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CONTENTS

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
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Tomul LIX (LXIII), Fasc. 1-2, 2013
Secţia
HIDROTEHNICĂ

OPTIMIZING THE DETERMINATION OF OPERATING REGIMES FOR PUMPING EQUIPMENTS WITHIN WATER SUPPLY SYSTEMS

BY

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Abstract. This paper refers to the possibility to determine operational regimes of pumps by means of an automatic computing program developed in MATLAB. The data have been entered in the program, in the corresponding sub-routines that are needed for computing the local head losses generated by 61 different singularities that may appear on pipeline routes (pumps communications and water conveying network). The water pumping energy and economic efficiency is afterwards evaluated by determining the pumping specific energy consumption and the unitary specific energy consumption. Moreover, the pumping operational domain has been determined in the absence of cavitation phenomenon.

Key words: optimization; pumps; operational regimes; energy and economical efficiency; cavitation.

1. Introduction

In designing process and also within the pumps operation, there is necessary to evaluate the operational regimes for the system constituted made

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by the pumping equipment and the network. This has to be performed in order to fairly assess at what extent the installation is properly serving the user and, also, in order to evaluate the energy consumption and the economic efficiency of the hydraulic processes. Moreover, it is useful to characterize the installation's working conditions in reference to undesired phenomena that may occur within networks, such as heavy start-ups, turbine-like speeding-up of pumps (when idling occurs without prevention of reversed flowing), unstable operational regimes, hazardous water hammerings.

In order to have full control over these elements related to pump operating, in reference to quasi-stationary operating regimes, there is need to know the way how the characteristic hydraulic values are to be computed. The main values taked into account are the flow, the head, the power, the efficiency, and the NPSH. Also, there is need to know how the pumping power specific consumption is evaluated. Considering this there is necessary to determine

a) the pumps' operating domain without cavitation phenomenon and the conditions in which this phenomenon may occur within installations;

b) the pump's behavior at start-ups and the need to impose operational restrictions;

c) the system's behavior when reversed flowing occurs (when pump is turned off) and the need to implement some measures in order to avoid the pumps' racing up (turbine-like speeding-up);

d) the intensity of water hammers and the need to implement certain measure in order to mitigate undesired phenomena.

In order to define the quasi-permanent regimes of the pump-network system there is a critical need to know the pumps' operational and energy-related characteristics, and to initially determine all the network's characteristics.

2. Theoretical Considerations

2.1. The Head Loss Characteristic

A basic diagram of a pumping plant (that provides all the energy transformations needed for the operation of hydraulic systems) is commonly including several pumps that are linked with two characteristic pools. The links are ensured by own communications – suction and connection to its connecting section to the upper pool and also *via* common pipelines – the pump's delivery pipes.

The components that provide the water's conveying inside the system are the *single-line pressure hydraulic systems* (SPHS).

Within the SPHS analysis, the connection (h_r *vs*. Q) between the flow (Q) and the hydraulic specific energy needed for its transportation, given by the corresponding head losses (h_r), is known as the head loss characteristic.

The total head loss includes, for every section (i) having the length L_i, the diameter D_i, the absolute equivalent roughness k_i, that implies the singularities S_{ij}, characterized by the local head loss coefficients ζ_{ij} , (j = 1, 2,…,ν_{si}), the distributed head losses (h_{rdi}) and the sum of local head losses (h_{rli})

$$h_{ri} = h_{rdi} + h_{rli}. \tag{1}$$

The distributed head losses are given by

$$h_{rdi} = \sum_{i=1}^{n} \lambda_i \frac{L_i}{D_i} \cdot \frac{v_i^2}{2g}, \tag{2}$$

where the Darcy-Weisbach linear resistance coefficient (λ_i) is, for the most general case, a function of the flowing regime characterized by the Reynolds number

$$\Re e_i = \frac{v_i D_i}{\nu} \tag{3}$$

and the relative roughness (k_i/D_i):

$$\lambda = \lambda(k/D, \Re e). \tag{4}$$

The local head losses on each section are resulting from

$$h_{rli} = \left(\sum_{j=1}^{\nu_{si}} \zeta_{ij} \right) \frac{v_i^2}{2g}, \tag{5}$$

where the ζ_{ij} are corresponding to the nature and the constructive particularities of the ν_{si} singularities present along its route.

For the hydraulic system that includes n different sections, having diameters D_i and lengths L_i , on which the average velocity in stream's transverse section, v_i , results from the continuity eq.

$$v_i = \frac{4Q}{\pi D_i^2}, \tag{6}$$

the total head losses are given by

$$h_r = \frac{8}{\pi^2 g} \sum_{i=1}^{n} \left(\lambda_i \frac{L_i}{D_i^5} + \sum_{j=1}^{\nu_{si}} \frac{\zeta_{ij}}{D_i^4} \right) Q^2 = M_r Q^2. \tag{7}$$

In the case of a given SPHS, the right member of the last eq. includes a factor that actually is a constant of the system, a value that characterizes its hydraulic resistance – the hydraulic resistance modulus:

$$M_r = \frac{8}{\pi^2 g} \sum_{i=1}^{n} \left(\lambda_i \frac{L_i}{D_i^5} + \sum_{j=1}^{\nu_{si}} \frac{\zeta_{ij}}{D_i^4} \right). \tag{8}$$

The significant SPHS for the analysis required by the design and operation of installations that provide the energy transformations involved in the operation of hydraulic systems can be systematized – together with the corresponding hydraulic resistance modulus

1º For each pump (k)

a) the suction pipeline, with modulus M_{rsk};

b) the delivery pipeline, with modulus M_{rrk};

c) the pipelines of the hydraulic machine, aith the corresponding modulus $M_{rck} = M_{rsk} + M_{rrk}$;

d) for the installation, globally.

2º The delivery pipeline with a hydraulic resistance modulus, M_{rR}.

The analysis of the plant that is providing energy conversions in hydraulic systems must take into account the following items.

3º The head loss characteristics on the pumps' suction pipelines – used in the cavitation analysis of the installation

$$h_{rsk} = M_{rsk} Q^2, \left(\mathrm{k} = 1,2,\ldots,\nu_p\right). \tag{9}$$

4º The head loss characteristics on the circuits of every hydraulic machine – used for the decreasing of their head characteristics at the same analysis section – the connection of the installation to the pipeline that provides the linking to the upper pool

$$h_{rpk} = M_{rpk} Q^2, \left(k = 1,2,\ldots,\nu_p\right). \tag{10}$$

5º The head loss characteristics on the pipeline that is providing the connection to the installation's upper pool – necessary for the determination of the network's characteristic

$$h_{rR} = M_{rR} Q^2. \tag{11}$$

2.2. The Characteristics of the Water Conveying Network

With reference to the specific hydraulic energy (H) within a remarkable section of a hydraulic system and the flow (Q) that is crossing it, in the context of its interaction with the hydraulic machines involved in its operation, the network characteristic is expressing, within pumping process, the relation between the head needed upstreams the delivery pipeline in order for this pipe to convey the pumped liquid towards the upper pool – where this must be ensured at the energy level required by the user (H_0) – and the flow of the respective stream.

When suction is performed from a liquid current on which surface the atmosphere pressure is exerting on, the reference system against which the heads are expressed is represented by the liquid level itself, within the suction pool. Within such conditions if the pump is delivering under a free level on which atmospheric pressure is exerting, the static head is represented by the lifting geometrical height, $H_0 = H_g$.

Taking into account the fact that the installation's hydrodynamic head is given by

$$H = H_0 + h_{rR}(Q), \tag{12}$$

by considering the head loss characteristic on the delivery pipeline (11), for the pumping network characteristic it results the analytic expression

$$H = H_0 + M_{rR}Q^2. \tag{13}$$

2.3. The Operational Regimes of a Pumping Plant

The quasi-permanent operating regime of a pump–network system can be assessed by means of the values that are characterizing (from user's point of view) the fluid flowing within a common section for the two components (the pumping plant and the network supplied by it) – section *O* in Fig. 1: the conveyed flow (Q) and the stream's specific hydraulic energy – the

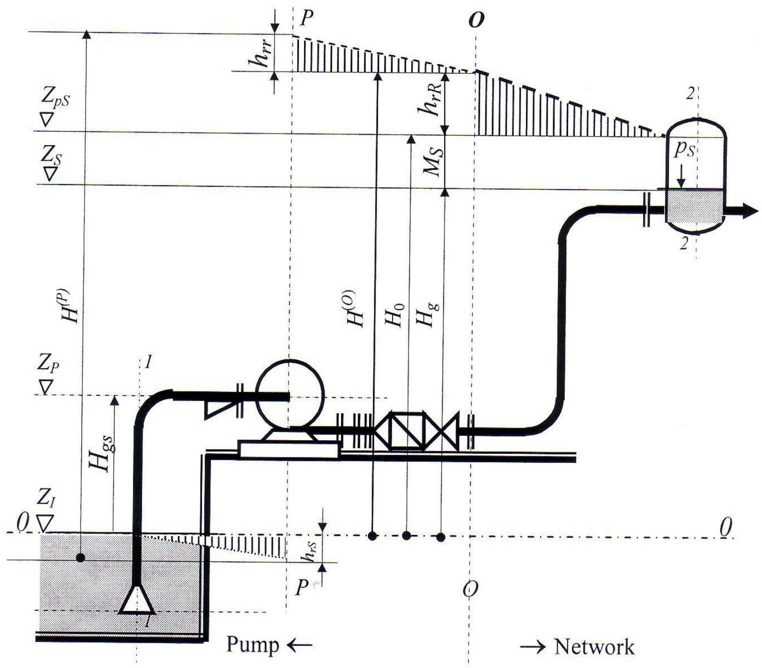


Fig. 1 – Diagram that defines the operational regime of a pump–network system.

hydrodynamic head in that section ($H^{(O)}$), assessed in comparison with the reference system adopted for the analysis – the energy level of the stream within the lower pool (*0-0*).

