
  - voltage asymmetry between phases;
  - lack of current in one phase;
  - undercurent (on idle status);
  - overcurrent (heavy start up, motor stalling);
  - short circuit;
  - current imbalance between phases;
  - decrease of insulation resistance;
- *protection to hydraulic events or of other nature*:
  - lack of water in $50m^3$ suction tank;
  - increase of discharge pressure beyond the programmable value;
  - anti-theft protection of equipment;
- *measuring and displaying of electrical parameters*:
  - phase voltages;
  - phase currents;
  - apparent power;
  - active power;
  - reactive power;
  - active energy;
  - reactive energy;
  - power factor;
  - frequency;
  - insulation resistance;
- *processing and displaying the signals generated by transducers within process, and defining of lower and upper limit thresholds between which the system is allowed to operate*:
  - water level in discharge tanks;

- pressure in the discharge manifold;
- discharge pressure;
- pumped flow;
- operating time;
- volume of pumped water ;

➢ *start/stop command for pumps and opening/closing of discharge valve depending on water level inside upper tanks*, and the rotation rotation depending on their state of availability and operation time, respectively the start up frequency control.

Operating modes allowed by the PLC will be:

- *manual mode:*

. local control (low voltage control panel);

. remote control, through commands for changing the state of an execution element, launched from the PLC keyboard;

- *automatic mode:*

. during normal operation, without exceeding the optimum pumping regime;

. in emergency/failure mode, when „*n*" restarts are allowed - programmable for each type of emergency/misfunction, switching to backup in case of failure and creation of a fault history file for a correct diagnosis.

Input signals*:*

- phase voltages;
- phase currents - via the power transformers;
- 4-20 mA analogic inputs;
- resistive inputs for:

. level sensors;

. pressure switch;

. winding thermoswitches;

- logical inputs for selecting of operating mode;
- metering inputs (pulse counting).

Output signals:

- relay control outputs (3A / 240Vac, 6A / 24 Vdc, 1A / 24V).

Communication:

- communication bus for bidirectional data transfer - preferably the industry standard RS 485.

Programmable parameters*:*

- daily operating program, with energy optimization target;
- surveillance duration for main parameters before motor start-up (voltage, insulation resistance, suction pressure, discharge water level, motor temperature etc.);
- rated current;
- allowed minimum current;
- overcurrent;

- heavy start-up current;
- stall current;
- permissible current imbalance between phases;
- current transformers ratios;
- detection time for faults, imbalances or undercurrent;
- rated operational voltage;
- minimum / maximum voltage allowed;
- permissible voltage imbalance between phases;
- voltage transformers ratios;
- detection time for faults, imbalance, over or under voltage;
- re-start time after a power failure, in order to avoid the simultaneous starting-up of several pumps;
- motor start-up duration;
- inrush current;
- minimum/maximum values allowable on 4-20 mA inputs and resistive inputs; - number of re-starts on each type of malfunction;
- time between restarts;
- sampling and memorizing rates for 4-20 mA parameters;
- serial communication rate.

Programming capabilities:
- local, through own keyboard and display;
- remotely, via serial communication.

The monitoring and control system is based on an universal PLC, focused towards energy management and capable to perform the functions described above.

The protection function is ensured by stopping the pumping unit in question, anytime when damage alerts are detected. The restart attempts will be carried out automatically (the number of restarts and the time between two successive attempts is a programmable value, depending on the type of malfunction), or manually. Both in automatic and manual operation mode, the motor cannot be started unless normal operating conditions are re-instated (in terms of power, insulation resistance, temperature, water levels, pressure).

The control function will be achieved in a scheduled mode for an operation set by user, corresponding to the regime recommended by the pump manufacturer and considering the existing operating conditions for the installation.

The energetic optimization of pumping plant will be ensured by the surveillance of instant and integrated parameters of pumped water (flow and volume), respectively the power consumption (active and reactive power, power factor, total consumed energy) and also, the total running time.

The preventive maintenance will be ensured through a follow-up of hydraulic parameters (flow, pressure, level) and electrical parameters (voltage, current, phase angle, frequency, insulation resistance) and other associated parameters for the 4-20 mA inputs. A decision related to the moment for an intervention or for intervention planning shall be based on the evolution of these parameters that are to be analyzed separately, but especially in correlation.

The PLC user interface will feature its own keyboard and LCD display that shall allow to verify the system's state, the pre-set parameters and the malfunctions. Both preset parameters and detected malfunctions (by type), will be saved (with the time when they occurred) in a non-volatile memory, thus the stored data being protected against accidental power cut-offs..

The monitoring and control system shall operate in real time and shall allow the scheduling of operation intervals during off-peak periods of the power system load curve, in operating modes as close as possible to the pumps' nominal capacity.

The local operation of the station will be ensured by the possibility of achieving any maneuvers in automatic mode, in remote manual mode (via PLC) or full manual mode (via the LV control panel). The monitoring and control system will operate autonomously, that is, any temporary unavailability of communication channels being not able to generate the undesirable malfunctions of the system.

The program shall run under Windows OS or other operating systems, ensuring a high degree of compatibility with various automation devices.

3.3. Local Dispatching

The local dispatcher level can be implemented in the Boldeşti RPS by means of a personal computer connected to the PLC via the communication bus used by the PLC. It will have the role of a graphic user interface, having a SCADA program for the management and the monitoring of processes that shall allow to access the process via a graphical block diagram with "active" elements.

The using of a PC will also allow the installation of a CCTV surveillance system (multimedia system), at low costs, able to provide sufficient resolution for detecting any "movement" inside the pumping station.

The main functions of the monitoring and control of the local dispatcher will be (Toma *et al.*, 2010):

- ***the operational controlling of the Boldeşti RPS***:
  - the system will provide the micro-cycles needed pumps starting, this including valve maneuvering valves, interlocks, controlled start-up depending on by current etc;
  - shall provide a pump regime able to ensure an even wear of pumps by soundly balancing the number of operating hours;
  - shall ensure that the plant operation is subordinated to the supplied tanks;

- shall allow the operator to issue decisions that can outrun the automatic reaction that is triggered only at certain thresholds;

➢ ***the local displaying of pumps process parameters***:

- represents the human operator's interface (permanent or occasionally present);
- displays on the monitor screen, as virtual instruments all parameters detected by transducers, which are afterwards stored in memory (on request or automatically, at scheduled intervals);

➢ ***alerting of operational staff in case of fault, malfunction or effraction***:

- visual and acustic alarms are triggered in case of malfunction (the nature of the fault is detailed);
- generates the history file for the incidents evolution;
- prioritized alarm in case when effraction sensors are activated.

The local display of process parameters is very useful in conducting technical analyzes and diagnoses or when unusual maneuvers are to be carried out. This display mode through virtual instruments is more economical than the classical solution of measuring instruments for electrical and hydraulic parameters.

3.4. Instruments Needed for Local Automation of the Boldeşti RPS and its Functioning Mode

Because the life expectancy of the SADU 100ax3 pump is expired, there is need to purchase a new pump in order to create a pumping group with 1+1 pumps (A Lowara 66 1/6 pump is recommended, providing that flow from the Boldeşti source is increased up to 21 l/s, in order to ensure that the Boldeşti RPS shall operate with fully open discharge valves).

There is also need to fully refurbish the general distribution panel within the Boldeşti RPS, panel that includes online gauges online for electrical parameters, pump motor protections, etc. Moreover, it is necessary to install an automation control panel for the processes within the pumping station. All safety and automation features will be carried out by a Siemens PLC system.

In order to measure flows pumped by the Boldeşti RPS it is recommended to mount on the discharge manifold a SIEMENS SITRANS F-M electromagnetic flowmeter, with a 4..20 mA output. The pressures on suction and discharge lines can be measured through pressure transducers (0...16 bar SIEMENS SITRANS P type, output 4...20 mA). For measuring electrical parameters (phase voltage, phase current, apparent power, active power, reactive power, active energy, reactive power, power factor, frequency etc.) we recommend to mount a monitoring unit, on every pump, with PROFIBUS or MODBUS outputs.

On the pumps discharge lines we recommend the mounting of AUMA actuated valves. In order to measure the temperature of the pump bearings there is need to provide thermocouples, connected to a monitoring unit.

The „low water” protection system for the Boldeşti pumps will be achieved using a floater. The measuring of water levels inside discharge tanks is recommended to be done by using NIVELCO Ecotrek ultrasound level transducers (10 m echo), with a 4...20 mA output.

The GSM modem or a MOTOROLA radio station will take the analogic signal from the ultrasonic sensor and will send it to the PLC.

The protection of pumping plant against technical faults will be provided by safety devices. Various visual alarms shall alert the operators as regards the constancy of a security state or the occurrence of a new situation, durable or not.

In the first case, the visual signs shall indicate the need to maintain the conditions necessary for the plant’s proper functioning. Its disappearance will usually trigger an alarm (if the alarm horn is active), by example: "presence of control voltage." In the second case, the phenomenon will cause a new visual and/or acustic alarm. The level of local dispatching can be implemented in the Boldeşti pumping station by using a personal computer (PC), interconnected via the communication bus to the PLC.

SCADA is a software for Supervision, Control and Data Acquisition. This program does not ensures a total control of the process, but focuses on the process supervising. The control mainly consists in changing some process parameters, on field.

The SCADA application, which will be implemented by means of an automation expert, consists of:

- server: parameters management, alarms, databases;
- customer: the user interface;
- communication: acquisition of PLC parameters.

It is recommended to purchase a MICROMASTER 420, 30kW frequency converter, in order to maintain pressure in the spill column of the Todireşti 500m^3 tank (and also to provide pressure towards consumers connected upsteams the 15 m^3 buffer tank before from the Todireşti commune).

The Todireşti re-pumping station, which draws water from the 15m^3 buffer tank, will operate normally as long as a minimum level is maintained in the tank, and will become a stand-alone system. In cases of high water demand the second pump will start automatically.

The control of this sector included in the Boldesti-Cotnari main pipeline, that is Boldeşti RPS - (households consumers + Todireşti pumping station) - Todireşti 500m^3 tank, can be performed by means of two parameters, the flow and the pressure. The proposed automation solution will work correctly and at normal parameters, only when the pumps discharge column will be adequate in terms of hydraulic characteristics. The pumps will be operated by two soft starters and frequency converters. These devices will be able to rotate so that any pump will be able to be connected to the converter.

Fig. 4 shows is the schematic diagram of the proposed local automation for the Boldeşti RPS. Table 1 shows a list of instruments needed for the Boldeşti plant automation for controlling its efficiency and a sound functioning of the installation. Estimated prices of all components are given in Lei (RON).

Table 1

Instruments (Devices/Equipment) Needed for the Local Automation of the Boldeşti Re-Pumping Station

No	Equipment/devices	Pcs	Comments
1	Equipped general distribution panel	1	- panel for distribution of control voltages and supply voltages towards the other consumers
2	Equipped general automation panel	1	-panel for the process automation
3	SIEMENS PLC, extensions included	1	- 1 hardware structure
4	Monitoring unit for electrical parameters, on each pump	2	- measures electrical parameters - PROFIBUS or MODBUS output
5	SIEMENS SITRANS F M electromagnetic flowmeter	1	- mounted on the station's discharge manifold montat - with 4..20 mA output
6	Pressure transducer, 0...16 bar, SIEMENS SITRANS P type	4	- mounted on the pumps suction and discharge lines - with 4..20 mA output
7	AUMA automatic actuated valves	2	- mounted on the pumps discharge lines
8	Thermocouples and temperature monitoring unit	2	- temperature transducer, on each pump's bearings - PT1000 or PT100
9	Floater	1	- pump protection system, against low water situations
10	NIVELCO Ecotrek level ultrasonic transducer (10 m echo)	2	- measures levels inside Todireşti tanks (500 m^3 tank and 15 m^3 buffer tank) - with 4…20 mA output
11	GSM modem or MOTOROLA radio station	2	- takes the analogical signals from the US sensors and send them towards the PLC
12	Alarm horn	1	- acustic alert in case of malfunction/fault
13	30 kW, MICROMASTER 420 frequency converter	1	- analogical input, 4..20 mA - 4 digital inputs and 4 digital outputs
14	SCADA software - Sielco Sistemi	1	- 256 tags
15	SCADA application development	1	- qualified personnel (one automation expert)
16	Computer (PC)	1	- achieving the local dispatching level

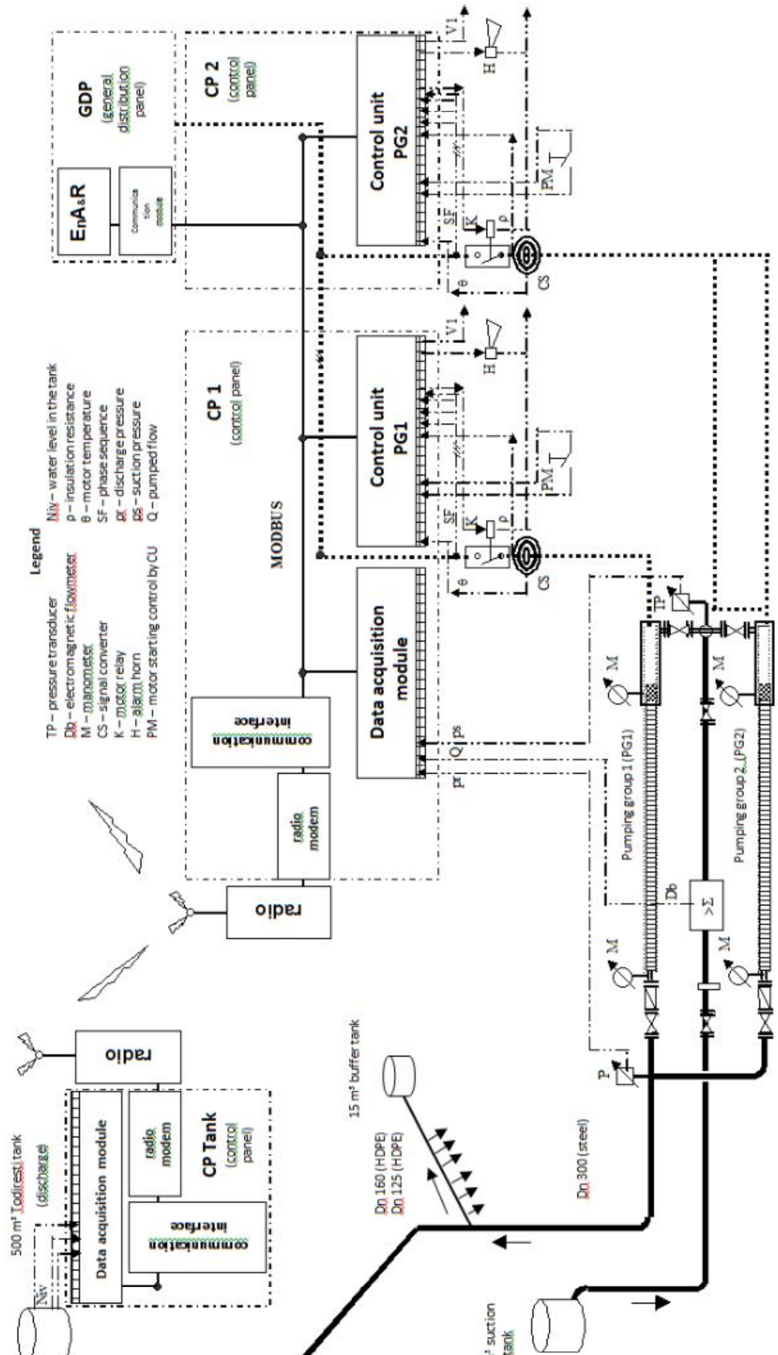

Fig. 4 – The schematic diagram of the proposed local automation for the Boldeşti RPS.