Considering that the two values are correlated (both for pumping equipment and network) the common operating regime will be characterized by the values Q_f , H_f – the solutions of a system constituted by the pumping plant's head characteristic, $(H\ vs.\ Q)_{IP}$ and the network characteristic $(H\ vs.\ Q)_R$, expressed in the same section – the common section of the two entities (*O*).

The pump head characteristic $(H\ vs.\ Q)_{IP}$, expressed in section *O* – its reduced characteristic – defines the link between the conveyed flow (*Q*) and the specific energy of the fluid stream, provided in that section ($H^{(O)}$).

The pump head curve (given by manufacturers in catalogs or in the pump's technical booklet, or, respectively, obtained by *in situ* measurements) is an element that defines the link $(H\ vs.\ Q)_P$ – between the conveyed flow and the head provided in the delivery flange section, link that can be analytically be expressed by means of a parabolic type function:

$$H = A_0 + A_1 Q - A_2 Q^2 , \tag{14}$$

where the coefficients are corresponding to the used hydraulic machine.

The correlation between the pumped flow and the head provided in the analysed section (*O*) can be obtained by substracting – for each flow took into the analysis (Q_k , (k = 1,2,…)) – from the ordinates of the head curve $(H\ vs.\ Q)_P$, the corresponding ordinates of the head loss characteristic on the pump's main pipelines (suction and delivery), that is h_{rp} vs. Q_k. The reduced head characteristic $(H\ vs.\ Q)_{IP}$, obtained by these means (Fig. 2), shall be analytically be expressed as

$$H^{(O)} = A_0 + A_1 Q - (A_2 + M_{rp}) Q^2 . \tag{15}$$

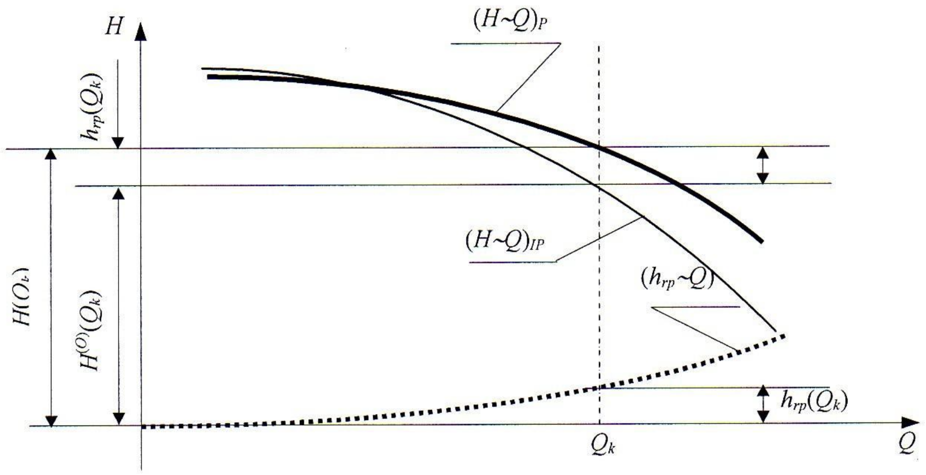


Fig. 2 – Head characteristics of the pump and pumping plant.

Taking into account the above elements, the values that are characterizing a quasi-permant operation regime for a pump–network system

(Q_f , H_f) results as a solution of the system made of the network characteristic and the eq. (15) namely

$$\begin{aligned} H &= H_0 + M_{rR}Q^2, \\ H &= A_0 + A_1Q - (A_2 + M_{rp})Q^2. \end{aligned} \tag{16}$$

Hence, the flow that is crossing the reference section (O) is resulting as a valid (positive) solution of the following 2nd degree eq.:

$$(A_2 + M_{rp} + M_{rR})Q^2 - A_1Q - (A_0 - H_0) = 0, \tag{17}$$

namely

$$Q_f = \frac{A_1 + \sqrt{A_1^2 + 4(A_0 - H_0)(A_2 + M_{rp} + M_{rR})}}{2(A_2 + M_{rp} + M_{rR})}, \tag{18}$$

whilst the hydrodinamic head of the pumped stream, in the respective section, results by the replacing of the value, Q_f, obtained in any of eqs. (16):

$$H_f = H_0 + M_{rR}Q_f^2 = A_0 + A_1Q - (A_2 + M_{rp})Q_f^2. \tag{19}$$

In compliance to the presented method the pump–network quasi-permanent regime can be also determined by means of graphs, being represented, in plane (Q,H), by point (F), this being the intersection of the pump's head characteristic, reduced at the analysis reference section (O), (H *vs.* Q)$_{IP}$, with the network characteristic, value which is obviously represented in the same section – the origin of the plant's delivery pipe (Fig. 3).

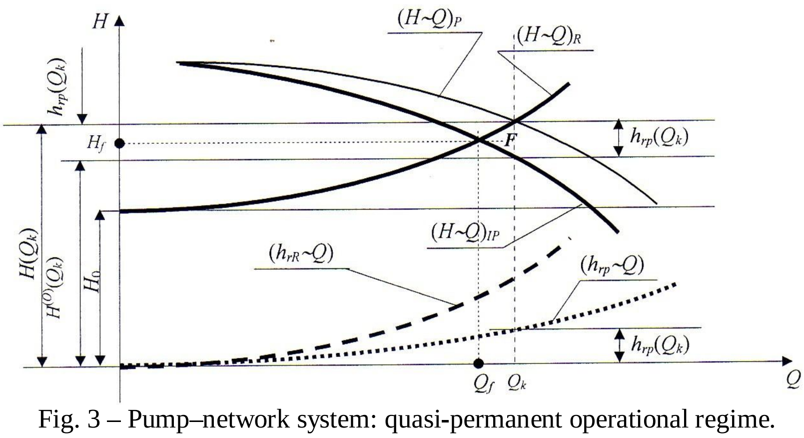


Fig. 3 – Pump–network system: quasi-permanent operational regime.

Knowing the flow pumped by the hydraulic machine in the respective operating regime, Q_f , corresponding to its value, on the diagram of its functional characteristics the next items can be immediately determined, at the intersection with the vertical Q_f namely

a) on the head curve $(H\ vs.\ Q)_P$ – the head in the delivery flange, H_f^R;

b) on the efficiency curve $\eta\ vs.\ Q$ – the pump's efficiency, η_f;

c) on the power curve $N\ vs.\ Q)$ – the shaft absorbed power N_{pf};

d) on the cavitation curve NPSH *vs.* Q – the required NPSH, NPSH_f.

These analytic eqs. are used to compute the characteristic values of the operational regime, F, as soon as the conveyed flow has been calculated with (18), fact that can be achieved by simply replacing the value Q_f in the eqs. (14), typical for each of them *i.e.*

1º The head on the pump delivery flange results from

$$H_f = A_{H_0} + A_{H_1} Q_f + A_{H_2} Q_f^2. \tag{20}$$

2º The power absorbed by the pump is given by

$$N_f = A_{N_0} + A_{N_1} Q_f + A_{N_2} Q_f^2. \tag{21}$$

3º The pump efficiency is to be computed with

$$\eta_f = A_{R_0} + A_{R_1} Q_f + A_{R_2} Q_f^2. \tag{22}$$

4º The NPSH required by the pump can be assessed with

$$\mathrm{NPSH}_f = A_{C_0} + A_{C_1} Q_f + A_{C_2} Q_f^2. \tag{23}$$

The pump's energy and economic efficiency can be evaluated by establishing certain parameters for each aspect that is to be characterized:

a) the specific energy consumption – the amount of energy used for the conveying of the volume unit of pumped fluid, under the head H_f

$$E = \frac{K_N \gamma}{3{,}600} \cdot \frac{H_f}{\eta_{Ef} \eta_{pf}}, \tag{24}$$

defined for the assessment of pumping efficiency in the particular conditions of the analysed pumping system;

b) the specific unitary energy consumption – the amount of energy used for the conveying of the volume unit of pumped fluid, on the measurement unit of pumping height

$$e = \frac{E}{H_f} = \frac{K_N \gamma}{3{,}600 \eta_{Ef} \eta_{pf}}, \tag{25}$$

used for computing the pump's energy and economic efficiency.

2.4. Cavitational Analysis of Pumping Plants

In order to avoid the cavitation phenomenon the following condition must be satisfied

$$\mathrm{NPSH}_{\mathrm{inst}} > \mathrm{NPSH}_{p}, \tag{26}$$

where: $\mathrm{NPSH}_{\mathrm{inst}}$ is the net positive suction head offered by the installation; NPSH_p – the net positive suction head required by pump, depending on its operation regime, determined on the pump's cavitation curve or computed for its nominal regime.

The operation of pumping stations outside the cavitation zone can be ensured by keeping them within those regimes that are fulfilling the condition (26). The achievement of this requirement means to know the limits of the domain in which are located the flows that are corresponding to such regimes. The defining of these limits is possible by means of the system's cavitational analysis, that is making a comparison between the NPSH required by the pump (NPSH_p) with the same parameter that is provided by the installation ($\mathrm{NPSH}_{\mathrm{inst}}$).

This analysis can be achieved easily by using the cavitation characteristics of the components included in the studied system. This can be performed by overlapping in the same plan the curves $\mathrm{NPSH}_{\mathrm{inst}} = f(Q)$ and $\mathrm{NPSH}_p = f(Q)$, ploted at the same scale.

The net positive suction head offered by the installation can be expressed as

$$\mathrm{NPSH}_{\mathrm{inst}} = 10.33 - \frac{Z_I}{900} - h_v(T) - H_{gs} - h_{rs}(Q), \tag{27}$$

where: Z_I is the level of the free surface within suction pool; $h_v(T)$ – pressure of saturation vapours at working temperature of pumped fluid; H_{gs} – geometrical suction height; $h_{rs}(Q)$ – head losses on the suction line.