4. Conclusions

The main benefits of implementing a monitoring and control system are (Toma *et al.*, 2010):

– optimization of pump operating in terms of energy factors, ensured by the continuous monitoring of all instantaneous values of pumped water and power consumption;

– preventive maintenance, ensured by a follow-up of all hydraulic and electrical values, thus reducing all costs associated to maintenance and repair;

– technical analyzes and diagnoses;

– programming of operating periods for the pumping groups, outside the periods of peak power load curves, thus ensuring significant power savings.

The main benefits of implementing a monitoring and control system has:

– optimization of pump operational regime in terms of energy factors, ensured by the continuous monitoring of all instantaneous values of pumped water and power consumption;

– preventive maintenance, ensured by the follow-up of all hydraulic and electrical values, thus reducing all costs associated to maintenance and repair;

– technical analysis and diagnosis;

– programming of operating periods for the pumping groups, outside the periods of peak power load curves, thus ensuring significant power savings.

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MONITORIZAREA ŞI CONTROLUL PARAMETRILOR FUNCŢIONALI – ENERGETICI AI STAŢIEI DE REPOMPARE BOLDEŞTI DIN CADRUL SISTEMULUI DE ALIMENTARE CU APĂ BOLDEŞTI – COTNARI

(Rezumat)

Articolul prezintă sistemul de monitorizare şi control al parametrilor funcţional – energetici ai staţiei de repompare Boldeşti din cadrul sistemului de alimentare cu apă Boldeşti–Cotnari. Reprezentând o parte a lucrărilor de reabilitare şi modernizare ale staţiei de repompare, implementarea acestui sistem are beneficii multiple: optimizarea energetică a exploatării a instalaţiei de pompare, asigurarea mentenanţei preventive, efectuarea analizelor şi diagnozelor tehnice şi programarea intervalelor de funcţionare în afara perioadelor de vârf ale curbei de sarcină a sistemului energetic.

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CERTAIN ISSUES ON THE CORRELATION BETWEEN THE GRAPHIC DATABASES AND THE ATTRIBUTE TYPE ONES IN A GIS PROJECT

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Abstract. In this paper I intend to show an example of performing the connections between the graphic databases and the attribute type ones. The example is from a GIS project for the forecast of soil erosion.

It is extremely important for the attribute type database to be developed from the beginning of the application. The number of tables (dbf) defines the complexity of the database. The database can be improved during the application. The connection keys developed in the application are of the essence because enable the further interrogations in the application. In order to enable the interrogation of the database in the set out project, I developed two types of connections: by mans of **„Fox keys”** and by means of **„SQL keys”.** Another important stage consists of specifying the common fields for the creation of connections between the tables. This paper shows the manner in which the indexed field is specified for each table, as well as the “Relation” of the relevant table with the other tables in the database (by means of the field name).

Keywords: database; indexed field; link; GIS.

1. Introduction

The area monitoring and management operations imply a considerable volume of data and processing and analyzing means thereof. In this context, the

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determination of soil quality and in particular of those affected by erosion degradation processes becomes highly important for both the agricultural owners and for the decision makers in agricultural management area.

If we refer to the determination of the erosional risk, in particular for large areas, this implies the thorough knowledge of all factors involved in the performance of the degradation process, namely of the parameters that characterize the climate, landscape, soil, use of land, agricultural operating technologies etc. However, taking into consideration that all these parameters have a spatial distribution, namely have a certain value at each point in space, the complex monitoring action can only take place within a Spatial Information System.

By implementing these techniques, one can even achieve an integrated ecological monitoring, by which the competent bodies can permanently oversee the status of natural resources, generally of the environment and anthropic impact factors, based on the spatial and temporal coverage parameters and indexes, which ensure the information framework required for the strategy and tactics on the prevention of consequences of the environment factors and human activities, for the development of forecasts and exercise of operational control on the recovery actions related to the ecological status.

2. Research Method Approached in a GIS Project

In order to determine the loss of soil due to the surface erosion, the USLE equation was initially selected, at a first stage, in the usual form used in our country.

In order to create the geo-referential database included in the above mentioned equation, the raster procedure was used, and this consisted of the overlap on the cartographic documentation of a rectangular grid of square cells with sizes that ranged mainly depending on the landscape, area of catchment basins related to the two basins, the variation of different types of soil and usage. The rectangular grid applied in this study is of 25×25 m.

For each information layer (topographic characteristics, distribution of soils, occupation of land by various use, distribution of anti-erosion actions in the area etc.) it was started the creation of a relational geo-referential database and of an attribute base, starting from the same cell of the rectangular grid.

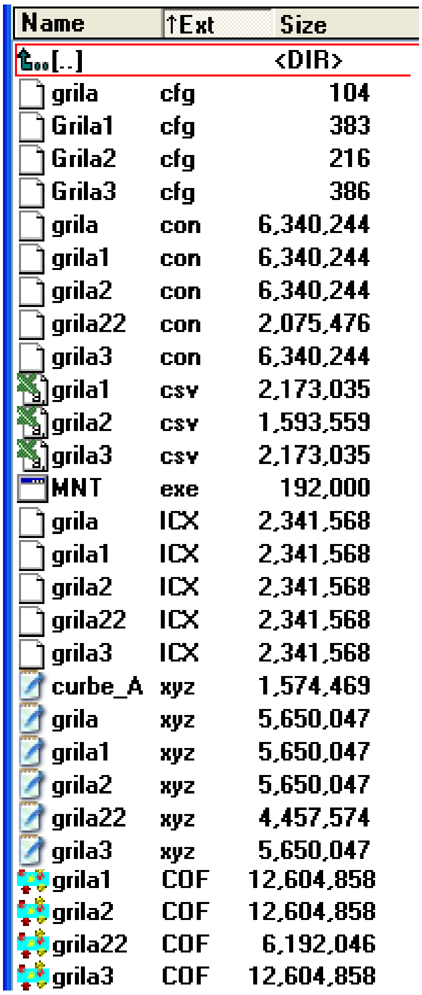
Further on, for each cell of the rectangular grid spatially reported by geodesic coordinates in Stereo 70 system, the USLE equation adjusted for our country by M. Moțoc was successively applied.

In order to determine the average annual loss of soil and afterwards the alluvial inflow from the catchment basins of the two above mentioned basins, we used a domestic software, namely Geo – Graph software. In this software there were created modules of application programs so that, after processing the acquired information, such information were displayed in both alphanumeric and graphic form.

3. Results Obtained in the GIS Project

In the attribute-type database (alphanumeric) for each separate cell can be found the characteristics (values) of interest for the determination of soil loss by erosion.

In the programs of „MNT.exe” and „*Eroziune.exe*” modules, it was determined that the numeric figures resulted after the processing should be saved both in ASCII files, with the extension *.xyz* and in „comma delimited” format, with the extension *.csv* (Fig. 1.)



Name	↑Ext	Size
[..]		<DIR>
grila	cfg	104
Grila1	cfg	383
Grila2	cfg	216
Grila3	cfg	386
grila	con	6,340,244
grila1	con	6,340,244
grila2	con	6,340,244
grila22	con	2,075,476
grila3	con	6,340,244
grila1	csv	2,173,035
grila2	csv	1,593,559
grila3	csv	2,173,035
MNT	exe	192,000
grila	ICX	2,341,568
grila1	ICX	2,341,568
grila2	ICX	2,341,568
grila22	ICX	2,341,568
grila3	ICX	2,341,568
curbe_A	xyz	1,574,469
grila	xyz	5,650,047
grila1	xyz	5,650,047
grila2	xyz	5,650,047
grila22	xyz	4,457,574
grila3	xyz	5,650,047
grila1	COF	12,604,858
grila2	COF	12,604,858
grila22	COF	6,192,046
grila3	COF	12,604,858

Fig. 1 – Output files following the use of ***„MNT.exe”*** software.

Output files are:

- ASCII type files ***.xyz*** with figures and coordinates for each cell

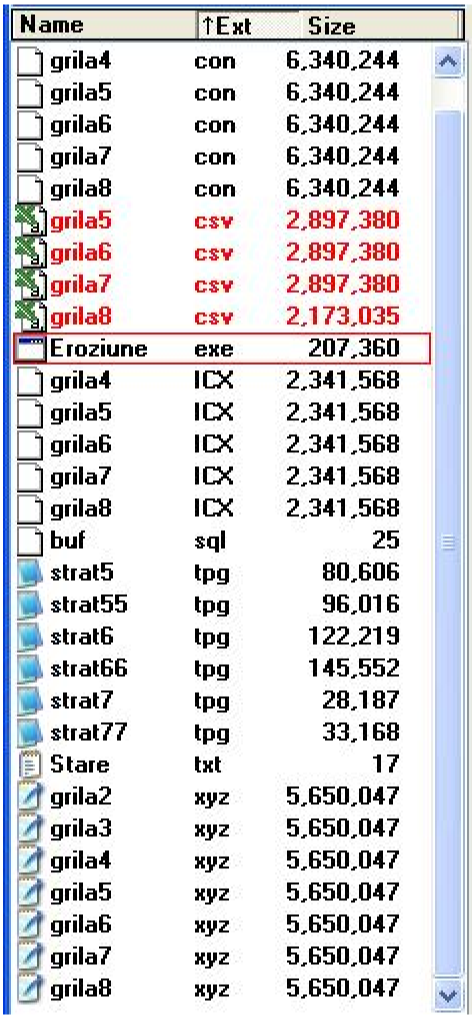
Obs. MNT.exe was programmed so as to ensure that the flowing directions are represented both in the form of color codes (*grid 2*) and in the form of arrows (*grid 22*).

- ***.icx*** type files where the reference system the drawing refers to is memorized (is identical for all layers).
- ***.con*** type files which memorizes the colors for each layer for the graphic representation; the ranges of values grouped by classes and associated color codes are determined in the configuration files.
- ***.csv*** type files which save the numeric values resulted following processing; this format (*comma delimited*) enables the import of these files to databases, such as Acces, dBase.
- ***.cof*** type files (Fig.2) represent the binary saving of the information layers resulted following the processing.

Please note that the resulting files were named as follows:

- ✓ grid 1 → average share of each cell;
- ✓ grid 2 → the flowing direction of each cell;
- ✓ grid 3 → average slope in each cell;

The assignment of certain colors (by means of color codes) for various value ranges resulting in the above mentioned files took place by means of the three „*.cfg*” type files:



Name	↑Ext	Size
grila4	con	6,340,244
grila5	con	6,340,244
grila6	con	6,340,244
grila7	con	6,340,244
grila8	con	6,340,244
grila5	csv	2,897,380
grila6	csv	2,897,380
grila7	csv	2,897,380
grila8	csv	2,173,035
Eroziune	exe	207,360
grila4	ICX	2,341,568
grila5	ICX	2,341,568
grila6	ICX	2,341,568
grila7	ICX	2,341,568
grila8	ICX	2,341,568
buf	sql	25
strat5	tpg	80,606
strat55	tpg	96,016
strat6	tpg	122,219
strat66	tpg	145,552
strat7	tpg	28,187
strat77	tpg	33,168
Stare	txt	17
grila2	xyz	5,650,047
grila3	xyz	5,650,047
grila4	xyz	5,650,047
grila5	xyz	5,650,047
grila6	xyz	5,650,047
grila7	xyz	5,650,047
grila8	xyz	5,650,047

Fig. 2 – Output files after rolling the ***„Eroziune.exe”*** program

„*grid1.cfg*” → represents the configuration of colors by share ranges;

„*grid2.cfg*” → represents the configuration of colors by the 8 flowing directions;

„*grid3.cfg*” → represents the configuration of colors by slope ranges.

The processing took place by means of the „*Eroziune.exe*” program (in Fortran language) which used an input all layers processed in the previous stages (Fig. 2.).

Were named:

Grid 4 – layer of the layer containing the topographic information $L^m \cdot i^n$;

Grid 5 – layer with the information on the distribution of usage categories (coef. C);

Grid 6 – layer with the information on the mapping of soil units (coef. C);

Grid 7 – layer with the information on the distribution of perimeters with anti-erosion systems (coef. C_s);

Grid 8 – layer with information on erosion-related soil losses **(E);**

Due to the fact that the number of cells / pixels for each information layer is extremely high (tens of thousand), it was highly required to ensure the ***automatic saving*** of the files both for the possibility to manage them in a database and for the possibility to create connection keys with the graphic database.

The **„csv"** format enabled the import of files in the Access type database. Following the operations required for the save thereof in *.mbd* (ACCESS) format, the export in the dBase IV format for FoxPro was enabled (Fig. 3).

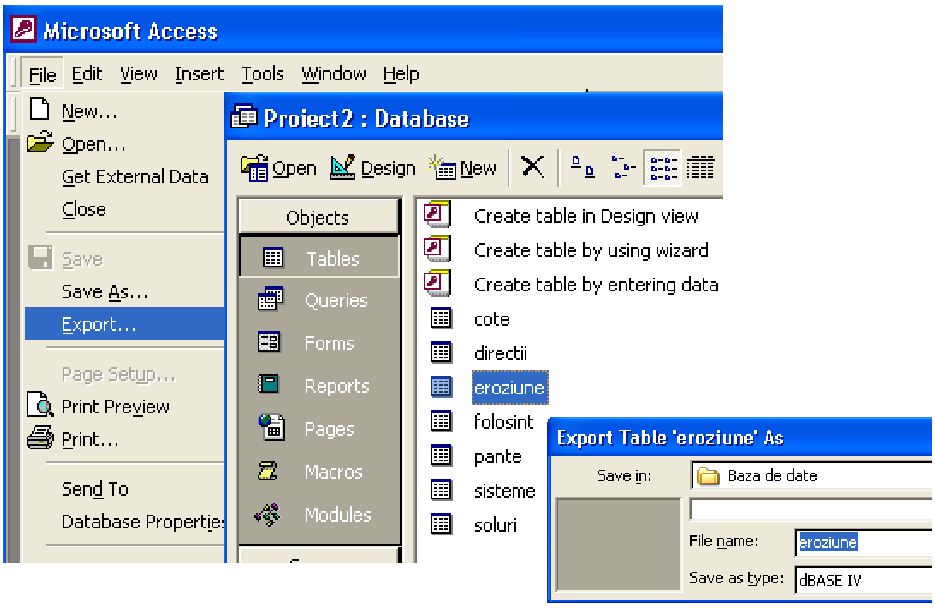


Fig. 3 – Export of files in dBase IV format.