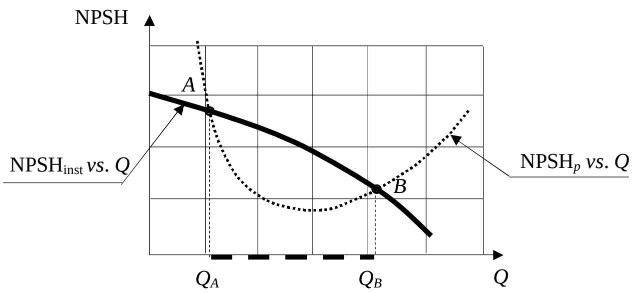


Fig. 4 – Cavitational analysis of a pumping installation.

By studying the eqs. that are defining the cavitation parameters it can be seen that these values are depending on the same variable – the flow that is crossing the pump–network system. If we mark with Q_x the flow at a given point for the pump–network system and we are indexing the flows corresponding to the intersection points of the cavitation characteristics of the pump and network with associated letters, the following conclusions may be draw:

a) if $Q_A < Q_x < Q_B$, the pump operates with no cavitation;

b) if $Q_x = Q_A$ or $Q_x = Q_B$, the pump operates at incipient cavitation ;

c) if $Q_x < Q_A$ or $Q_x > Q_B$, the pump operates at full cavitation.

The limits of flows domain for flows that could be pumped with no cavitation are $Q_{\min} = Q_A$, respectively $Q_{\max} = Q_B$.

3. Optimizing the Analysis of Operating Regimes. Case Study

The analysis of operating regimes of pump-network systems means to take into account the head loss characteristics, both on the hydraulic machine's communications (the individual suction and delivery pipes), and on the pipe that provides connection to the upper pool (the delivery pipe of the pumping plant).

The hydraulic resistance moduli are to be computed by taking into account all factors that are conditioning the distributed hydraulic resistance and, also, the local resistances brought by various hydro-mechanical devices that are included in the studied SPHS.

Calculations are laborious and usually there is need to use tables and graphs from the technical literature. In order to simplify calculations, various available eqs. can be used, by transposing them in an adequate algorithm for automatic calculation.

Within the REGFUNCT application, developed in MATLAB, data have been entered in the corresponding sub-routines, needed for computing the local head losses generated by 61 different singularities, that may appear on the pipelines of pumps and water networks: 28 types of pipeline inlets, 8 types of direction changes, 5 types of diameter changes, ramifications, confluences, 4 types of maintenance taps, 9 types of closing taps and valves and 5 types of pipeline outlets.

The proposed application is using the data related to the nominal functional characteristics of the SPHS:

1º Nominal functional characteristics:

a) installed flow Q_0, [m^3/s];

b) pump characteristic curves, $(H\ vs.\ Q)_P$, $(N\ vs.\ Q)_P$, $(\eta\ vs.\ Q)_P$, (NPSH *vs.* $Q)_P$;

c) mean temperature T, [$^{\circ}$C].

2º Network characteristics:

a) level of free water surface within suction pool Z_I, [m];

b) geometrical suction height H_{gs}, [m];

c) lifting geometrical heights H_{g1} and H_{g2}, [m].

3º System structures:

a) number of sections, N;

b) sections lengths, L_i, [m];

c) sections diameters D_i, [m];

d) sections absolute roughness k_i, [m];

e) singularity types, (Sg_{ij}):

- pipe inlets;
- direction changings/elbows/turnings

- diameter changings: reductions, enlargements;
- ramifications;
- confluences;
- maintenance taps;
- closing taps and valves
- pipe outlets,

and allows the solving of the main calculation issues for a SPHS, according to necessities

1° determination of the linear resistance coefficient, λ_i , (the Darcy-Weisbach coefficient);

2° determination of the local head loss coefficients, ζ_{ij};

3° calculation of the hydraulic resistance modulus, M_{ri};

4° calculation of the head loss on pump's communications, h_{rs}, h_{rr} and h_{r0} and on the delivery pipe h_{rR};

5° characteristics of head losses, $h_{rs}(Q)$, $h_{rr}(Q)$, $h_{r0}(Q)$ and $h_{rR}(Q)$;

6° pump reduced characteristic in the origin of delivery pipe, $(H\ vs.\ Q)_{IP}$;

7° characteristics of the water network $(H\ vs.\ Q)_R$;

8° determination of the operating regimes of the pump–network system;

9° determination of energy and economic characteristics (the specific energy consumption, E, and the specific unitary energy consumption, e);

10° determination of operating domain for the pumping installation without cavitation phenomenon.

In order to demonstrate the usefulness of the REGFUNCT application we shall determine the operating regimes for the Boldeşti re-pumping station, facility included in the Boldeşti–Cotnari water supply system, and which re-pumps the water from the Izvor Boldeşti PS along the Boldeşti–Todireşti sector. The facility is sheltered in an adequate housing and features all the needed endowments for a proper operating. The Boldeşti facility is equipped with 1+1 pumps, as it follows:

A. LOWARA pump, with $Dn_{\mathrm{asp}} = Dn_{\mathrm{ref}}$ = 100 mm, which, at an efficiency η_{prm} = 75% (as given by supplier) is pumping a nominal flow Q_0 = = 75 m^3/h under nominal head H_0 = 116 m, absorbing at shaft a power N_{p0} = = 30 kW, being driven by an A4C 200 LA2 asynchronous motor, with nominal power N_m = 40 kW and efficiency η_m = 92.5%, motor which being supplied at voltage U = 380 V is absorbing a nominal current I_n = 54.4 A, at a power factor $\cos\varphi$ = 0.84, in the case AP1.

B. SADU 100 a x 3 (D_2 = 210 mm) pump, with Dn_{asp} = 100 mm and Dn_{ref} = 80 mm, which at an efficiency of η_{prm} = 55% (stated by supplier), is pumping a nominal flow Q_0 = 70 m^3/h under nominal head H_0 = 120 m, absorbing at shaft a power N_{p0} = 43 kW, and being driven at a speed of n = = 2,930 rot/min by an MIB 4-250 M 80-2 asynchronous motor, with nominal power N_m = 55 kW and efficiency η_m = 92%, which is supplied at a voltage U = = 380 V and is absorbing a nominal current I_n = 102 A, at a power factor $\cos\varphi$ = = 0.91, in the case AP2.

Suction is provided from a 50 m^3 tank located nearby the pumping station – in order to receive water pumped by the Izvor Boldeşti PS, *via* a suction pipe with *Dn* 250 and length of 28 m, which supplies – *via* a suction manifold of *Dn* 250/150 and the 90º ramifications *Dn* 150 – the pumping equipments AP1 and AP2:

a) The AP1 pumping equipment has a length of 1.90 m, a 150/100 confusor, a wedge-drawer tap and a 90º bend – *R*/*Dn* = 1.

b) The AP2 pumping equipment has a length of 1.00 m, a wedge-drawer tap for pump isolation during maintenance/repairs and a 90º bend – *R*/*Dn* = 1.

Delivery takes place via the pumps delivery communications namely

a) The AP1 pumping equipment has a *Dn* 100 section with a length of 2.90 m, having two 90º bends – *R*/*Dn* = 1, a check valve, a wedge-drawe tap and a section enlargement 100/200.

b) The AP2 pumping equipment has a *Dn* 100 section with a length of 1.00 m, on which a 90º bend is mounted – *R*/*Dn* = 1 and diffusers 80/100, respectively 100/150 and a *Dn* 150 section with a length of 1.70 m, including a check valve, a 90º bend – *R*/*Dn* = 1 and a wedge drawer tap, ended by a 90º confluence with the *Dn* 200 delivery manifold.

The delivery manifold has a length of 5.00 m and includes a wedge-drawer tap (for closing and adjustments).

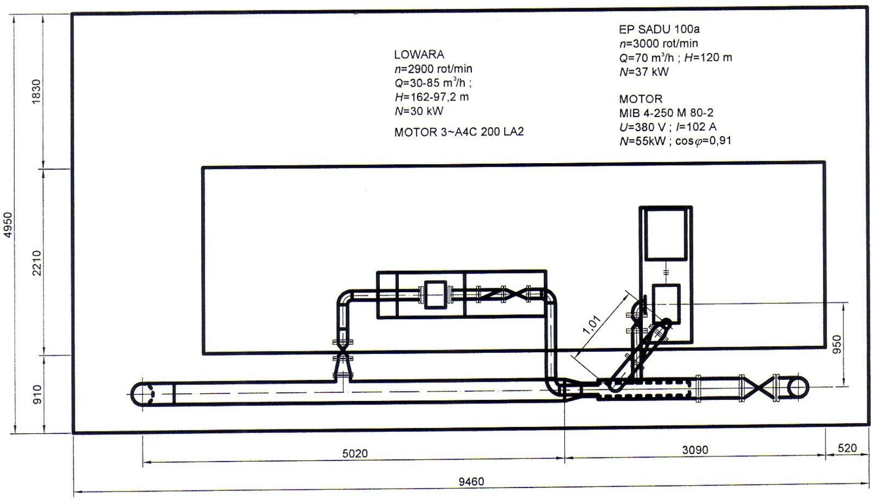
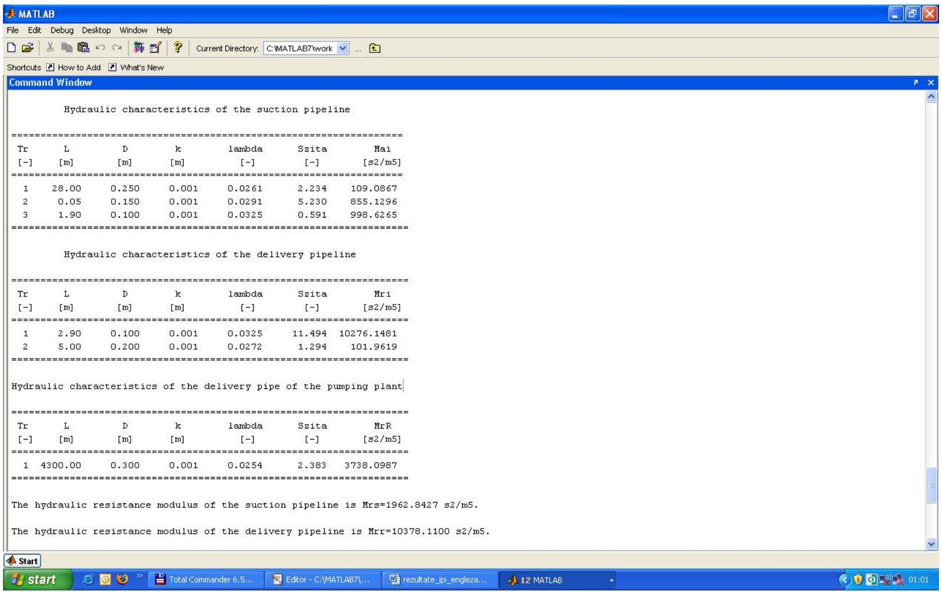


Fig. 5 – Boldeşti RPS: general layout.

The pumping station's delivery pipe is made of *Dn* 300 asbestos-cement tubes, and has a length of 4,300 m. On this pipe the singularities are four 90º bends – *R*/*Dn* = 1 and the pipe outlet – an immersed outlet, inside the 500 m^3 Todireşti water tank. The geometrical lifting height, H_g, varies between 87... 93 m. The characteristic curves of the Lowara pump have been experimentally determined. Fig. 5 shows the general layout of the Boldeşti re-pumping station.

After the running of the REGFUNCT application the values indicated in Figs. 6,…,18 have resulted:



Hydraulic characteristics of the suction pipeline

Tr [-]	L [m]	D [m]	k [m]	lambda [-]	Szita [-]	Mai [s2/m5]
1	28.00	0.250	0.001	0.0261	2.234	109.0867
2	0.05	0.150	0.001	0.0291	5.230	855.1296
3	1.90	0.100	0.001	0.0325	0.591	998.6265

Hydraulic characteristics of the delivery pipeline

Tr [-]	L [m]	D [m]	k [m]	lambda [-]	Szita [-]	Mri [s2/m5]
1	2.90	0.100	0.001	0.0325	11.494	10276.1481
2	5.00	0.200	0.001	0.0272	1.294	101.9619

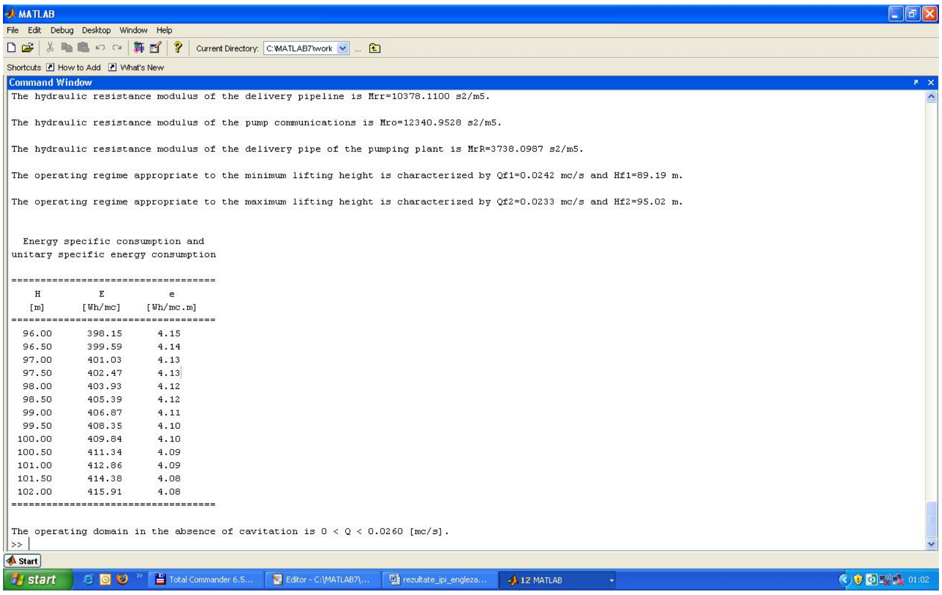
Hydraulic characteristics of the delivery pipe of the pumping plant

Tr [-]	L [m]	D [m]	k [m]	lambda [-]	Szita [-]	MrR [s2/m5]
1	4300.00	0.300	0.001	0.0254	2.383	3738.0987

The hydraulic resistance modulus of the suction pipeline is Mrs=1962.8427 s2/m5.

The hydraulic resistance modulus of the delivery pipeline is Mrr=10378.1100 s2/m5.

Fig. 6 – Hydraulic characteristics of pump communication and delivery pipe.



The hydraulic resistance modulus of the delivery pipeline is Mrr=10378.1100 s2/m5.

The hydraulic resistance modulus of the pump communications is Mro=12340.9528 s2/m5.

The hydraulic resistance modulus of the delivery pipe of the pumping plant is MrR=3738.0987 s2/m5.

The operating regime appropriate to the minimum lifting height is characterized by Qf1=0.0242 mc/s and Hf1=89.19 m.

The operating regime appropriate to the maximum lifting height is characterized by Qf2=0.0233 mc/s and Hf2=95.02 m.

Energy specific consumption and
unitary specific energy consumption

H [m]	E [Wh/mc]	e [Wh/mc.m]
96.00	398.15	4.15
96.50	399.59	4.14
97.00	401.03	4.13
97.50	402.47	4.13
98.00	403.93	4.12
98.50	405.39	4.12
99.00	406.87	4.11
99.50	408.35	4.10
100.00	409.84	4.10
100.50	411.34	4.09
101.00	412.86	4.09
101.50	414.38	4.08
102.00	415.91	4.08

The operating domain in the absence of cavitation is 0 < Q < 0.0260 [mc/s].

Fig. 7 – Energy and economic efficiency and no-cavitation operating domain.

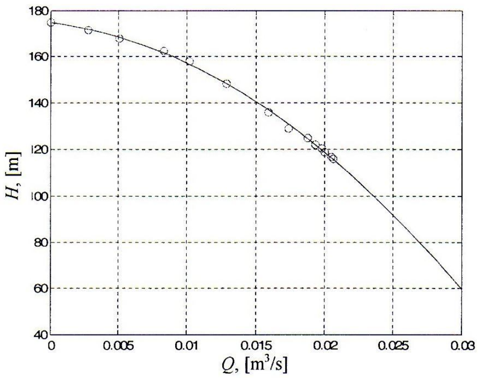


Fig. 8 – Pump head characteristic.

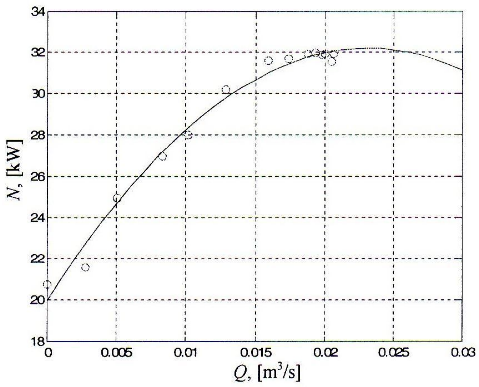


Fig. 9 – Pump power characteristic.

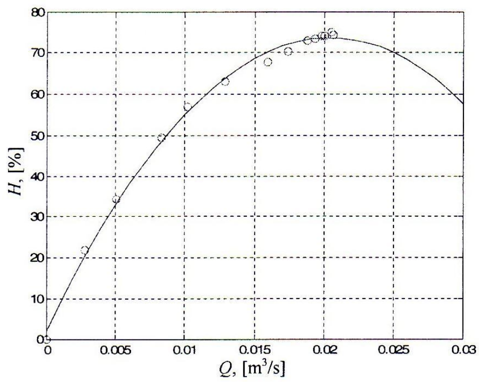


Fig. 10 – Pump efficiency characteristic.

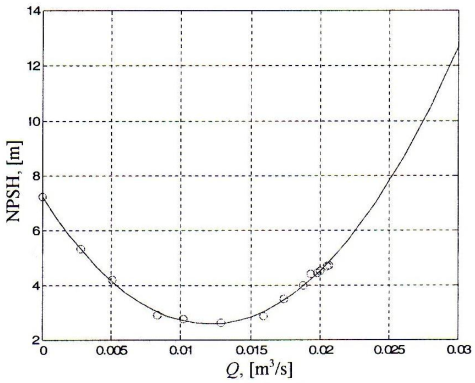


Fig. 11 – Pump cavitation characteristic.

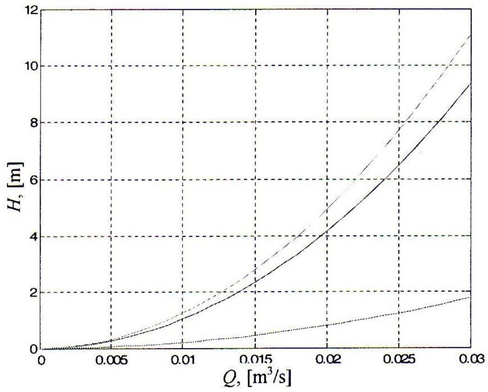


Fig. 12 – Head losses characteristics on pump communications.

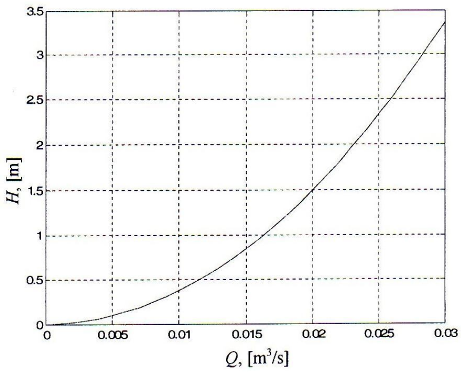


Fig. 13 – Network head losses characteristics.

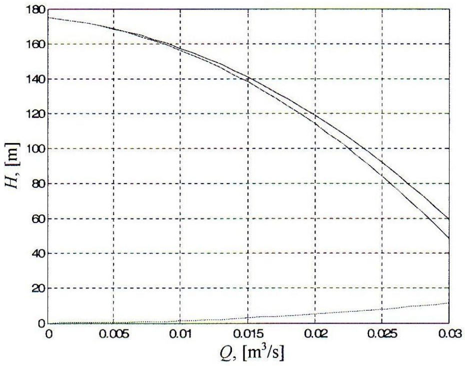


Fig. 14 – Pump and pumping plant head characteristics.