The management of an alphanumeric database for the two catchment basins set out herein takes place under FoxPro 2.6. This S.G.B.D. is a system for the management of relational type databases. In a simple sense, a relational system implies several databases (generally called *„tables"*) which are opened at the same time, connected by means of common fields. The number of databases and common connection fields define the complexity of the S.G.D.B. (Fig. 4).

The *.dbf* tables of the database were developed automatically, after the processing (except for the table *„Coef S"* related to soil characteristics according to the soil units files, based on which the erodability coefficients S were determined).For each *.dbf* table, the structure was defined first, by means of: name of fields, type and length thereof (Fig. 5), depending on the nature of data to be uploaded.

The structure defined in a first stage can be amended at all times by the user through the "*modi stru*" control (Fig. 6), but it is highly important that, as of the creation of the "connection keys" between the alphanumeric database and the graphic database, to avoid the change of this structure, otherwise the interrogation will have errors or will not be available at all.

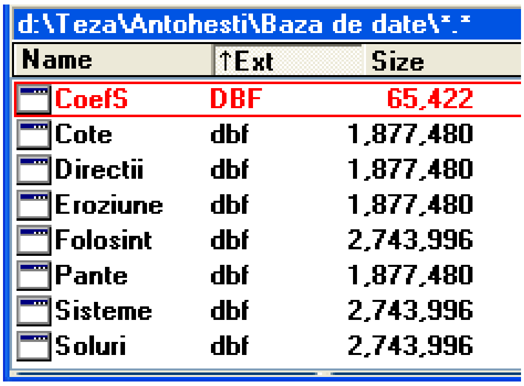


Fig. 4 –„*.dbf*" files which make the alphanumeric database of the GIS project.

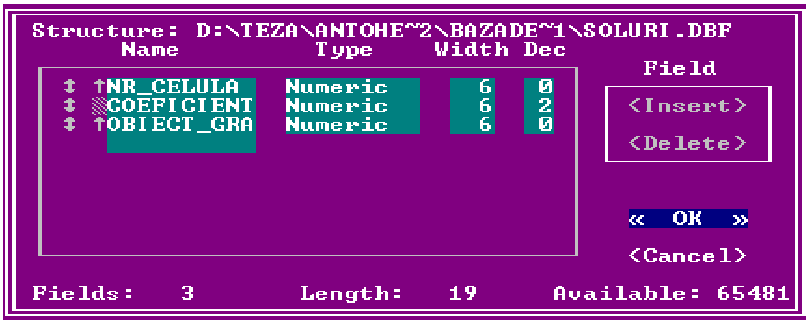


Fig. 5 – Sequence of the „*Soils.dbf*" table and description of the structure thereof.

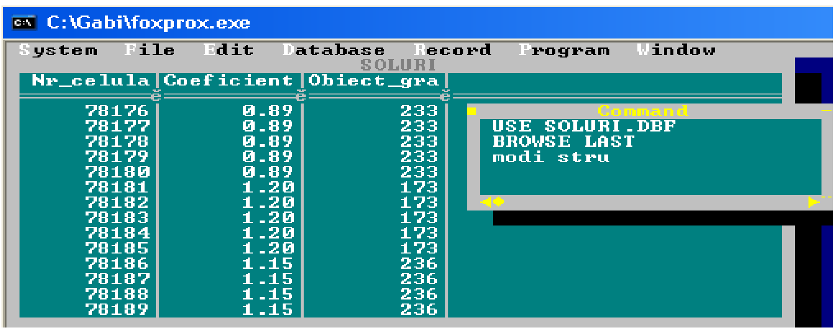


Fig. 6 – Sequence of the „*Soils.dbf*" table and "*modi stru*" control.

4. Creating the Connection Between the Alphanumeric Database and the Graphic One

In order to enable the interrogation of the database both by means of ***„Fox keys”*** and ***„SQL keys”*** in the stage immediately following the completion of *.dbf* tables, it was required to design the correlation between the files of the alphanumeric database and those of the graphic database. Thus, the *.ast* type files (Fig. 10) were created, by taking into consideration the following rules:

- ⇨ the files with the extension *.ast* should have the exactly same name as the *.dbf* files (tables);
- ⇨ the creation in the work directory of the „Catalog.ast” file, which contains the list of all tables regarding which one considers a “relation” for the interrogation and the indexed fields for the connection between tables (Fig. 7);
- ⇨ these files should be edited by maintaining the structure of each table in FoxPro through the *„disp stru*” control (Fig. 8), by specifying the connection fields between the tables for interrogation purposes;

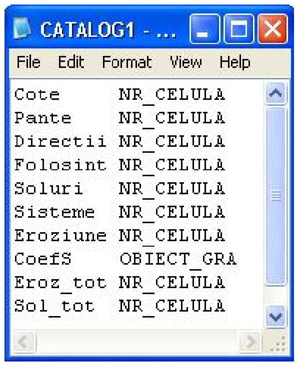


Fig. 7 – List of “Catalog.ast”.

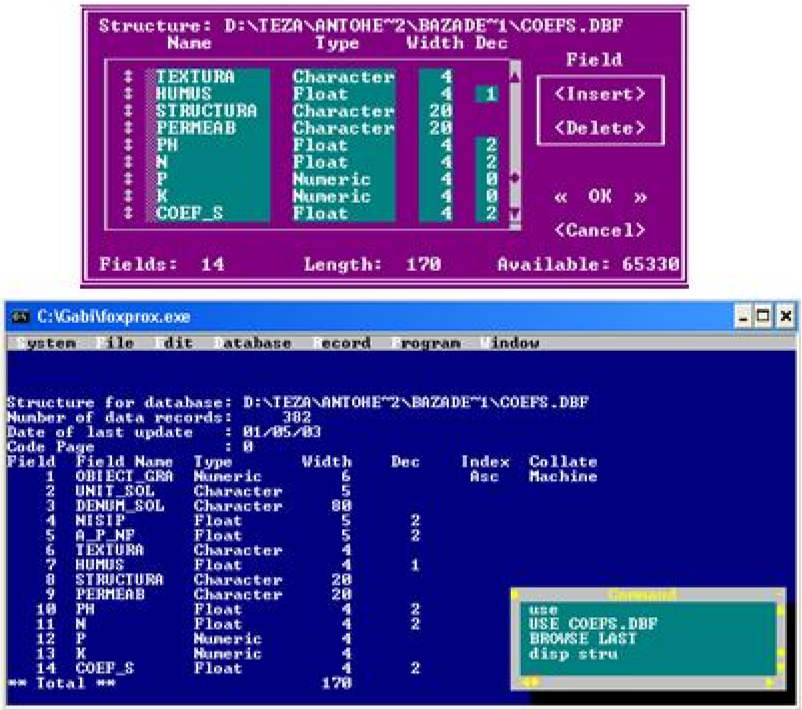


Fig. 8 – Validation of the *„CoefS.dbf”* table structure.

⇨ indexation of the fields in the database, required for interrogation (Fig. 9).
bservations:

⇨ The „*Field Name*” should have the same name as in the *.dbf* ;

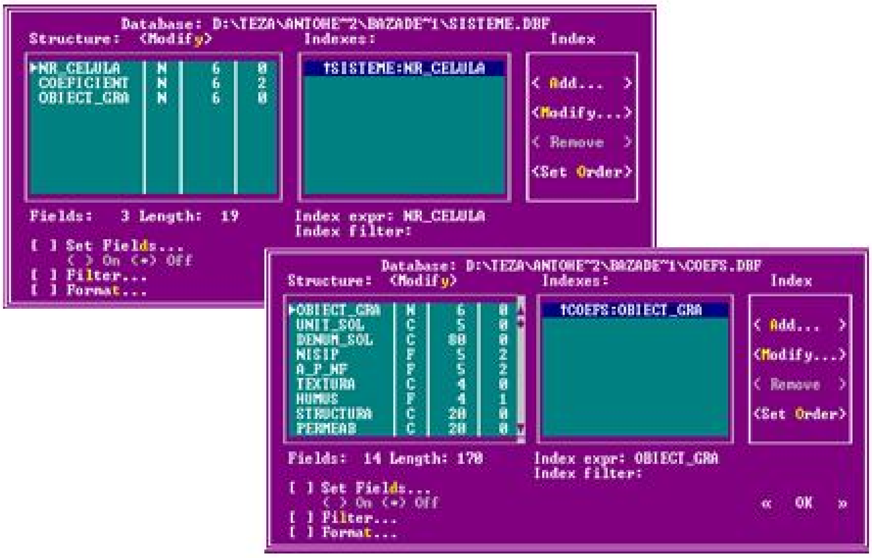
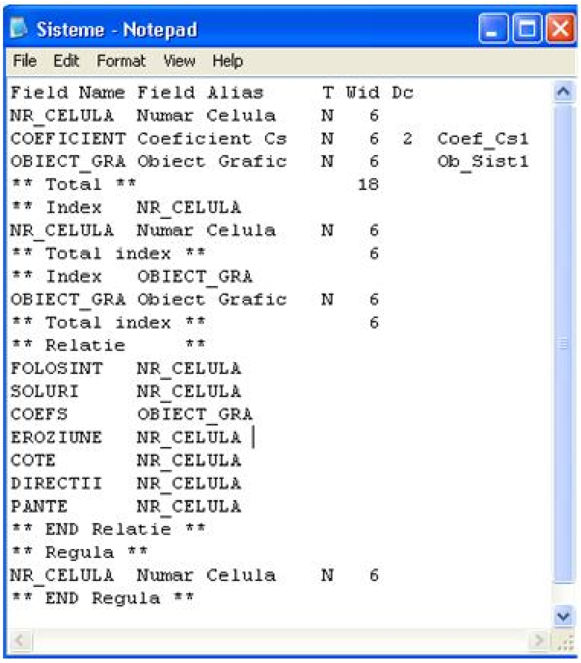


Fig. 9 – Examples of fields indexation.




```
Field Name Field Alias    T Wid Dc
NR_CELULA  Numar Celula   N   6
COEFICIENT Coeficient Cs  N   6  2  Coef_Cs1
OBIECT_GRA Obiect Grafic  N   6     Ob_Sist1
** Total **                  18
** Index    NR_CELULA
NR_CELULA  Numar Celula   N   6
** Total index **             6
** Index    OBIECT_GRA
OBIECT_GRA Obiect Grafic  N   6
** Total index **             6
** Relatie      **
FOLOSINT   NR_CELULA
SOLURI     NR_CELULA
COEFS      OBIECT_GRA
EROZIUNE   NR_CELULA
COTE       NR_CELULA
DIRECTII   NR_CELULA
PANTE      NR_CELULA
** END Relatie **
** Regula **
NR_CELULA  Numar Celula   N   6
** END Regula **
```

Fig. 10 – Editing syntax of a ***.ast*** type file.

⇨ „*Field Alias*" represents the explanation of fields (not more than 15 digits);
⇨ The „*Coef_Cs1"* and „*Ob_Sist1"* notes on the right side mean that, on the interrogation of the database for the two fields, supporting tables called dictionaries will be displayed; such dictionaries are developed by the user, with no specific requirements related to the format, in order to provide fast interrogation information
⇨ The indexed field will be specified for each table, as well as the "Relation" of the relevant table with the other tables in the database (by means of the field name).

5. Conclusions

The management of the alphanumeric database for the two catchment basins in this application takes place under FoxPro 2.6. This S.G.B.D. is a system for the management of relational type databases. In a simple sense, a relational system implies several databases (generally called „*tables"*) which are opened at the same time, connected by means of common fields. The number of databases and common connection fields define the complexity of the S.G.D.B. An application becomes complex when it uses more than four databases opened at the same time.

The *.dbf* tables in the database were automatically created following the processing. The only table "manually" uploaded in the system was the one related to the characteristics of soil "Coef S" according to the soil unit files, based on which the erodability coefficients S were determined.

For each *.dbf* table, the structure was defined first, by means of: name of fields, type and length thereof (fig. 4), depending on the nature of data to be uploaded. The structure defined in a first stage can be amended at all times by the user through the "*modi stru*" control, but it is highly important that, as of the creation of the "connection keys" between the alphanumeric database and the graphic database, to avoid the change of this structure, otherwise the interrogation will have errors or will not be available at all.

The management system of data organized in this example in databases – tables, complies with the primary functions of a SGDB for a GIS, enabling:

⇨ the definition of the database structure by the user, as well as of the validation and access requirements;
⇨ update of the date (up-to-date);
⇨ extraction of data in the envisaged form;
⇨ save of the structure configuration of each table in order to edit the connection "keys" between the alphanumeric database and the graphic database;
⇨ definition by the user of the own field indexation requirements, in order to create the "relations" between the tables managed by SGDB.

The benefits of using the SQL controls within the application are several:

- ⇨ the interrogation can be performed on any uploaded information layer; the relational type of the database ensures the provision of the envisaged information;
- ⇨ the existence of virtual tables in the project enable criteria analyses through the interrogation of various tables from the alphanumeric database;
- ⇨ the possibility to conduct statistics on the information acquired following processing; if for the values of coefficients C, S, C_s one could have estimated with a certain approximation, the related areas, directly from the site plans, in case of landscape parameters (gradient, flowing directions) and erosion, within the analyzed basins, this would not have been possible.

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UNELE ASPECTE PRIVIND REALIZAREA CORELAŢIEI DINTRE BAZELE DE DATE GRAFICE ŞI CELE DE TIP ATRIBUT ÎNTR-UN PROIECT GIS

(Rezumat)

Este arătat un exemplu de realizare a legăturile dintre bazele de date grafice şi cele de tip atribut. Exemplul este dintr-un proiect GIS pentru estimarea eroziunii solului.