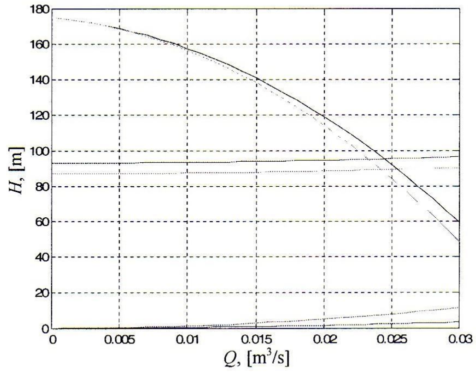


Fig. 15 – Quasi-permanent operating regime of pump-network system.

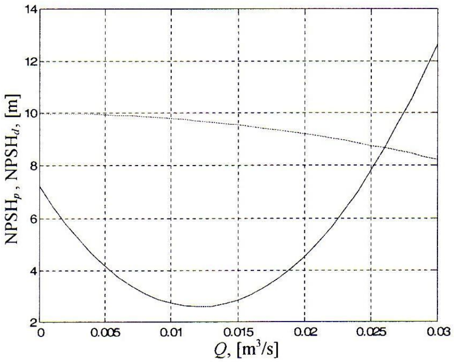


Fig. 16 – Outside cavitation domain.

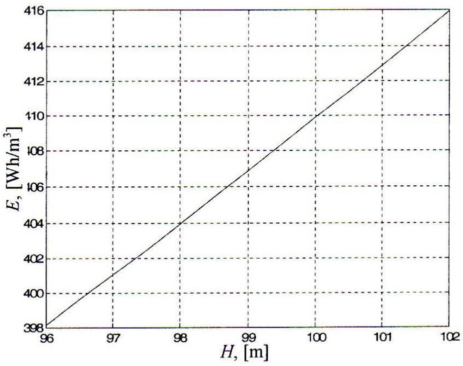


Fig. 17 – Energy specific consumption.

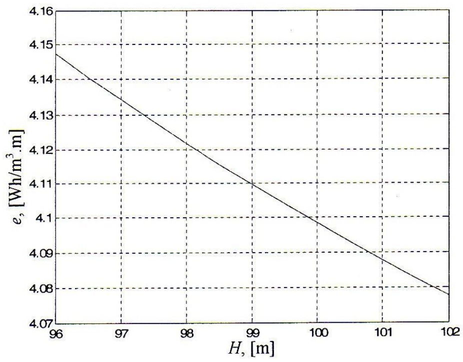


Fig. 18 – Unitary specific energy consumption.

4. Conclusions

The determination of operating regimes for the Boldeşti re-pumping station has been achieved by solving an equation system made of the active pump analytic characteristic and the network characteristic by means of the REGFUNCT application (developed în MATLAB).

The assessment of the water pumping energy and economical efficiency has been achieved by the determination of the pumping equipments' operating domains and by determining the pumping specific energy consumption and the unitary specific energy consumption (by means of the experimentally determined analytic equations of head and efficiency curves for the pumps).

The application helped also the determination of the pumping equipment operating domain in the absence of cavitation phenomenon.

All results have been finally presented in tables and graphs.

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OPTIMIZAREA DETERMINĂRII REGIMURILOR DE FUNCŢIONARE ALE INSTALAŢIILOR DE POMPARE DIN CADRUL SISTEMELOR DE ALIMENTARE CU APĂ

(Rezumat)

Se studiază posibilitatea de determinare a regimurilor de funcţionare ale instalaţiilor de pompare prin intermediul unui program de calcul automat elaborat în MATLAB. În cadrul programului s-au introdus datele, în subrutine corespunzătoare, necesare calculului pierderilor de sarcină locale introduse de 61 de singularităţi diferite ce pot apărea pe traseul comunicaţiilor pompelor şi a reţelei de transport a apei. Se evaluează eficienţa energo-economică a pompării apei prin stabilirea consumului specific de energie pentru pompare şi a consumului specific unitar de energie. Se determină de asemenea şi domeniul de funcţionare a instalaţiilor de pompare în absenţa fenomenului de cavitaţie.

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THE PURSUIT OF MONITORISING IN TIME OF SOME CONSTRUCTIONS WITH THE STRUCTURE MADE OF CONCRETE AND MASONRY

BY

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Abstract. The paper presents some aspects concerning the following activity study, through topographic methods, of the behavior in time of one constructions with structure made of concrete and masonry, namely: the administrative building of the S.C. ARGOS S.R.L., from Cluj-Napoca, standing on the Onisifor Ghibu street. In this case the cause that engendered the appearance of manifestations in the buildings was the existence of an underground gap below the construction or in near proximity. In this case, because the volume of the gap created throughout the realization of the collector channel for the household waters was not big (diameter in light of 2.15 m), the manifestations emerged during the execution of the channel ended with the finalizing of the works in the area of the administrative building of the S.C. ARGOS S.R.L and reestablishing of a new state of equilibrium of the terrain in the respective area.

Key words: monitorizing through time; pursuit; survey methods.

1. Introduction

The main purpose of the activity pursuit in time is that of preventing possible constructions accidents which lead to important material losses and

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sometimes even casualties of human lifes and to maintain a more larger period of work for the constructions founded in exploitations in safe conditions.

The activity of pursuing the behavior of constructions in time is an action settled through the Law no. *10*/1995 regarding the quality in constructions, respectively the Normative regarding the pursuit of behavior in time of the constructions P *130*, 1999, as well as throughout a series of normative documents and specific technical regulations. This activity is developed through the entire period of life of the constructions, it assumes the gathering and capitalization of information obtained through observation and measurements and has as purpose the tracking in time of the deficiencies emerged and the establishing of the retrieval measurements of these, therefore it can satisfy the stipulations regarding the maintaining of the resistance's requests, stability and endurance of the constructions, as well as the other essential requests.

The pursuit of behavior in time of the constructions can be actual or special, in admission with the category of importance of the construction, the way of following and the methodology of effectuation of this being established by the designer or by the expert through the Technical Book of the construction.

The special pursuit is organized by the owner on the basis of a project of special pursuit elaborated by a firm that has expertise in the field or by the planner and it is executed by specialized personnel and specialists with complex and specialized means of measuring and observation.

The special pursuit is applied only in certain situations (Nistor, 1993):

a) in the case of the new constructions of a particular or exceptional importance;

b) in the case of the constructions in exploitation with dangerous development, established through a technical expertise;

c) at the owner's request, at the Inspectorship of State in Constructions or of the organizations approved by this on specialized domains.

2. Theorethical Reasons

A building submitted to the solicitation regime determined by external factors or by its functional conditions can suffer linear, angular and specific displacements and abnormalities, namely

1. Linear displacements and abnormalities

a) settlements/ landslips;

b) bulging;

c) arrows of certain construction elements;

d) dips;

e) crevasses and crazes;

f) horizontal displacements.

2. Angular displacements and abnormalities

a) dips of the constructions, determined by the rotation of the foundation elements in vertical plan;

b) twists of the constructions determined by the rotation of the foundation elements in horizontal plan;

3. Specific abnormalities

a) stretchings and shortcuts of certain construction elements under the effect of straining or compression – decompression of the respective elements.

2.1. The Determination of the Constructions Settlements/Landslips

The most precise method of the establishing of a construction settlement/landslip is the method of the geometric grading. The method assumes the execution of certain repeated observations over some slidable marks (dabs of settlement) clamped into the elements of resistance of construction, which moves at the same time with this, communicating with some fix marks (control marks), placed outside the influence area of the building (Fig.1) (Ortelecan, 1999).

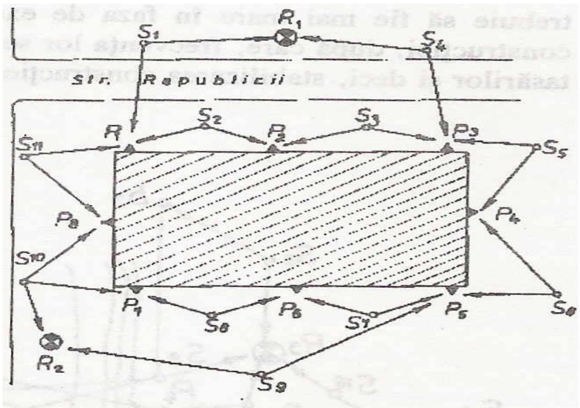

Fig. 1

The control marks, R_1, R_2, are placed in such a way that their level can't be modified in time through: the influence of construction, the variation of the level of phreatic water and the subterranean waters, vibrations, the circulation of automobiles. The control marks are collocated so that they can cover equally the area surrounding the construction. Their placement is made keeping in count

a) the geotechnical and hydrological conditions;

b) the necessity of assuring the proper conditions for the performing of the readings;

c) the systematization of the ground surrounding the building, etc.

The dabs of settlement, $P_1 \ldots P_8$, embed in the resistance elements of the construction, at its corners, in the proximity of the joints of settlement and at the characteristic points of the construction. Given their location, the dabs of settlement are reproducing accurately the vertical movements of the construction and they make it possible to be measured.

The measurements where performed using contouring preciseness instruments and special stages of invar. The execution of the observations comprises the implementation of a geometrical contouring from the middle of order I and II, in favourable atmospheric conditions, executed in a direct and inverted sense, or with two plans of sighting. The non closure of the contouring has to fit in tolerance T = ±0.5 mm$\cdot\sqrt{n}$, where n represents the number of stations.

The accurate geometrical contouring will be executed in each stage, as possible, on the same ranges and in similar technical conditions. The frequency of the stages of measurements is established in accordance with how active is the phenomenon of settlement/landslip; once the phenomenon is established the distance between the measurements will grow.

The estimation of the vertical movements of the dabs of settlement can be made through one of the following procedures:

a) based on the level differences between the following points;

b) based on the quotes of the settlement dabs.

The absolute or total settlement of each dab (T_i) is calculated as difference between the quote of the cycle of current observations (H_i^i) and the quote of the cycle of initial observations (H_i^0),

$$T_i = H_i^i - H_i^0 , \tag{1}$$

The medium settlement of the whole construction is calculated with relation

$$T_m = \frac{T_1A_1 + T_2A_2 + ... + T_nA_n}{A_1 + A_2 + ... + A_n} , \tag{2}$$

where: T_1, T_2, T_n are the absolute settlements of the dabs of settlements; A_1, A_2,…, A_n – the surfaces of the soles foundations relevant to the elements of resistance on which are fixed the settlement dabs.

The medium settlement can be calculated as well as the arithmetic sum of all the settlements of the control marks.

2.2. The Determination of Dips of Construction

The procedure that assures the biggest precision in the determination of the constructions` dips is based on the angular measurements using very precise instruments (1^{cc}) for the angles measurements.

The method consists in the placement at a distance equal to 2…3 times the height of the construction, on the direction of the wall, of two clamps from which will be measured the horizontal angles formed by a point situated at the superior leaf of the wall and at a stable point placed outside the influence area of the construction (Fig. 2) (Arsene & Morar, 1998).

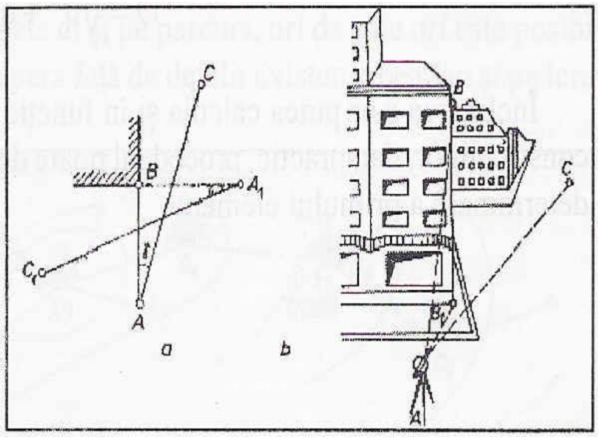

Fig. 2

The size of the angular dip of the wall is determined as a difference between the horizontal angles measured in two consecutive stages

$$\gamma = \gamma'' - \gamma' . \tag{3}$$

The linear size of the dip is calculated with the relation

$$l = \frac{\gamma^{cc}}{\rho^{cc}} D , \tag{4}$$

where: γ^{cc} is the angular dip, expressed in centesimal seconds; γ^{cc} – the factor of transformation; D – the horizontal distance between the clamp on transit and the point situated on the superior leaf of the wall.

3. Practical Aspects

Next will be present the proposed method and the results of the pursuiting in time of one building with the structure made of masonry affected by the same cause: the existence of an underground excavation under the building or in the proximity of this one.

3.1. The Pursuit of Monitorizing of the Administrative Building

The administrative building of the S.C.Argos SRL from Cluj-Napoca is situated on the Onisifor Ghibu street. The current building is composed from two associated bodies, each of them having separate foundation.

In front of the building, along the Onisifor Ghibu street, at an horizontal distance of approximately 6 m but placed at a depth of 11 m, was built the collector channel right levee Little Somes, section Mihai Viteazu market – Mărăşti (Fig. 3).

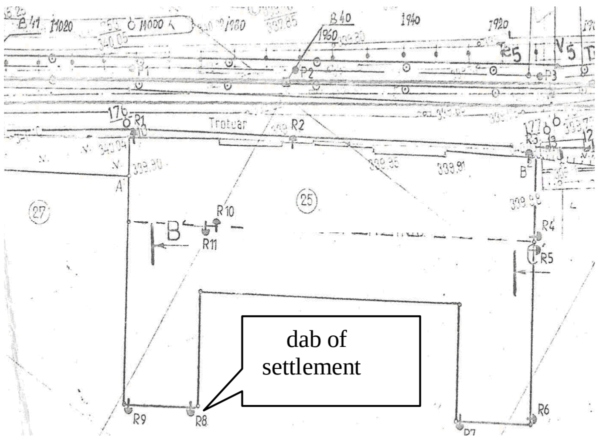

Fig. 3

As expected, the existent disturbance of the state of natural equilibrium, caused by the execution of the works at the collector channel, has determined the appearance of certain manifestations in the state of stability of the constructions in the proximity of the collector channel. Therefore, in the administrative building appeared bracks, in vertical plan, in the associate area of the two bodies of the building.

For the pursuit of the behavior in time, through topographic methods, was elaborated the following plan and it was realized the following network. As control marks were used the aggregation settlement VI. The settlement marks were clamped in the elements of resistance of the building, in the old body: R1 – on the N corner, *R*2 on the NE side, *R*3 – on the E corner, *R*4 – on the S corner and *R*10 inside on the SW side, as well as in the new body; the marks: *R*5 – on the E corner, *R*6 – on the S corner, *R*7 and *R*8 on the SW side, *R*9 – on the W corner and *R*11 inside on the NE side (Contract 88-1108, 1999).

On this following network were made observations through the method of the geometrical levelling from the middle. It was used the precision levelling NI 002 Zeiss with a compensator of a fly type, with a double position, of whose constructive position is of 0.2 mm/double km of levelling fillet of invar. After the execution of the first measurement (the basic initial measurement), the next steps have happened at interval of approximately one month.

Because the vertical movements were caused by the appearance of the underground gap arised after de realization of the collector channel, we deal with a diving phenomenon. The studied parameters were

a) the diving on the period

$$\Delta s_i = H_i^i - H_i^{i-1}, \text{ [mm]}; \tag{5}$$

b) the absolute and total diving

$$S_i = H_i^i - H_i^0, \text{ [mm]}; \tag{6}$$

c) the diving speed

$$v = \frac{\Delta s_i}{n}, \text{ [mm/month]}, \tag{7}$$

where n represents the elapsed time period between two consecutive measurements, expressed in months.

The registered values for the above parameters in the case of the 11 dabs of settlement, are presented in Table 1.

Table 1

The observation stage	The first periodic measurement (at 29 days from primary measurement)			The second periodic measurement (at 49 days from primary measurement)			The third periodic measurement (at 79 days from primary measurement)		
Determined parameters / Label dabs of settlement	Δs mm	S mm	v mm/month	Δs mm	S mm	v mm/month	Δs mm	S mm	v mm/month
*R*1	–0.9	–0.9	-0.9	+0.6	–0.3	+0.6	+1.0	+0.7	+1.0
*R*2	–1.0	–0.9	–1.0	+0.6	–0.4	+0.6	+0.7	+0.3	+0.7
*R*3	–0.9	–0.9	–0.9	+0.4	–0.5	+0.4	+0.3	–0.2	+0.3
*R*4	–0.9	–0.9	–0.9	+0.7	–0.2	+0.7	+0.7	+0.5	+0.7
*R*5	–0.3	–0.3	–0.3	+0.2	–0.1	+0.2	+0.2	+0.1	+0.2
*R*6	–0.1	–0.1	–0.1	+0.1	+0.0	+0.1	+0.0	+0.0	+0.0
*R*7	–0.3	–0.3	–0.3	+0.2	–0.1	+0.2	+0.1	+0.0	+0.1
*R*8	–0.4	–0.4	–0.4	+0.3	–0.1	+0.3	+0.3	+0.2	+0.3
*R*9	–0.3	–0.3	–0.3	+0.3	+0.0	+0.3	+0.1	+0.1	+0.1
*R*10	–1.5	–1.5	–1.5	+0.6	–0.9	+0.6	+0.6	–0.3	+0.6
*R*11	–0.8	–0.8	–0.8	+0.6	–0.2	+0.6	+0.2	+0.0	+0.2

Analizing the dates from the Table 1 it is possible to observe that, although at the first periodical measurement ,the values of the three parameters were relatively big in the case of the dabs of settlement clamped in the old wing of the building, after the channel was built and in the surrounding rocks it was reinstalled a state of equilibrium, the followed parameters have come back to normal, the movement phenomenon being attenuated till it vanishes.

4. Conclusions

The activity of the monitorizing of the behavior in time of constructions receive a special importance in the actual conditions when the majority of constructions from our country have a minimum age of 19 years. In the same time, the pursuit of the behavior in time of constructions represents a source of informations for the designing activity, regarding the type of behavior in real conditions of the intended constructions and the interaction of elements with the environment. Throughout the dates and the given informations, the following activity in time offers the posibility to compare the results obtained through modeling and experimentally with those from the exploitation. Even if it is about the actual pursuit, but especially in the case of the special pursuit, this activity must be approached with professionalism and the projects of special pursuiting to ensure the identification of causes that are producing the effects appeared in the followed constructions and in the same time to propose measures that can limite to minimum these effects. When it is needed (in the case of the special pursuit) the pursuit through topographic methods is necessary to be realized with instruments that can ensure the necessary precision in these kind of labours, to apply the proper method to each case individually and the period between two stages of measurements to be according to the amplitude of the phenomenon of settlement/diving or of the dip of construction.

In the same time, the beneficiary is obliged to apply the exact dimensions proposed for preventing possible accidents and to ensure a exploitation of constructions in safety conditions.

In the first presented case it was observed that through the pursuit of behavior in time by topographic methods it was determined of the fugitive nature of the phenomenon of settlement/diving caused by the execution of the collector channel, not being necessary anymore measures for the stabilization of the construction.

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* * * The Law no. *10*/1995 regarding the quality in constructions.

URMĂRIREA ÎN TIMP A UNOR CONSTRUCŢII CU STRUCTURA DIN BETON ŞI ZIDĂRIE

(Rezumat)

Se prezintă aspecte privind activitatea de urmărire, prin metode topografice, a comportării în timp a unei construcţii cu structură din beton şi zidărie, şi anume: clădirea administrativă a SC ARGOS SRL, din Cluj-Napoca, localizată pe strada Ghibu Onisifor. În acest caz, cauza care a generat apariţia manifestărilor a fost existenţa unui gol subteran sub construcţia din imediata apropiere. În acest caz, deoarece volumul golului creat prin realizarea canalului colector pentru apele menajere nu a fost mare (diametrul de 2,15 m), manifestările apărute în timpul executării canalului s-au încheiat la definitivarea lucrării în zona clădirii administrative a SC ARGOS SRL şi restabilirea unei noi stări de echilibru a terenului în zona respectivă.