Este foarte important ca baza de date de tip atribut să fie concepută chiar de la începutul aplicaţiei. Numărul de tabele (*dbf*) sunt cele care definesc complexitatea bazei de date. Pe parcursul aplicaţiei, baza de date se poate dezvolta şi îmbunătăţi. Cheile de legătură create în aplicaţie sunt vitale deoarece fac posibile interogările ulterioare din aplicaţie. Pentru a fi posibilă interogarea bazei de date din proiectul prezentat am conceput 2 tipuri de legături: atât prin ***„chei Fox"*** cât şi prin ***„chei SQL.***

O altă etapă importantă constă în specificarea câmpurilor comune pentru crearea legăturilor dintre tabele. În prezenta lucrare este arătat modul în care se specifică câmpul indexat pentru fiecare tabelă în parte şi totodată „Relaţia" tabelei în cauză cu celelalte tabele din baza de date (prin numele câmpului).

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STUDIES ON MONITORING THE BEHAVIOUR OF HYDROTECHNICAL CONSTRUCTIONS

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Abstract. The type of **-** special or current – dam monitoring is determined, over time, based on the categorization of dams according to their importance, in compliace with the rigours imposed by the quality system for constructions (OUG nr.244/2000).

This case study presents the manner in which the behaviour of the Hydraulic Stânca-Costeşti Power Plant was monitored through topo-geodetic methods.

The dam is classified as Class II according to importance and in (B) category of major importance, its behaviour requiring special monitoring.

The monitoring work was carried out through highly accurate planimetric and altimetric geodetic measurements on 229 marks.

In the case of dams in operation, the management mainly consists in monitoring their behaviour over time and conducting regular safety assessments.

These assessments must confirm that the dams are safe, or identify the safety deficiencies and establish the necessary measures that have to be taken in order to reduce the risks.

Keywords: monitoring the behaviour of hydrotechnical constructions; topo-geodetic methods; quality in constructions; dam safety management.

1. Introduction

Monitoring the behaviour of hydrotechnical constructions is a systematic activity of collecting, recording and capitalizing on the information obtained from

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observing and measuring the parameters that define the state and evolution of hydrotechnical structures (NP87-2003).

This activity is a component of the quality system for constructions that allows to:

a) assess the technical condition of the constructions being monitored;

b) prevent damages and accidents;

c) provide data necessary for regular assessments;

d) establish the works necessary for safe operation.

Terrestrial measurement technologies (*i.e.* GNSS technology, robotic total stations, 3-D terrestrial laser scanners, etc.) have developed over the past few years, which made it possible to monitor the in situ behaviour of constructions, in real time, by using deformation spacial monitoring systems, like we are proposing in this paper (Onu, 2014).

Currently, the main parameters are being monitored with the help of measuring equipment, as well as by carrying out topographic measurements by means of highly accurate geodetic methods.

In the case of dams in operation, the management mainly consists in monitoring their behaviour over time and conducting regular safety assessments. The latter must confirm that the dams are safe, or, on the contrary, identify the safety deficiencies and propose the measures that ought to be taken in order to reduce the risks.

2. Case Study

The quality system in constructions is applied differently, based on the categories and classes of importance of the constructions in question. The classification into classes of importance is based on the economic and social importance of the development according to STAS 4273-83, while the classification of dams into categories of importance is made according to the value of the risk index associated with the dam in compliance with NTLH - 021/2002.

The type of – special or current – dam monitoring is determined, over time, based on the categorization of dams according to their importance, in compliance with the rigours imposed by the quality system for constructions (OUG nr.244/2000).

This case study presents the manner in which the behaviour of the Hydraulic Stânca-Costeşti Power Plant was monitored through topo-geodetic methods (Fig. 1).

The Stânca-Costeşti dam is a complex development on the Prut River erected in 1978. It has a particularly long retention front (over 3 km), consisting of various types of dams. From the right bank (Romania) to the left (Republic of Moldova), there are two concrete dams (the first a buttresses dam and the second a gravity dam), the spillway of large amounts of water, the main dam, a dam made of reinforced concrete, cased, and an earth-filled dam that encloses an old quarry.

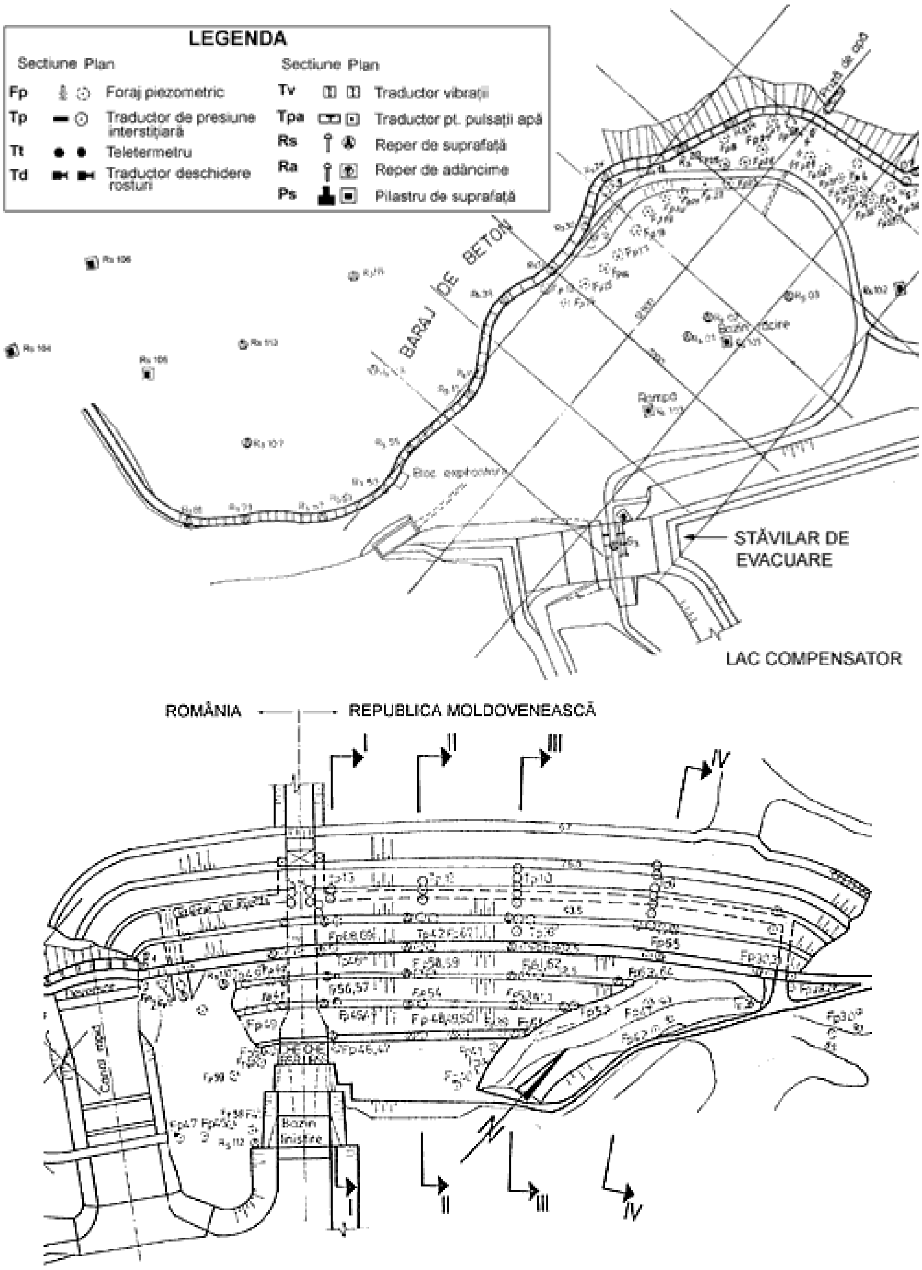

Fig. 1 – Dam site plan (www.baraje.ro).

This development has a complex use: drinking and industrial water supply, flood control, electricity production, fishery, irrigation. The dam is classified as Class II according to importance and as (B) in the category of major importance, its behaviour requiring special monitoring.

The border between Romania and the Republic of Moldova passes through the pressure node located within the main dam. The work is monitored separately by either of the two parts that administer it.

In the part of the dam located in Romania, a micro-triangulation network is established.

The deformations and the horizontal and vertical displacements were determined based on the planimetric coordinates and on the quota of the measuring marks from the support network, the determination network and the mobile measuring mark network.

Since the beginning of the monitoring process, as far back as 1980, highly accurate planimetric and altimetric geodetic cycles and measurements were carried out every year on the following objectives:

i) concrete dam;

ii) gravity dam, right bank;

iii) earth-filled dam;

iv)penstock;

v) spillway.

The monitoring was conducted through highly accurate planimetric and altimetric geodetic measurements on 229 points, as follows:

a) 15 points in the support network;

b) 19 points in the determination network;

c) 195 mobile measuring marks.

The planimetric measurements were conducting by stationing the marks from the support network and those from the determination network with the Theo 0.10 B-type theodolite, in programmes comprising 4 series, in the case of the marks from the support and determination networks, and 2 series, in the case of the mobile measuring mark network.

The distance between the points was measured by means of a Leica T.C. 1010 total station.

The altimetric measurements were carried out through the simultaneous geodesic levelling method, ensuring the precision of the “I”-type levelling. Two geometrical Koni 0.07-type levelling instruments and 1.75 m and 3.00 m levelling rods were used.

The measuring elements on the field were processed through rigorous calculation methods in order to obtain the planimetric coordinates and the quota of the points from the monitored network.

3. Results and Discussions

By comparing the elements obtained in the cycle from 2012, in relation to the initial cycle from 1980, the following results, as shown in Tables 1,...,3, are obtained.

Table 1
Horizontal and Vertical Movements in the Basic Measuring Mark Network

Nr. pct.	d*x* mm	d*y* mm	dz mm	Nr. pc.	d*x* mm	d*y* mm	dz mm
1	2	3	4	1	2	3	4
101	–7.8	–14.7	–24	108	–0.9	–1.9	
102	–0.9	0.5	–9.4	109	0.6	0.3	–6.7
103	–6.2	–5.7	–12.2	110	–7	2	–13.3
104			–0.2	111	29.1	–15.8	–148.4
105			2	112	8.5	–7.1	–8.8
106			–0.5	113	0.7	0.6	
107	–1.4	–1.9		114	4.2	–0.2	

Table 2
Horizontal and Vertical Movements in the Determination Mark Network

Nr. pct.	d*x* mm	d*y* mm	dz mm	Nr. pct.	d*x* mm	d*y* mm	dz Mm
1	2	3	4	1	2	3	4
2	0.6	–11.7	–12.1	60	31.4	–0.7	5.5
8.9	2	3.9	–8.4	63	6.7	0.7	–5.8
14	2.5	4.2	–2.8	67	10.8	7.7	–6.2
20	5.9	–3.2	–8.5	73	5.3	–6.3	–5.4
26	3.3	–0.2	–8.4	80	13.3	–11.5	–6.8
30	6.5	9.1	–11.8	110	–4.6	3.5	–13.5
34	21.6	–2.7	–10.2	111	29.1	–15.8	–148.4
38	–13.4	–13.3	–2.2	112	8.5	–7.1	–8.8
44	6.7	3.1	–7.5	D1	–10.5	–6.8	–20.4
46	3	9.1	–5.9	D7	–7.1	–12.6	–6.1
56	7.1	2.8	–4.8	S3	19.5	–14.4	9.3

Table 3
Horizontal and Vertical Movements on the Earthen Dam

Nr. pct.	d*x* mm	d*y* mm	dz mm	Nr. Pct.	d*x* mm	d*y* mm	dz mm
1	2	3	4	1	2	3	4
The crown				Berm II			
500	6.7	13	–78.3	507	21.6	–11.1	–46.7
501	99.3	–42.8	–125.7	508	20.4	–9.5	–59.6
502	81.6	–91.1	–173.8	509	16.9	–15.0	–56.0
503	39.3	–28.5	–153.3				
Berm I							
504	15.8	6.6	–82.2				
505	10.8	6.8	–94.2				
506	6.6	5.7	–101.9				

The following deviations were found as a results of the measurements performed:

Planimetric results:

1. In the support control network (basis):

Maximum deviations;

In abscissae; +29.1 mm in point 111; On the ordinate; – 4.7 mm in point 101;

2. In the determination control network:

a. On the concrete dam: maximum deviations:

In abscissae; +31.4 mm in point 60;

On the ordinate; –11.5 mm in point 80,

b. On the spillway: Maximum deviations:

In abscissae; –10.5 mm in point D1;

On the ordinate; –12.6 mm. in point D7;

c. On the penstock: Maximum deviations:

In abscissae; +19.5 mm in point S3;

On the ordinate; –14.4 mm in point S3;

d) On the earthen dam: Maximum deviations:

In abscissae; +99.3 mm in point 501;

On the ordinate; –91.1 mm in point 502;

Altimetric results

1. In the support control network (basis):

Maximum tracing; –148.4 mm in point 111;

Minimum tracing ; –6.7 mm in point 109;

2. In the determination control network:

a. On the concrete dam:

Maximum tracing; –12.1 mm in point 2;

Minimum tracing; –2.2 mm in point 38;

b. On the spillway:

Maximum tracing; –20.4 mm in point D1;

Minimum tracing; –1.0 mm in point D30;

c. On the penstock:

Maximum tracing; –21.6 mm in point S5;

Minimum tracing; +10.4 mm in point S30;

d. On the earthen dam:

Maximum tracing; –173.8 mm in point 502;

Minimum tracing; –46.7 mm in point 507;

Accentuated tracing is done at the level of the crown of the earthen dam.

The tracing is diminished towards berm I and berm II.

The tracing recorded in this cycle comply with construction monitoring norms.

4. Conclusions

According to the law in force, the compliance with dam safety-related performance requirements is mandatory in all the stages of implementation and exploitation.

Monitoring the behaviour of hydrotechnical constructions is a component part of the quality system. This system is applied differently based on the categories and classes of importance of the constructions.

In the case of dams in operation, the management mainly consist in monitoring their behaviour over time and in conducting regular safety assessments.

These assessments must confirm that the dams are safe, or identify the safety deficiencies and establish the measures that have to be taken in order to reduce the risks.

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* * * STAS 42773/1983.

* * * NTLH 021/2002.

* * * www.baraje.ro.

STUDII PRIVIND SUPRAVEGHEREA CONSTRUCȚIILOR HIDROTEHNICE

(Rezumat)

Stabilirea tipului de urmărire în timp a barajelor – specială sau curentă – se realizeaza în funcție de încadrarea în categorii de importanță a barajelor, în conformitate cu rigorile impuse de sistemul calității în construcții (OUG nr.244/2000).

Studiul de caz prezintă realizarea urmăririi comportării obiectivelor Nodului Hidrotehnic Stânca–Costeşti, partea română prin metode topo-geodezice.

Barajul este încadrat în clasa a-II-a de importanță şi în categoria de importanță deosebită (B), comportarea lui necesitând o urmărire specială.

Executarea lucrării s-a efectuat prin măsurători geodezice planimetrice şi altimetrice de mare precizie asupra unui număr de 229 puncte.