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ANALYSIS OF THE PHENOMENON OF INFILTRATION IN THE DAMS OF EARTH DEGRADED

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Abstract. Earth dams changes over in time the their structural condition. The earth dams present substantial discrepancies of the constructive and hydraulic parameters in comparison with those initially designed. Structural change determines the changing parameters of infiltration phenomenon. The phenomenon of infiltration evolves from laminar flow regime to a transient and turbulent one. Changing the flow regime led to the emergence of the phenomenon of sufozie in the body of a dam. The obtained results revealed new safety parameters of the high water discharge structure and suggested modernization solutions.

Key words: dams; infiltration; safety parameters; flow regime.

1. Introduction

Climate actions and mechanical changes modify the structural and functional parameters, of the dams of earth, in time.

The political and economic changes, which occurred in Romania after 1989, have in some cases determined the partial modification of functions in

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some hydrotechnic systems. In this case the hydrotechnic system undergoes new demands not initially taken into consideration, while designing. These modifications affect the safety of exploiting by introducing supplementary risk factors. The hydraulic expertise allows for an analysis of the way in which hydrotechnic constructions behave in the new exploitation circumstances. What results are the characteristics of the new hydraulic regime and, at the same time, an insight into the safety measures required while exploiting.

Analysis of infiltration is carried out based on the measurements and researches of land to construction of water projects in operation. In certain situations has not been respected the way of structuring the material in body of earth dams.

In other situations was changed the state due to the high waters. All these have influenced the process of infiltration through the body of the dam. The infiltration phenomenon passed in the field of linear flow in nonlinear field. The result of the regime's change is represented by seeping the emergence of the phenomenon of suffuse. Structural degradation over time affects the stability of the dam. Application of structural rehabilitation measures requires analysis of infiltration through the body of the dam.

2. The Dam of Land Degraded. Case Study

In the analysis it was considered a dam of ground where the process of infiltration has been modified over time negatively. New regime parameters of infiltration have imposed reducing the level of exploitation. The stability of the dam was influenced by lifting the curve of infiltration. The phenomenon of seeping through the body of the dam caused the training of fine material (clay and dust).

The analysed hydrotechnic system is located in Northern Romania. The accumulation was deigned with the purpose of reducing flood waves with a probability of overflowing of 1% and 0.1%, irrigation, fish farming and supplying with water a town.

The hydrographic basin corresponding to the accumulation measures 310 km^2. The hydrotechnic system started to be exploited in the year 1979. In the later years the hydrotechnic system underwent several structural and functional modifications.

The storage basin is achieved through a frontal dam with a heterogeneous structure executed with local materials. The construction parameters of the dam are: maximum height – 14.0 m, width at the crest – 5.0 m, length – 2,160 m, average width of the road territory – 80.0 m, etc.

The storage basins specific volumes are: on the total – 46.2 million m^3, accumulated – 39.86 million m^3 at the maximum level of exploitation (p = 1% and elevation 243.94 m of reducing flood waves 24.60 million m^3, etc. The calculus discharges are: $Q_{1\%}$ = 330 m^3/s of the design discharge and $Q_{0.1\%}$ = = 516 m^3/s of the verification discharge. The flow absorbed from the basin for the water supply is Q = 0.75 m^3/s.

The dam's upstream facing is described by two slopes and is protected by a layer of riprap (in the initial project the slope was of 1 : 3.5 and the protection realized out the concrete slab). The downstream facing of the dam with 1 : 2 and 1 : 3.50 slope, shows two berms with a width of 2.0 m, located at an elevation of 239.50 m and, respectively, 234.50 m. The downstream slope presents a drainage system.

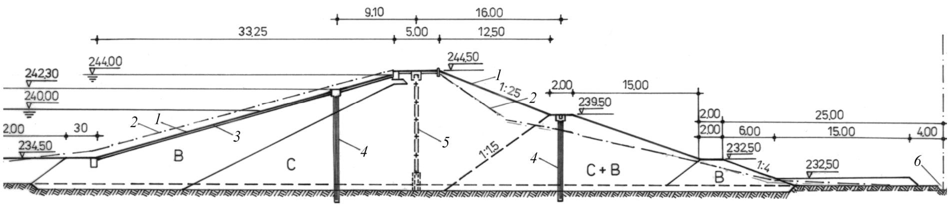


Fig. 1 – The transversal profile of the dam: *1* – the initial form; *2* – the present-day form; *3* – pitching of the concrete slab; *4* – piezometer tubes; 5 – mark of depression; *6* – channel.

Fig. 2 – The downstream facing of the dam.

After 30 years of exploitation, the dam shows a satisfactory functional status as regards the structural integrity, its hydraulic response and its mechanical stability. After the year 1989, the functions of the hydrotechnic system were modified. At present, the achieved functions are: reducing the flood waves, water supplying of two towns, fish farming, tourist area, etc. Changing the initial function has determined, consequently, the designing and execution of several modifications in the dam's structure, as well as in that of the intake tower and execution of a supplementary intake tower.

The new conditions of exploitation have determined the maintaining of a raised retention level and the intense usage of the hydromechanics devices within the intake tower. At the same time, the hydrotechnic system has repeatedly undergone actions of an endogenous nature. These actions have led to a diminishing state of safety in exploiting the hydrotechnic system, especially of the earthen dam of the intake tower. The modification of the functioning conditions and the absence of corresponding constructions specific to earthen dams, now determine a decline in the safety of the exploitation.

In exploiting time the accumulation, some important deficiencies have been noted, as a result of incomplete implementation of the execution design, of the interaction between the construction and the incorporating medium, of the action of the endogenous and exogenous factors, etc.

3. Research on Seepage through the Dam Body

Theoretical and experimental studies have emphasized the following observations:

a) The dam presents a less slender transversal profile than which the design has specified.

b) Instead of the protective layer made out of concrete slabs of the upstream face of the dam there is a layer of riprap. As a result there is an active process of infiltration through the dam, with significant water loss from the storage basin. The infiltration current initiates and intensifies the internal erosion phenomenon.

c) The absence of waterproofing works of the dam has affected its stability, situation which has claimed imperatively a decline in the normal level of exploitation of the water in the storage basin.

d) The drop-down curve rises to the surface at relatively high elevations on the downstream face of the dam, which affects its stability.

e) The internal erosion phenomenon and its effects in time have determined modification within the structure of the material within the dam’s body.

f) The unequal subsidence of the emptying gallery at the old intake tower, with values up to 55 cm in its central area, due to the internal erosion phenomenon.

g) For normal pool level (NPL), boiling areas have been observed with ascending springs at the bottom of the collecting channel, but no dislodging of sold sediment.

h) The physical and chemical analysis of the water evacuated by relief well indicates the presence of clay, of the internal erosion phenomenon, respectively. The reddish colouring of the evacuation channel of the infiltration waters confirms the existence of this phenomenon. The absence of fine material in some relief well indicates that the internal erosion phenomenon is not permanent active.

a *b* *c*

Fig. 3 – The effects of the phenomenon of infiltration over the dam: *a* – the relief well of the downstream facing of the dam; *b* – the fountainhead of the downstream face; *c* – the presence of water on the downstream face.

Field test have emphasized a relatively non-uniform stratification in the studied section of the dam. This stratification is made up two geological types: waterproof soils at the surface (dusty clay and argillaceous dust), under which lay cohesion less soils. The level of the underground water has been observed at depths of 1.60…4.80 m. This level is mostly located in the area of the waterproof formation at the surface. This shows the presence of a current under pressure located in the cohesion less deposits beneath the waterproof layer.

Researches conducted in the field have highlighted an intense sufozie process through the body of the dam. This process is exemplified by the following structural and functional aspects:

a) in the body of the dam has been developed an active phenomenon of sufozie (involve material fine stream of water); this is determined by the structural and hydraulic causes;

b) the dam has not complied with the structuring of the layers of material;

c) the operation of the dam have not been observed water levels imposed by the design; the curve of infiltration was high on the downstream face of the dam;

d) the high level of water caused a hydraulic gradient that has exceeded a critical value; on certain sections of the dam appeared the phenomenon of sufozie;

e) the phenomenon of sufozie is highlighted by the transport of material from the body of the dam; this transport is uneven on the length of the dam;

f) the phenomenon of sufozie is marked on the ground by red clay components included in the body of the dam; water discharged by some downloading wells has the colour red on sections where there is present the phenomenon of sufozie;

g) on the downstream face of the dam water springs appeared; they show the appearance of flow paths in the body of the dam where no longer satisfied the law of linear filtration;

h) intense red colour of the water of the colourful grass of the downstream face of the dam in the mouth; it also has coloured in red pitching channels collecting water seeping;

a *b* *c*

Fig. 4 – Marking of water transport loaded with fine material in the body of the dam: *a* – channel collectors; *b* – channel intersection node; *c* – channel.

For the calculus of the infiltration a computer programs has been used, compiled in Turbo Pascal, for homogeneous and heterogeneous dam (through the virtual method), with or without downstream waters, for drained dams.

The analysis of the infiltration process was carried out for the present day functional situations, as well as for the hypothesis of the rehabilitation and modernization of the dam. The verification was carried out in five different significant sections for calculus. New safety parameters for the dam corresponding modernization solution have resulted.

The analysed versions were the follwings:

V e r s i o n 1: earthen dam with a drainage system, maximum level (p = 1%, calculus insurance) with the subversion:

A – functioning drain of the downstream facing of the earthen dam;

B – blocked drain of the downstream facing of the earthen dam.

V e r s i o n 2: earthen dam with a drainage system, maximum verification level (p = 0.1%) with the subversions:

A – functioning drain of the downstream facing of the earthen dam;

B – blocked drain of the downstream facing of the earthen dam.