Pentru baraje aflate în exploatare, baza managementului constă în urmărirea comportării în timp a acestora şi în evaluările periodice ale siguranței.

Aceste evaluări trebuie să confirme că barajele sunt sigure, sau să identifice deficiențele de siguranță şi să stabilească măsurile necesare reducerii riscului.

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ASPECTS REGARDING FLOOD MODELING WITH MOHID

BY

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Abstract. This paper refers to flood modeling in Enxoé watershed using MOHID Land. It presents calibration and validation of the watershed covering area of 6080 ha. The concept of watershed modeling is embedded in interdependence use of soil, water, climate and land and is represented by means of mathematical abstractions. MOHID is an integrated modeling tool able to simulate physical and biogeochemical processes in the water column as well as in the sediments, and is also able to simulate the coupling between these two domains and the latter with the atmosphere. Hydrological modeling of ungauged catchments has focused on obtaining reliable estimates of runoff, it was achieved by linking parameter values to catchment characteristics.

Keywords: ungauged watershed; hydrological modeling; forecast; MOHID.

1. Introduction

Flood is a natural phenomenon of rapidly and significant increase and decrease of levels and water flows. It occurs as a result of heavy rainfalls over a catchment which often overlap a soil that was moistured by previous rainfall of a lower intensity (Giurma, 2003).

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In recent history, floods are becoming more frequent and severe. In Europe, flooding, is the most common natural disaster and the most costly in economic terms. The Emergency Disasters Data Base (EM-DAT) has recorded a total of 238 flood events in European region from 1975 to 2001.

The frequency of occurrence and the intensity of damages and losses of lives resulting from floods made it known all over the world that flood is a great treat to humanity. However, since serious floods occur in a certain location with a return period of years or decades, the lessons learned from previous flood may have been forgotten (Miller, 1997).

The direct effects of floods includes: serious loss of lives, large loss of property, disruption of transportations, communications, health and community services, crop and livestock damages and interruptions and losses in business.

The consequence of floods requested a growing attention because of the need to prevent or control flood damages in our society. Mitigating flood damages can be drawn in two possible ways: structural measures and non-structural measures.

The concept of watershed modeling is embedded in the interrelationships of soil, water, climate and land use and is represented by means of mathematical abstractions. The behavior of each process is different and controlled by its own characteristics and its interaction with other processes within a given catchment. Rainfall is one of the predominant hydrologic processes, in addition to interception, evapotranspiration, infiltration, surface runoff, percolation and subsurface flow (Gosain *et al*., 2009).

MOHID is an integrated modeling tool able to simulate physical and biogeochemical processes in the water column as well as in the sediments, and is also able to simulate the coupling between these two domains and the latter with the atmosphere. This program is designed to simulate hydrographic basin and aquifers. MOHID Land is a physically-based, spatially distributed, continuous, variable time step model for the water and property cycles in inland waters and main mediums (http://www.mohid.com/).

2. Case study

Portugal, is a country located in Southwestern Europe, on the Iberian Peninsula. It is the westernmost country of mainland Europe, and is bordered by the Atlantic Ocean to the west and south and by Spain to the north and east.

2.1. Enxoé Catchment Description. General Characteristics

The Enxoé river basin forms part of the basin of the Guadiana River and is located in Serpa Municipality, in Beja District (Fig. 1). The study area, corresponding to the Enxoé catchment area of the reservoir, is 6080 ha and has an average altitude of about 200 m. The main river is Ribeira do Enxoé that has a length of around 10 km from headwaters up to the reservoir. The Enxoé reservoir has a total volume of 10.4 hm^3 a surface area around 2 km^2 and an average depth of 5 m.

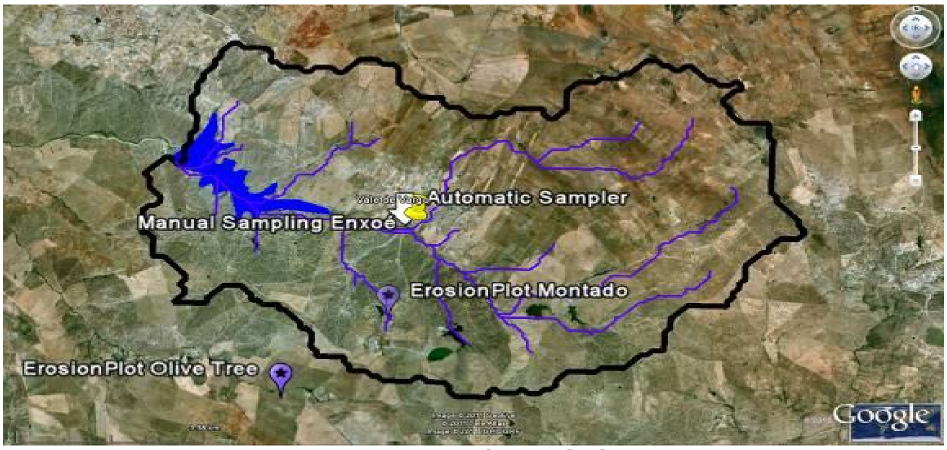

Fig. 1 – Enxoé watershed.

2.2. Hydro-Climatic Conditions

The hydrological regime of the catchment is pluvial and is characterized by strong inter-annual and intra-annual variations in discharge. The Enxoé basin has dry Mediterranean characteristics, with hot summers, high insolation and high evapotranspiration. The annual average precipitation in the basin is about 500 mm, but the inter-annual distribution of precipitation is extremely irregular, with more than 80% of the annual total concentrated between October and April (usually occurring intense and concentrated precipitation events that create flood rise and fall in couple of hours). During summer, the Enxoé river frequently runs dry (flow is really low or absent). The annual average temperature is about 16°C and annual reference evapotranspiration varies between 1,200 mm and 1,300 mm.

2.3. Soil Characteristics

In the Enxoé catchment, the dominant soils are Luvisols covering 45% of the area (13% Calcic Luvisols), Cambisols covering about 30% and Calcisols about 15%.

Soil texture (proportion of sand, clay, etc.) is a soil property that can depict the water movement from derived parameters as hydraulic conductivity, porosity, density, etc. These parameters influence groundwater flow, soil water and infiltration and water distribution between surface and groundwater. Soil texture for Enxoé has a distribution that range from coarser (less than 18% clay and more than 65% sand) to fine (between 35% and 60% clay) representing both 74% of the area (http://eusoils.jrc.ec.europa.eu/).

2.4. Land Use

The dominant land uses in the Enxoé basin are olive groves (2,740 ha), and agro-forestry of holm-oak (2,005 ha). Winter crops, maize and pastures (1,050 ha), water (205 ha) and urban area (80 ha) are also important land uses to consider.

The main land uses in Enxoé it is presented in Fig. 2 and around 30% is olive trees, 30% oak silvipastoral system and 30% annual crops and only 1% is urban (the small town Vale de Vargo with around 1000 inhabitants) (http://www.aguaflash-sudoe.eu/study-sites/the-river-enxoe-location).

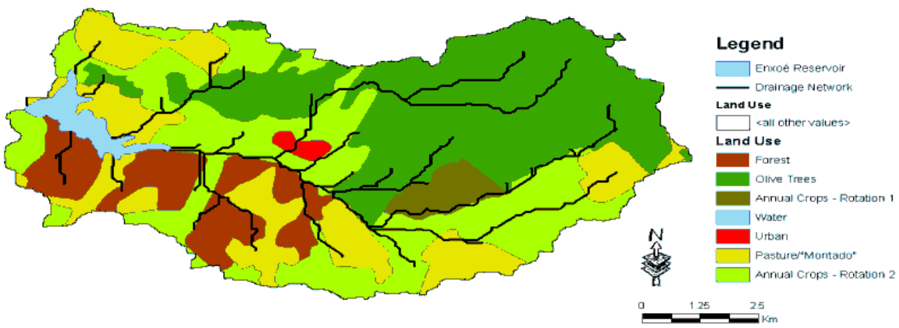

Fig. 2 – Land use in Enxoé (http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000-clc2000-seamless-vector-database).

The main component of floods and specifically of fast floods (or flush floods) in arid or semi-arid region (without macropore or karstic flow) is runoff water or subsurface water that arrives faster to the river than groundwater flow. In Enxoé watershed flood peaks occur within 1 to 5 hours after flood start and as a direct response of rain events.

Enxoé was an ungauged watershed in the river, thus, to define the state of the river and validate the model, data collection was performed during 2010-2011 in the two main tributaries to the Enxoé reservoir (Enxoé river and the river that passes through the only village, entering Enxoé before the beginning of the reservoir). Flood data was obtained with an automatic sampler and a coupled multiparametric YSI 6000 probe (measuring level, turbidity, temperature, conductivity and oxygen). Automatic sampling was performed when measured level raised or lowered more than 10 cm. The river manual data in low water conditions was collected in a weekly basis during winter and spring and when available water existed during summer (temporary river). In terms of flow validation, monthly data from Enxoé reservoir discharges and consumption, precipitation and evaporation were used to estimate reservoir inflow (2006-2009). Level measures obtained during floods by probe in 2010-2011 were also used to validate MOHID Land ability to describe the processes (Brito *et al*., 2000).

The river sections were spatially interpolated with an automatic tool and verified against field observations. Since water level was one of the results to compare to data, the section geometry definition was of great importance. The water level sampling location is in a permanent pool (so that probe sensors were always inside water) and at the station topography has a depression that is not shown by Digital Terrain Model resolution (Fig. 3).

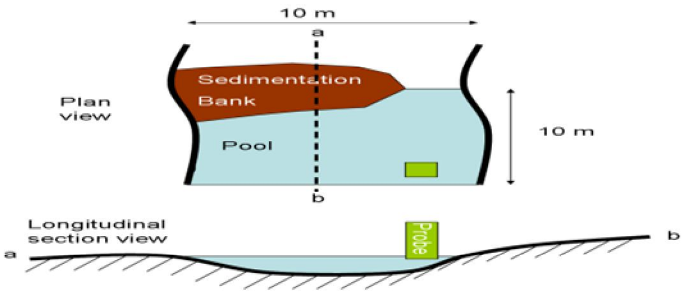

Fig. 3 – Level sampling river section.

2.5. Calibrating Parameters

Model calibration is an essential process needed to assure that the simulation outputs are close to real observations.

From the recorded floods with automatic sampler in Enxoé (four floods, two in October 2010, one in February 2011 and one in March 2011), in general, the first peak rises observed in level field data seemed to be missing in first MOHID simulations because the precipitation water was infiltrating and was not getting to the river.

For model validation were used monthly data from Enxoé reservoir: discharges and consumption, precipitation (Fig.4) and evaporation.

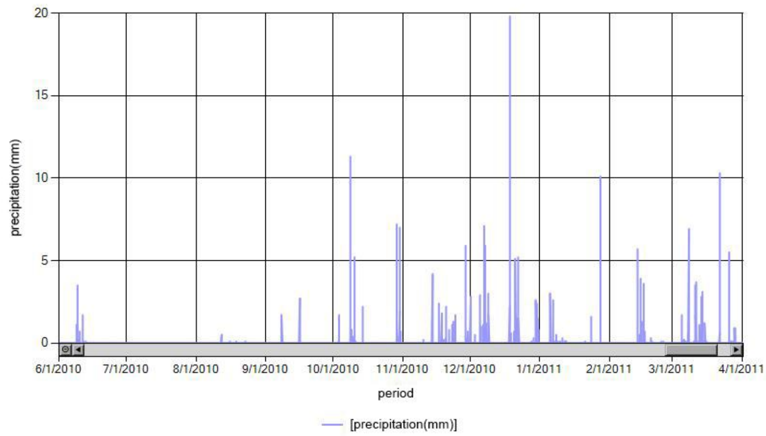

Fig. 4 – Monthly precipitation.

The simulations with the model MOHID Land were performed in two stages.

The first step was to start running simulations with the data from the period 1.06.2010 - 31.03.2011 and with the cell size of 200m.

In the second stage, to play a finer resolution of the flooded area, was performed with MOHID Land Studio a flood modeling from 28 to 31 December 2009. In this simulation the cell size is 40 m, the Porous Media module it is inactive and the step time is half an hour.

3. Results and Discussions

3.1. Simulation of the Period 1.06.2010 – 31.03.2011

After running the program MOHID Land, with initial data inputted, it has resulted the following graph of the simulated water level in the river Enxoé (Fig. 5). As it can be seen, at the top of the chart was represented precipitation in mm for the period fixed for the simulation (1.06.2010-31.03.2011). At the bottom of the graph the program simulated water levels in the river Enxoé, over which it have been overlapped four peaks of flood levels measured in the field.

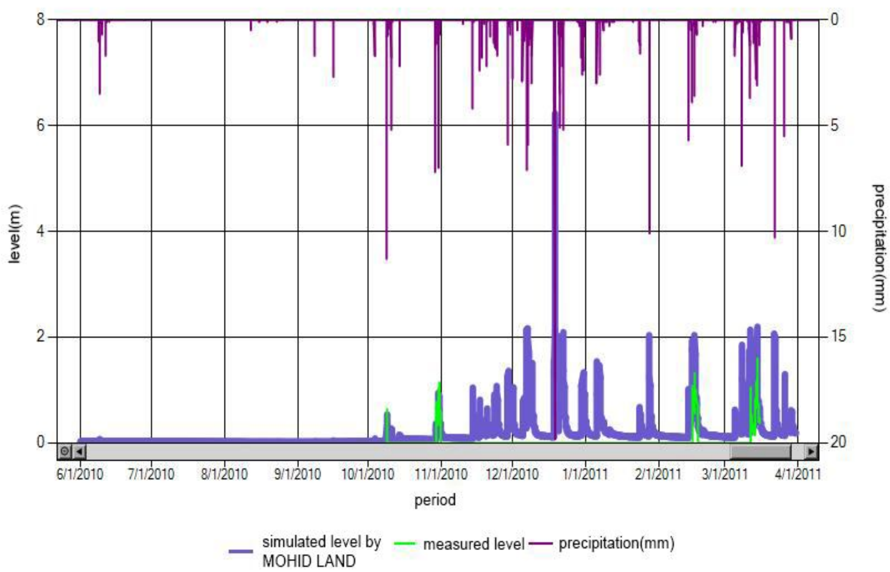

Fig. 5 – Graph of the simulated levels by MOHID Land.

The program also simulates the water content in the soil.

Starting with 08.10.2010, when the first peak of the flood occurs it can be seen the increasing water content in the soil (Fig. 6). The next day the soil is already saturated (Fig. 7).

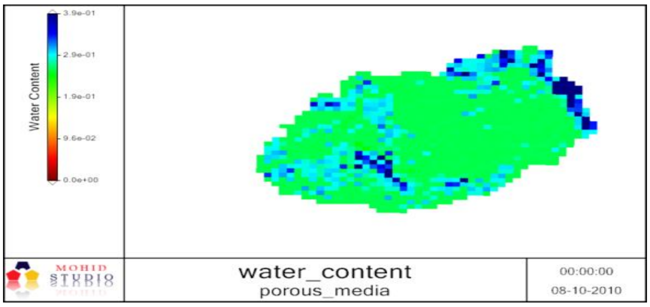

Fig. 6 – Water content in soil 8.10.2010.

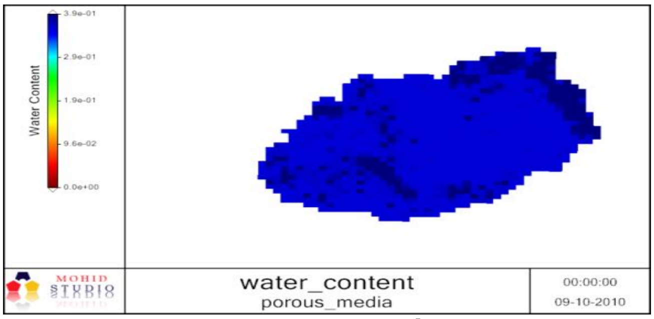

Fig. 7 – Water content in soil 9.10.2010.

In order to make a comparison of simulated and measured levels, further is presented a detail of the simulation graph in the four peaks of the measured level in field.

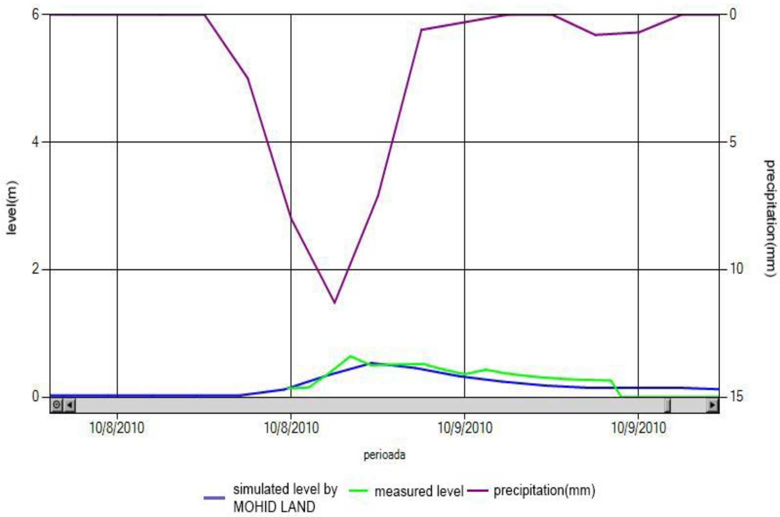

Fig. 8 – Detail of the first peak observed.

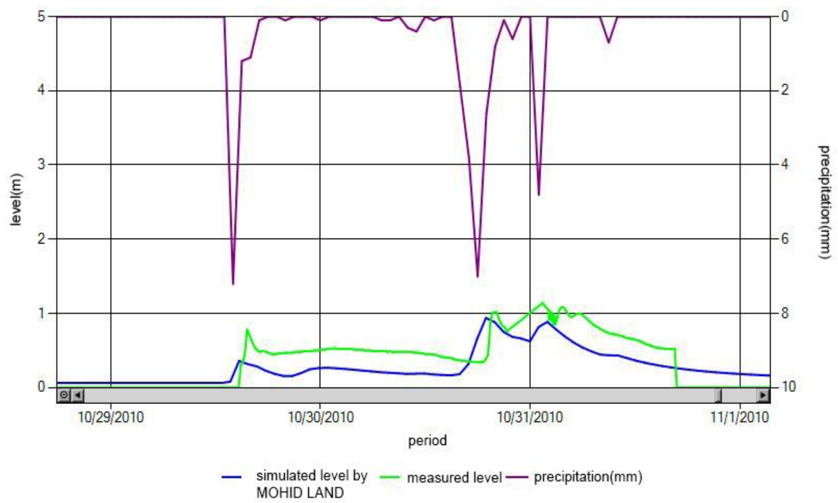

Fig. 9 – Detail of the second peak.

From Figs. 8 and 9 it can be seen that the allure of the simulated level in MOHID Land is similar to the allure of the measured level. The same thing can be seen in Figs. 10 and 11.

As the results provided by MOHID Land are close to the measurements, further we made a simulation of the flood from December 2009. For this flood there were no data measured in field.

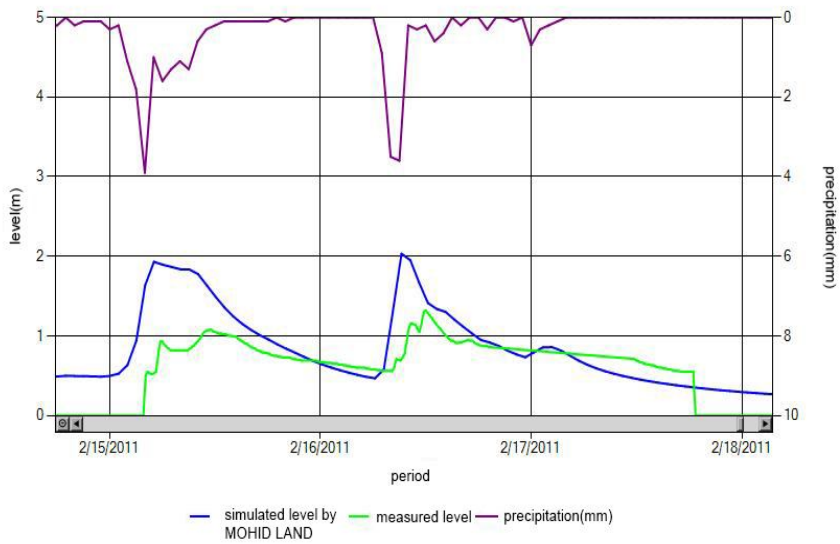

Fig. 10 – Detail of the third peak.

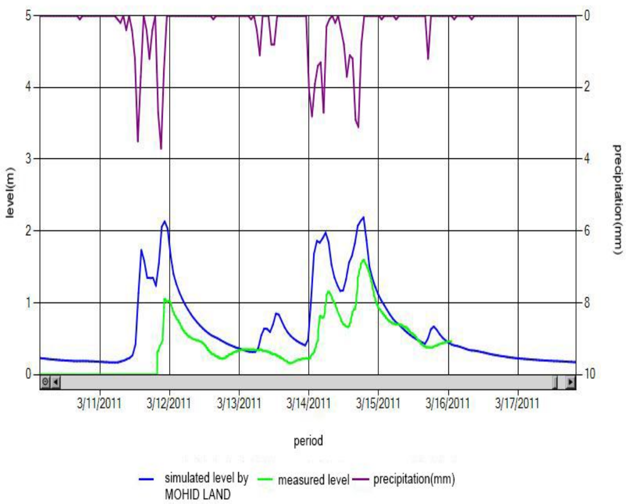

Fig. 11 – Detail of the fourth peak.

3.2. Flood from 28 – 31 December 2009 (Cell Grid Dimension: 40m)

To study the dynamics of floods in turbulent regimes, such as the one in Enxoé watershed, where flood can grow in an hour, it is needed a model with time steps of seconds, minutes in order to accurately predict processes and loads.

The flood in December 2009 had a return time of the order of decades or even a century. In the beginning of December there was reduced flow and in the end the month it flooded the plains and the small town Vale de Vargo.

In Fig. 12 is presented the graph of the simulated flood of 28 to 31 December 2009 for a cell with size of 40 m.

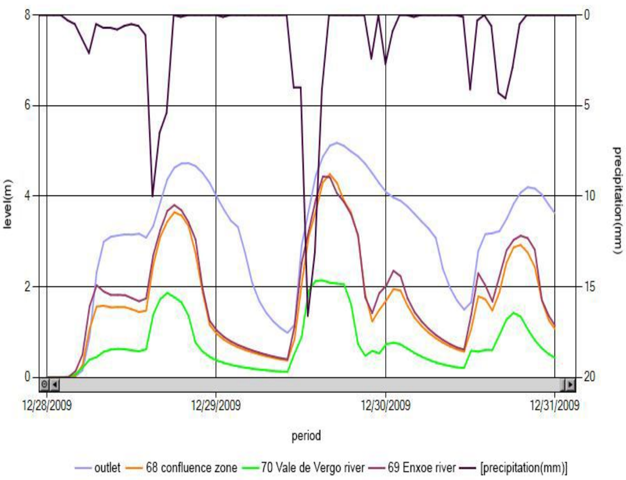

Fig. 12 – Simulated levels by Mohid Land.

In Fig. 13 it is presented the water column in Enxoé watershed of the same period.

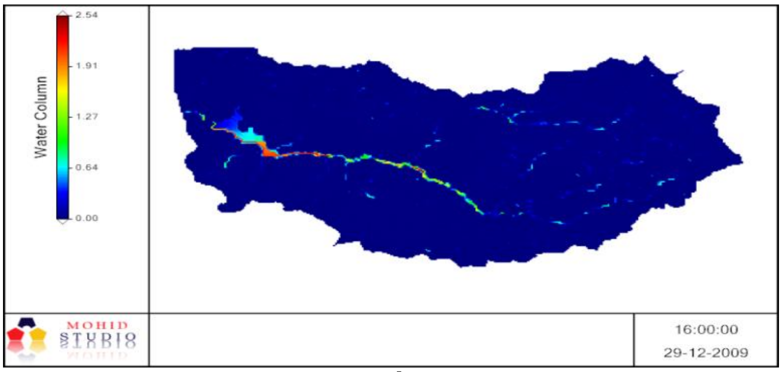

Fig. 13 – Water column 29.12.2009.

4. Conclusions

Simulation of water dynamics with MOHID Land showed that the program can reproduce the movement of water in soil in a 1D acceptable simulation but it is necessary that the input data such as precipitation, temperature and soil characteristics (hydraulic parameters) to be representative for the study area. This is a necessity for the implementation of each hydrological model.

Following the results obtained from the simulations it can be concluded that MOHID Land is a program suitable for short description (floods) and long term (monthly and annual) of water dynamics.

The model can serve as a base for building a flood forecast model and for a pre-warning system for floods.

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ASPECTE PRIVIND MODELAREA VIITURILOR CU PROGRAMUL MOHID

(Rezumat)

Se face referire la modelarea viiturilor în bazinul hidrografic Enxoé cu programul MOHID Land. Se prezintă calibrarea şi validarea modelului pentru un bazin hidrografic cu suprafaţa de 6 080 ha. Conceptul de modelare a bazinelor hidrografice este încorporat în interdependenţa de utilizare a solului, apei, climei şi terenurilor şi este reprezentată prin intermediul unor abstracţii matematice. MOHID este o unealtă integrată de modelare utilă pentru simularea proceselor fizice şi biogeochimice atât în coloana de apă cât şi în sedimente şi este de asemenea utilă pentru simularea racordării dintre aceste două domenii şi atmosferă.

Modelarea hidrologică a bazinelor hidrografice netarate s-a concentrat pe obţinerea unor estimări fiabile ale scurgerii de suprafaţă, ce a fost realizată prin corelarea valorilor parametrilor caracteristici ai captării.

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ASPECTS REGARDING THE EROSION AND SEDIMENT TRANSPORT IN THE TÂMEGA WATERSHED USING THE MODEL MOHID STUDIO

BY

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Abstract. The water erosion affects large areas worldwide. Soil erosion caused by water is the result of the rain detachment and the vulnerable transport of soil, either directly through splashes of rain or indirectly through gullies and deep erosion. The process of erosion and the transport of the sediment by water is a key process in modeling a river basin and has important environmental and economic consequences. This paper provides an overview of the problem of soil erosion in the Tâmega watershed, based on the data collected from the three gauging stations taken into account: Alb.Torrão (Semealho), Praia Aurora (Alb.Torrão) and Foz Tâmega (Alb.Crestuma).

Keywords: MOHID Land; modeling; cohesive sediments; runoff.

1. Introduction

Erosion is a physical phenomenon resulting from the destruction or dissolution of rock and soil particles through the action of water, wind, ice and gravity forces.

Currently, soil erosion is perceived as a process of degradation determined by many factors. The anthropic factor is the most important from

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this point of view, followed by the application of inappropriate agricultural management on cropland which acts negatively on soil quality though loss of structural stability while fostering the emergence of different degradation processes such as erosion by water and wind.

Erosion is one of the main processes that lead to the degradation of the soil and still the most extensive form of degradation. In this respect, it is estimated that over 76 million tons of topsoil are lost annually through erosion. Erosion by water is worldwide the most extensive soil degradation type, holding 55.7% (Stadnic, 2010).

The direct effects (effects in - site) of erosion are soil loss (soil profile thickness reduction), the formation of rills or gullies and the decreasing soil fertility with negative impact on its productivity. The erosion also determines less obvious negative effects (effects off - site), such as the environmental pollution, the increased risk of floods due to the accumulation of large quantities of sediment on the bottom of the rivers which in turn affects important areas in the vicinity of the location where the actual erosion occurs (Grimm Jones & Montanarella, 2002).

The purpose of this paper is to analyze the negative effects of surface runoff and soil erosion in watershed, to understand how the MOHID Studio model works, to realize simulations in MOHID Land, but using the new interface and a new executable, which led to changes in keywords and to analyze the problems of soil erosion and sediment transport dynamics. Hydrological models are suitable to simulate various combinations of the different scenarios of the land and water management in a watershed and therefore they are useful for the comparative analysis of different options and as a guide to what as a model can be adopted to minimize water erosion and its effects.

2. Case Study

2.1. General Basin Description

The Tâmega river basin has a total area of 3252.1 km^2, out of which 80% is located in Portugal and 20% in Spain (Fig. 1). Soils are typically loamy (with 40% of sand, 40% of silt and 20% of clay), but also soils typical for the hill and mountain regions on the Eastern and Western parts of the river basin. The Tâmega site is mainly covered by shrubs and pine forests, more specifically, "Closed to Open Shrubland" occupies 45.9% of the total area, and the "Needleleaved Closed to Open Trees" with 17.9%. Together these classes cover more than 63% of the area. The agriculture areas altogether occupy nearly 20% (Almeida, 2002).

In the outlet of the Tâmega basin there is a reservoir called Torrão (Fig. 2). The Torrão reservoir was constructed in 1989 and produces energy with a capacity to supply the needs of a total of 600,000 inhabitants.

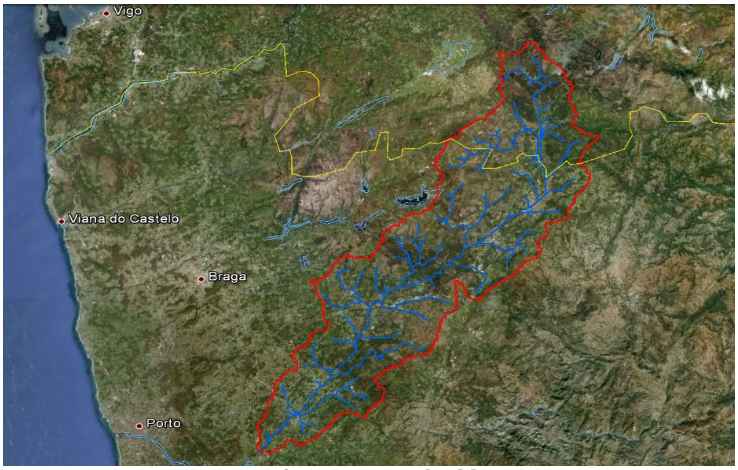

Fig. 1 – Tâmega watershed location.

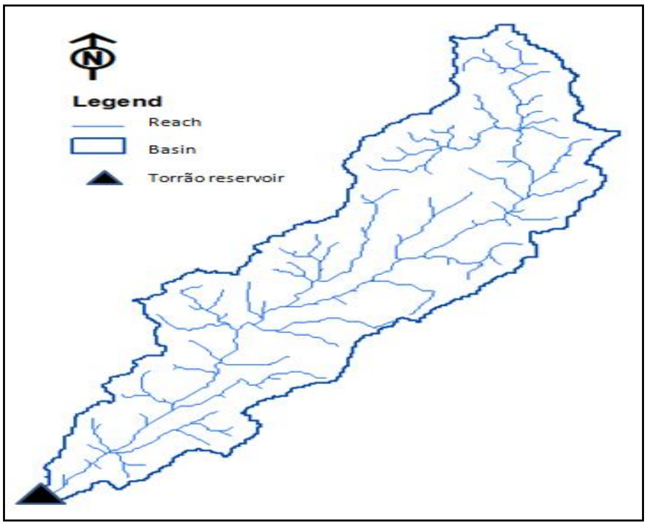

Fig. 2 – Torrão reservoir location.

2.2. Basin Meteorology

Considering the data from the MM5 model between 2004 and 2008, the average monthly temperature is 21.5°C. The maximum temperature registered was in August, namely 27.4°C, while the minimum was of 1.4°C in February (Fig. 3).

The Tâmega watershed registered precipitation with an annual average that varies between a maximum value of about 1,400 mm and a minimum value of approximately 600 mm (Fig. 4). Meteorological stations considered are represented in figure 4 and precipitation values are expressed in Table 1.

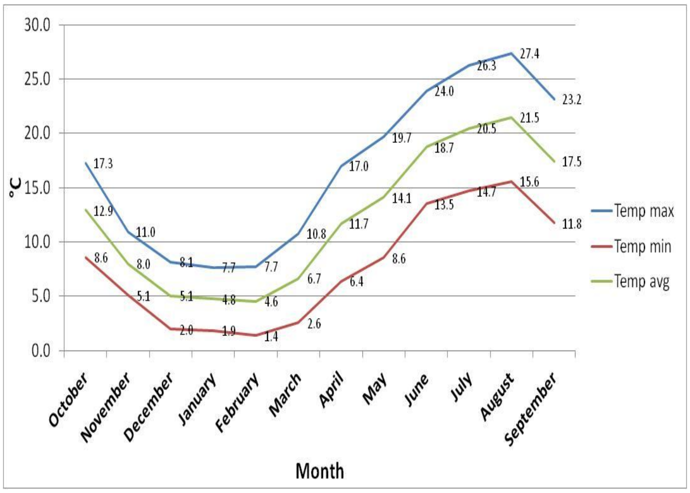

Fig. 3 – Average, maximum and minimum monthly temperature in Tâmega watershed.

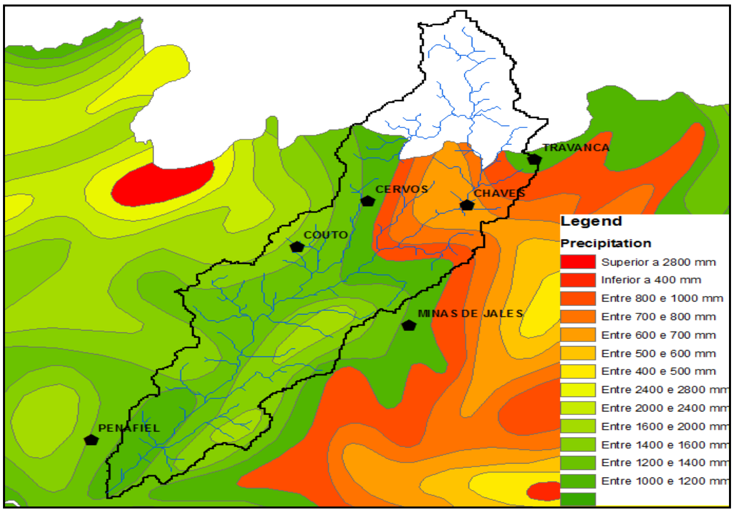

Fig. 4 – Isohyets map with precipitation station location in Tâmega watershed.

Table 1

Annual Precipitation for Each Station from Isohyets Values

(sources: SNIRH - National Water Institute and MM5 - Meteorological Model 5)

Hydrometric station	Precipitation, [mm]		
	MM5 2004-2007	SNIRH 1931 - 2009	Isohyets values
Travancas	900	910	1,000 – 1,200
Cervos	1,128	1,015	1,000 – 1,200
Couto	508	1,431	1,400 – 1,600
Chaves	438	653	600 – 700
Penafiel	1,416	1,365	1,200 – 1,400
Minas de Jales	1,061	1,175	1,000 – 1,200

2.3. General Flow Characterization

The main flow stations in the watershed, with their respective drainage areas and daily flow (maximum and average) are showed in Table 2. Considering Torrão station as representative of the whole basin the average flow is about 30.88 m^3/s. The maximum measured flow in Tâmega was observed in Fridão with 1,217 m^3/s and is the location with a higher daily average flow, considering the stations and the period available.

The Tâmega flows high during winter seasons and lower during the summer and this difference results in a need of management of the watershed flows in the Torrão reservoir location.

Table 2
Flow Station Description with Drainage Area, Period Considered and Daily Flows

Flow station	Drainage area km^2	Period	Daily maximum m^3/s	Daily average m^3/s
Ponte Cavez	2,014.7	1988-2006	1,023	26.18
Fridão	2,635.4	1988-2006	1,217	43.07
Torrão	3,279.0	1988-2012	396.3	30.88

2.4. Tâmega Water Balance

In a watershed, all of the water falling as precipitation can be stored in the soil, returned to the atmosphere, or released from the watershed via runoff or subsurface flow. In this case it will be considered the water as runoff, percolated in the soil and lost to the atmosphere as evapotranspiration. For the purpose of this study on the SWAT model, it was taken into account the same period (between 1988 and 2008). In the Tâmega watershed the water from precipitation (an average of 1,081 mm in the period considered) was lost mostly as actual evapotranspiration (about 44%) and groundwater (about 43%) and only 13% was released as runoff (Table 3).

Table 3
Water Balance (mm and %) *in Tâmega Watershed*

	Average	
	mm	%
Precipitation	1,081	–
Runoff	145	13%
Groundwater	469	43%
Percolation	499	46%
Actual evapotranspiration	478	44%
Lateral flow	12	1%
Water yield	625	58%

Considering the same period considered above, the monthly water balance can be distributed as figure below (Fig. 5).

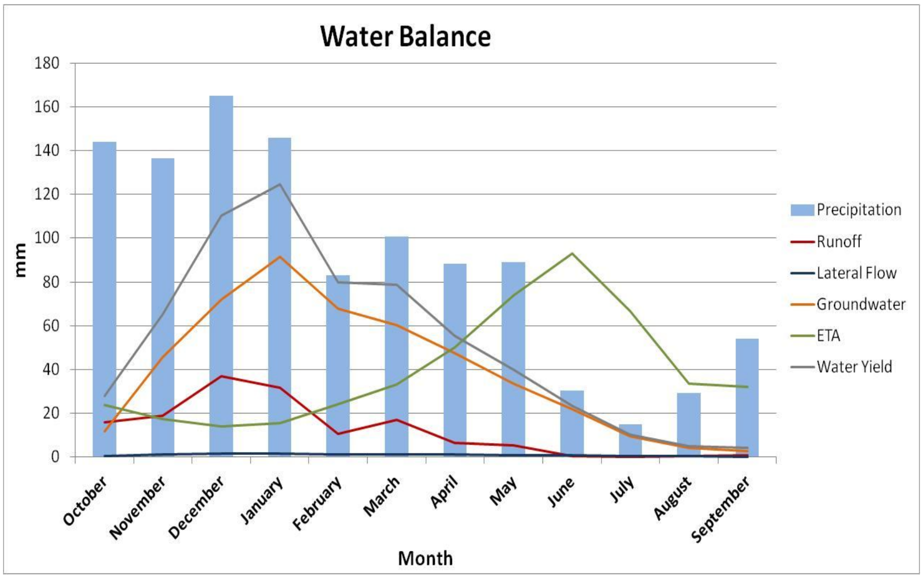

Fig. 5 – Monthly water balance: precipitation, runoff, lateral flow, groundwater, actual evapotranspiration and water yield.

2.4. Model Implementation

It is a recognized fact that the data for validating the estimates of the losses of soil using the erosion models are rare and that the present models generally forecast the leakage as an intermediate necessary for the prognosis of the sediment transport.

To implement and validate the model in order to get good results, the data need to be integrated.

The basic data needed in order to implement a model are the Digital Terrain Model, the land use, the soil characteristics and the precipitation. MOHID Land uses the ASCII file format of the input data as configuration files, the data series or network and the HDF format of time and space.

After the detailed description of the model, it is absolutely necessary to calibrate it (the parameters are corrected until the output is acceptable), to validate it (determining whether the output of the model reflects the real values by comparison of these data with the data output obtained by field observations) and to perform a sensitivity analysis (evaluating the response of the model to changes in parameters and hence determining the most important parameters). The verification of the correct functioning of a model basically implies that the data obtained implementing it corresponds to the results achieved by direct measurement.

3. Results and discussion

3.1. Simulation of Cohesive Sediments in the Tâmega River During the Period 24.11.2010 - 18.12.2010

The chart below represents the rainfall quantities expressed in mm for the period established in the simulation (24.11.2010 **-** 18.12.2010) (http://www. mohid.com/).

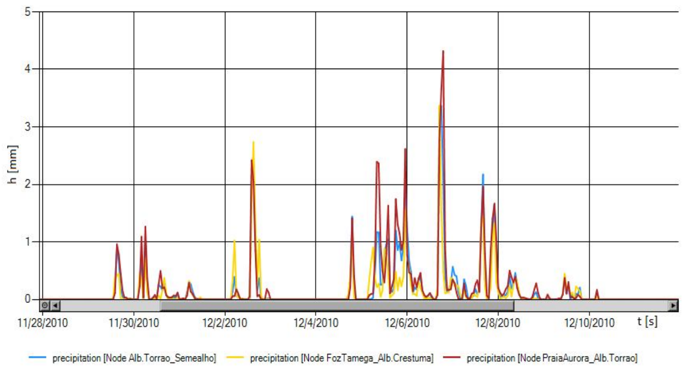

Fig. 6 – Rainfalls fallen on duration established.

The erosion and deposition are in relation to the shear stress at the soil surface, meaning that higher velocities will tend to erode material and lower velocities will tend to deposit sediment material (Grimm Jones & Montanarella, 2002).

After running the Mohid Land program with the initially introduced data, we were presented with the following graphic for the simulation of the cohesive sediments (Fig. 7) and of the shear stress (Fig. 8).

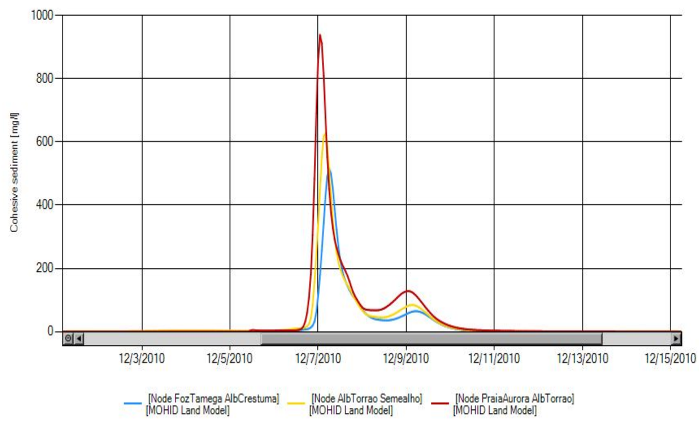

Fig. 7 – Graphic of simulation of the cohesive sediments.

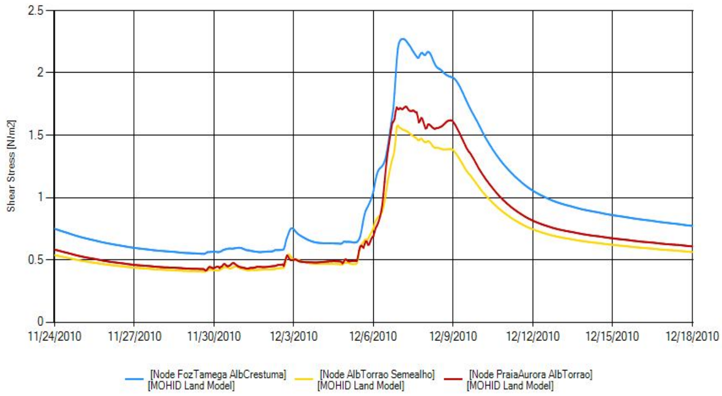

Fig. 8 – Graphic of simulation of the shear stress

Cohesive sediments at the bottom of the basin must be greater than 0 in order for the deposition to take place (Fig. 9).

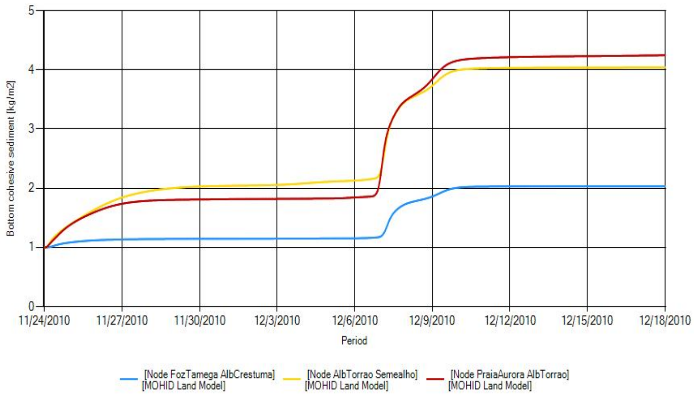

Fig. 9 – Cohesive sediments on the bottom of the riverbed in the three nodes.

4. Conclusions

It can be concluded that in the validation and appreciation of the model sensitivity for the spatial distribution of rainfall can have an important impact.

The results of the simulations showed that MOHID Land, with the adjustments that were made (Module RunoffProperties, Drainage Network), has become a reliable tool in analyzing issues relating to the soil erosion and the transport dynamics of the cohesive sediment. The model can be used on the entire surface of the basin.

The RunoffProperties module and the DrainageNetwork module were esential to achieving this paper.

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ASPECTE PRIVIND EROZIUNEA ŞI TRANSPORTUL SEDIMENTELOR ÎN BAZINUL HIDROGRAFIC TÂMEGA FOLOSIND MODELUL MOHID STUDIO

(Rezumat)

Eroziunea prin apă afectează la nivel mondial cele mai mari suprafeţe. Ea este rezultatul de desprindere şi transport vulnerabil de sol, fie direct prin stropii de ploaie sau indirect prin rigole şi eroziunea în adâncime.

Procesul de eroziune şi transportul de sedimente prin apă este un proces cheie în modelarea bazinului hidrografic şi are consecinţe de mediu şi economice.

Această lucrare oferă o imagine de ansamblu a problemei eroziunii solului în bazinul hidrografic Tâmega, pe baza datelor colectate de la cele trei staţii hidrometrice luate în considerare: Alb. Torrão (Semealho), Praia Aurora (Alb. Torrão) şi Foz Tâmega (Alb. Crestuma).

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CONSIDERATION REGARDING ENVIRONMENTAL PROBLEM AND RISK OF GEOMORPHOLOGIC NATURE IN STRAJA AREA, SUCEAVA COUNTY

BY

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Abstract. Through “Consideration regarding environmental problem and risk of geomorphologic nature in Straja area, Suceava county” work, we propose to realize an analysis from physical-geographical point of view in Straja area and to present considerations regarding environmental aspect correlated with geomorphologic conditions. The environmental problem and geomorphologic risks which it is confronting Straja area mass moves (especially land slide), floods that implies geomorphologic processes, such as: corrosion, transport, sedimentation), the environmental impact of forest exploitations.

Keywords: environment; floods; corrosion; sedimentation; transport.

1. Introduction

The perimeter of are studied is delimitated in North by state border with Ucraina, in South by a line oriented West-East which passes through Suceviţa locality, in West by Brodinioara river, and in East by a line oriented North-South which passes through Vicov-Margine localities.

The aspects presented are agremanted with statistic date from forest districts in studied area: Forest District Brodina, Forest District Putna and

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Forest District Falcău, and for floods study in 2015 we used hydrologic date from Waster Management Service of Suceava and photos.

From geological point of view the research region is part of Tarcău unit (Tarcău nape, average marginal unit), the most large unit of external flysch area. This area belongs to sedimentation domain of external flysch. To the East is carried over Vrancei unit which in different sector it is covered and comes directly with pericharpatic unit (pericharpatic Miocene). Vrancea unit is situated at the exterior of external flysch, at contact with molasses zone (Vrancea nape, external or marginal unit). From climatic point of view, the North part of large Obcine Fits in a predominant background central-european with boreal influence, with variation of climatic elements in altitudinal way and from East to West.

The middle amplitude is 20ºC, which characterizes a moderate temperate climate to excessive. The number of the days with equal temperatures or under 0ºC varies between 150 in East and 180 on heights from West. Also must be remarked the production of some thermal inversions in depression basin that accompany the courses of same rivers and the fact that the slopes with eastern and south-eastern orientation are warmest than western and north-westerns one.

Regarding atmospheric dynamic is remarked predominant circulation northwestern (with a frequency over 40%) and subordinate of the south-eastern (with a frequency approximately 14%). Evapo-transpiration is approximately 500,…,550 mm, resulting a surplus water balance about 300,…,400 mm, what determines a humid moderate climate, with a water regime of soils, dominant percolation. Soils are differentiated in to areas mountain and plateau. In piedmont plateau predominate clay-alluvial evaluate (albic luvisoils, brown luvic) on piedmont heals and mol soils, young alluvial oils and hydro-morphic, in depression.

The vegetation is characterized by the presence of the forest in East, spruce beech in West and of meadows. Fauna, by its contribution to maintaining biological balance of the ecosystems, plays an important role in social-economical domain of this area. We have to mention that because of hunting and abusive fishing in past, same species with economic and scientific value that was populating the land and waters of this regions had disappeared; some of them are going to disappear. Rational keeping and using sow production vegetal fond and fauna fond is a base between in maintenance the balance between all of environmental components and superior capitalization of the region.

2. Experimental

Lake general aspects are:

a) peaks and valleys parallelism on direction NV-SE, according to directional development of principal structural;

b) reduced altitude (1,145,…, 1,192 m in Şandru – Strigoaia peak and

921,…, 1,152 m in principal peak of Large Obcina) and on energy of relief about 350,…,700 m;

c) inclination with values of 5,…,45º, with values smaller on pre-quaternary field and with higher values on fields with quaternary evolution, when valley goes deeper with approximately 200 m;

d) geomorphologic contact Obcine-plateau along which Large Obcina dominate Rădăuți depression from North, West and South about 500 m.

Up to present were succeeded for step of landslide this remodeling right slope of Sandru river on a length of 1,250 m, a width between 80 and 150 m, an energy of 300 m and an average slope of 20º. The top of an slide body has covered entirely proluvial cone of 10 m of Brodina river (614 m absolute altitude).

Landslide has a superior cornice at about 900 m altitude, the body being fragmented by a series of secondary cornices, that marks different moments in sliding investigations mode, based on information giver by local people shows existence of some initial movements of diluvium, in 1974–1975 after which has appeared a diluvium body slip-ridge.

Detachment of diluvium was performed at 700,…,800 m altitude, the sling covering lower part of proluvial cone. Resulted cornice is willing in semicircle on a length about 100,…,110 m has a height about 5 m, and the top of the sliding body is disposed in circle arch on a length about 140 m.

In second stage is found the trigger of a displacement with aspect of muddy flow on left flank of sliding that trains in movement diluvium material and rock (clay, purple marl). The flow can be accumulation result and water drainage behind “sliding 1975” body, also raised humidity determinate by meant quantities of precipitation fallen in that time.

In first to stages were in approximately two weeks, in October 2002 was found the increasing in dimension of cracks on all three axes. The 2003 summer marks trigger of third stage diluvium moving due to stability break as result a new cornice, of 6,…,8 m, height at 880 m altitude, and behind sliding body appears a small accumulation of water. Central displacements favor rational lateral separation.

Fourth stage is manifesting through production of a small sliding, that moves central part of superior cornice with 20 m difference of the level (900 m absolute altitude) from initial position. In present the top of the sliding parasite terrace bridge of 10 m, at about 4,…,5 m of hes stop. We can appreciate fact that this one displace from July 2002 till October 2004 with approximately 40 m.

The landslide is the result of many local factors: litho-logy, structure, alluvium thickness, precipitations, phreatic horizon, slope, initial displacements.

As result of this landslide trigger was destroyed a surface of 14 ha coniferous forest, 1 ha meadow and it was affected network of high tension.

Continuing the process may block communal becomes risk factor for the 4 household situated in movement range diluvium, at distance between 30,…,60 m.

The gravitational movements are the bark's movements from the top side of the slope to the bottom one under the influence of the gravity force,whithout the water air or ice's influence. The movement of the materials at the land surface and the metorization have a role in the emergence and in the general progress of the relief.

Weathering rather not create landforms. Where rock debris are not moved, they are accumulated up to a critical thickness. Once exceeded this critical value, the materials are moved from where they were weathering, leaving unprotected rock in situ, creating conditions for the emergence of new forms of relief. Denudation is the process of weathering deposits are removed from their place of training.

The ratio between the amount of material moved and those formed in place by weathering called morphogenetic or denudational balance sheet. The eproces direction of action is summarized in Fig. 1 A, and the main resulted situations in this report are shown in Fig. 1 B.

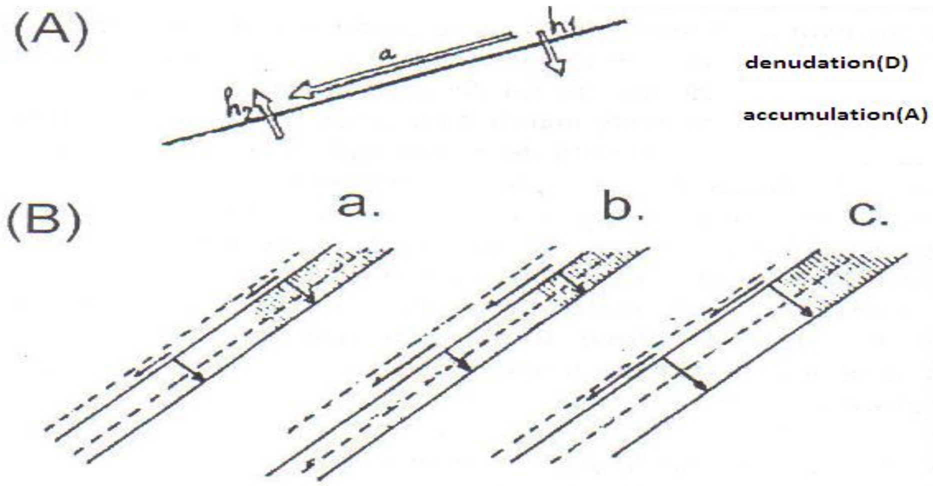

Fig. 1– A – Line of action of slope processes in assessing balance denudational;
B – Balance denudational the slopes.

The movement of the deposits on a slope can be represented in the form of balance equations, analogous to water's balance in nature: A = D, A > D, A < D, where A is the accumulation (it includes all assembly processes involved in the formation of deposits Version: alteration, disruption, accumulation scrubbing processes for mass movement etc). This component was called normal component ,which is perpendicular on the slope's profile. D is the denudation (it includes all assembly processes involved in the removal of the slope) and was named the parallel component to the slope's gradient.

This formulation of the balance sheet in very simple terms, applied in the geomorphological mapping in relation to the processes that generate them, can give the conclusive picture on the slope's evolution stage in the ratio of the two terms of the balance. Usually the slopes with a based concave profile are slopes with a positive balance and they have a thick coating of deposits that can be easily driven into the river collector. Rather, the based convex profile slopes are slopes with negtaive balance, respectively, the slope's deposits are reduced or even absent. The material's movement is fueled by gravity. It is achieved in two main ways: a) through a carrier agent, b)through autodirection. The movement throught an agent is called *transport* and is usually realised by the rivers, ice-caps, sea water, wind. Autodirection is also called mass movement. The general motive of the movements is the gravity. But this can not occur, the exceptions are very rare,on vertical, but only indirectly on the local slope angle direction. The tilt or slope land plays an important role in moving. The higher the slope is, the stronger gravity is, and conversely, as the slope is shrinking,the possibilities that the materials can't move are growing.

3. Results and Discussions

The studied area is presenting a risk of geomorphologic nature.

A part of ravens from studied area were reactivated because of a factors of geomorphologic nature, hydrological and anthropogenic.

The landslide was produced in four stages:

a) fist stage – July 2002 – slide with detrusiv character;

b) second stage – October 2002 – displacement trigger with aspect muddy flow;

c) third stage – July 2003 – diluvium stability break;

d) fourth stage – July 2002 – October 2004 : production of a small landslide.

Floods from 2005, 2006, 2008 had a destructive character, material lasses were significant. This were the result of torrential character (big intensity of the rain and reduced time of concentrate) of the precipitation which leads to abundant drain on the slopes and at landslide, and on the other hand, because of dislocations and logs training and wooden wastes which produced successive blocking and unlocking.

Also the maintenance streams on localities territories studied was poor.

Materials losses were result of hydraulically bridges on the Putna river, this one failing. Registered debit at historical floods from 26 July 2008, was about 1,957 m^3/s, and material lasses significant.

Erosion is favored of human intervention by deforestation: forest road design and windfalls of the trees.

The real energy of the studied processes depends on other factors:

i) passive: the lithology, the structure;

ii) active: neotectonics, climate, rivers, vegetation, soil, man; they have different roles: of triggering, of favorizing and of braking.

The mass gravitational movements had contributed and so are now in the modelling of the slopes.

4. Conclusions

The geomorphological note of the studied area is given by the dominance of the hogbacks, which are made by parallel heights and look like secondary hogbacks and tectonical-erosive basins, located mainly in Suceava Valley and Putna Valley.

The morphostructurals features of the relief are firstly conditioned by the geological structure and by the mechanical denudational factors, which actioned in the region.Tarcau's,Vrancea's and Audia's blades, on whose deposits Obcinele Mari's ,Obcinele Brodinei's and Obcinele Feredeului's alignements of heights were formed are found sariaj relations.being materializated by geomorphological slopes (the front of the major hogbacks, discharged to east).

The denudational factors selectively actioned,gradually replacing the primary forms,like the monoclinic field,throught a derived relief, strongly influenced by the alternation of the hard and soft rock layers. In monoclinal structures with an alternance of hard and soft rock,the specific forms are:asymmetrical interfluves or cuestas, the subsequent depressions and the structural valleys; at those were added some infantile forms.

The fluvial accumulative or sculptural processes are very important for the physiognomy of the area that we are studying.This type of relief is closely linked to the evolution of the river. The mountain is characterized by a rectangular river system, with a main course represented by the Suceava River. Between Brodina-Straja, Suceava Valley has a transversely course, oriented west-east. In this section the valley has a tectonic control, following an major tectonic transverse accident with WSW-ENE direction, which causes a dive of the northern compartment. The longitudinal tributaries fave a northern and southern orientation. Those generally have a tectonic or lithologic controll, following the major tectonic directional accidents or lithological contacts.

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CONSIDERAȚII PRIVIND PROBLEMELE DE MEDIU ŞI RISC AL NATURII GEOMORFOLOGIEI ÎN ZONA STRAJA, JUDEȚUL SUCEAVA

(Rezumat)

Prin prezenta lucrare ne propunem realizarea unei analize din punct de vedere fizico-geomorfologic a zonei Straja şi prezentarea aspectelor privind mediul corelate cu condițiile geomorfologice. Problema de mediu şi riscurile geomorfologice cu care se confruntă zona Straja sunt deplasările de teren (mai ales alunecările), inundațiile care implică procese geomorfologice, precum coroziunea, transportul sedimentelor şi impactul exploatărilor forestiere asupra mediului.