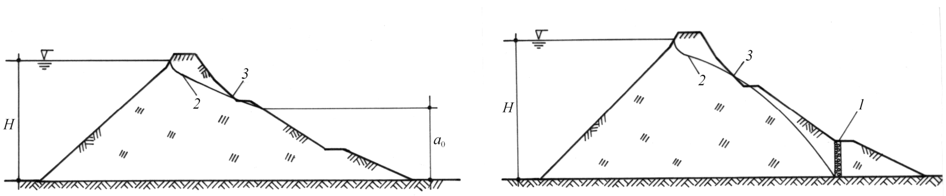
V e r s i o n 3: earthen dam with a central concrete/steel concrete diaphragm (the new design version), with maximum level and maximum verification level.

V e r s i o n 4: earthen dam with a steel concrete screen (the design version).

The verification of the parameters of the infiltration phenomenon indicates a high diversity of values due to the heterogeneous composition of the filling materials and to the considered calculus hypothesis. Even in the case of a functioning drain there emerge situation in which the depression curve is in the close neighborhood of first berm and of the surface of downstream face of the dam, due to the characteristics of the material and the slender shape of the dam.

The analysis shows that the maximum level of infiltration through the dam is traced in calculus section *3* (near the first/initial intake tower, with the parameters of the material: k_{med} = 1.16 cm/s, ρ = 1,915…2,031 kg/m^3, ϕ = 8^o 15…15^o 35, C_{med} = 0.44…0.58 daN/cm^2). For the storage basin level with the calculus probability 1%, the maximum specific infiltrated flow is q_{max} = 15 × 10^{-8} m^3/ms, with the height of trickling downstream face of the dam of a_0 = 3.82 m (Fig. 2).

For the level with the calculus probability of 0.1%, calculus section *3* becomes the most strained, here the height of trickling downstream face of the dam of a_0 = 6.03 m is at its highest value and the depression curve intersects first berm. In the hypothesis of the blocked drain, the maximum specific infiltrated flow results in section *2*, with the value q_{max} = 24 × × 10^{-8} m^3/ms. The means that a possible try to over-increase of the level of exploitation can determine the loss of the dam's stability, due to the appearance of the springing phenomenon on the downstream slope at very high elevations (higher that 6.0 m).



a *b*

Fig. 5 – The position of the seepage curve in the maximum level hypothesis (*p* = 1%): *a* – blocked drain; *b* – functioning drain; *1* – drain; *2* – seepage curve; *3* – zone of the spring.

General condition unsatisfactory structural and functional rehabilitation of the dam body was imposed. To stop the tide of infiltration was used a vertical wall of reinforced concrete.

4. Conclusions

1. A partial or total modification of the initial functions of hydrotechnic system induces a series of new actions that can affect the safety in exploiting the system by inducing supplementary risk factors.

2. The special heterogeneous structure of the filling within the dam's body negatively influences its response to the infiltration waters, determining in some places mechanical erosion processes and scouring, even in the construction area and that of the incorporated equipment.

3. In the study case of the hearth dam, modifying the initial function, correlated with the absence of any waterproofing works undergone, led to the decrease in the normal retention level in order to avoid risking the dam's stability and loosing water from the storage basin.

4. The phenomenon of sufozie is developed in the body of the dam due to changes in the hydraulic gradient by using a higher level of water. The phenomenon is intense and affects the stability of the dam.

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ANALIZĂ ASUPRA FENOMENULUI DE INFILTRARE LA BARAJELE DEGRADATE, CONSTRUITE DIN MATERIALE LOCALE

(Rezumat)

Barajele de pământul se schimbă în timp, în starea structurală. Barajele de pământ prezintă discrepanţe substanţiale ale parametrilor constructivi şi hidraulici, în comparaţie cu cele proiectate iniţial. Schimbarea structurală determină schimbarea parametrilor fenomenului de infiltrare. Fenomenul de infiltrare evoluează de la regimul laminar la unul tranzitoriu şi turbulent. Schimbarea regimului de curgere duce la apariția fenomenului de sufozie în corpul unui baraj. Rezultatele obținute dezvăluie noi parametri de siguranță ale structurii de deversare a apelor mari si sugerează soluții de modernizare.

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WASTE WATER REUSE IN AGRICULTURE – A GLOBAL PERSPECTIVE

BY

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Abstract. The rapid growth rate of world population, urbanization, climate change and the looming fresh water crisis, have increased the gap between the supply and demand for water is widening and is reaching such alarming levels that in some parts of the world it exists a threat to human existence. Many cities in the developing world face a myriad of problems in providing water supply, solid and liquid waste management, and food security to their growing populations. Given the global water crisis problem an alternative for that is to reuse of waste water to refocus on one of the ways to recycle water in agriculture for irrigation and other purposes. In this context, the authors of this paper highlight the importance of reusing waste water in agriculture for rational use of water resources in the future, without environmental risks.

Key words: agriculture; effluent; irrigation; waste water.

1. Introduction

The rapid population growth in many countries of world and also effects of climate change leading to arid and semiarid areas of world, continues to place increased demands on limited fresh water supplies, the gap between the

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supply and demand for water is widening and is reaching such alarming levels that in some parts of the world it exists a threat to human existence. The population increase has not only increased the fresh water demand but also has increased the volume of waste water generated. It is an opportunity time to refocus on one of the ways to recycle water through the reuse of urban waste water, for irrigation and other purposes.

Treated or recycled waste water appears to be the only water resource that is increasing as other sources are dwindling. This could release clean water for use in other sectors that need fresh water and provide water to sectors that can utilize waste water, *e.g.* for irrigation and other ecosystem services. In general, waste water comprises liquid wastes generated by households, industry, commercial sources, as a result of daily usage, production, and consumption activities. In developed countries where environmental standards are applied, much of the waste water is treated *prior* to use for irrigation of fodder, fiber, and seed crops and, to a limited extent, for the irrigation of orchards, vineyards, and other crops.

Other important uses of waste water include recharge of groundwater, landscaping (golf courses, freeways, playgrounds, schoolyards, and parks), industry, construction, dust control, wildlife habitat improvement and aquaculture. Waste water is used to irrigate 10% of the world's crops, according to the first ever global survey of waste water irrigation. This is a largely hidden practice and is outlawed in many countries. Municipal treatment facilities are designed to treat raw waste water to produce a liquid effluent of suitable quality that can be disposed to the natural surface waters with minimum impact on human health or on the environment.

Thus, waste water can be considered as both a resource and a problem. Waste water and its nutrient content can be used extensively for irrigation and other ecosystem services. Its reuse can deliver positive benefits to the farming community, society, and municipalities. However, waste water reuse also exerts negative external effects on humans and ecological systems, which need to be identified and assessed.

Analysing the global current situation it is noted that in recent years in some areas drinking water supplies are in decline getting up to disappearance in dry periods. Current trends in the treatment of waste water and closing water circuits based on management practices, recommends applying the principles of reduction, recycling and reuse of effluent.

In this context the authors, based on an extensive bibliography researched, consider using waste water in irrigation a global perspective in order to save water resources and rational use of water availability.

2. Waste Water Reuse – a Necessity

50 years ago water was considered as an inexhaustible resource. But water needs for all uses on Earth have evolved over time, from about 580 km^3/s, at the end of the nineteenth century at more than 3,950 km^3/s in year 2000 and it

is projected to increase by 1.32 times to the year 2025, respectively about 5,214 km^3/s (Fig. 1).

Key determinants of lower global water resources are represented by population growth, economic development, and effects of climate change, especially by increased drought, results that led to the expansion of irrigated agricultural areas. Is estimated that for drinking, domestic, industrial, agricultural and energy production consumption are removed annually from watercourses and groundwater basins of about 2,200 billion m^3 of water. From that consumption, about 1,050 billion m^3 of water are returning to rivers as waste water for which neutralizing is need other 1,500 billion m^3 clean water.

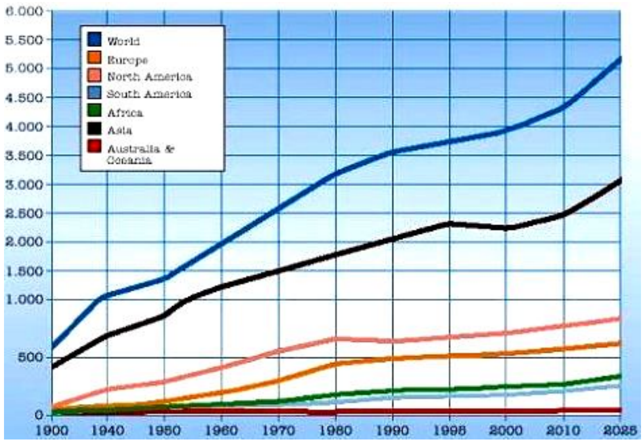

Fig. 1 – Global water consumption in period 1900…2025
(organized by regions and measured by regions, in billion m^3/year);
source: world resources sim center.

In most of the world, the pressure of population growth on water demand is already accentuated by increasing the use of additional water to irrigate agricultural land to feed the growing population (Gore and the New Orwellian World, 1984).

According to a study conducted in 2011 by researchers in America, (Chartres *et al.*, 2010) it was found that 1/5 of the world population lives in areas where there is not enough water to meet all demands, 1/3 of the world population (2.3 billion people) do not have access to clean drinking water, 1.6 billion people live in areas with a declining economy, due to lack of water resources, through the impossibility of the authorities to satisfy water demand. Thus, it was found that a decrease in water resources and a growing population will lead to the impossibility of food production needed in the future in many parts of the world.

To prevent such a global water crisis will have to find solutions concerning increasing productivity in order to satisfy increasing demands for food, and ways to use water rationally. In the future, Earth's population is expected to grow to 9 billion in the year 2070 (Fig. 2), so water needs continue to grow even more to produce necessary food. Specialists calculation shows that an additional 2.5 or 3 billion people would mean an additional 5 million km^3 of water (Fig. 3).

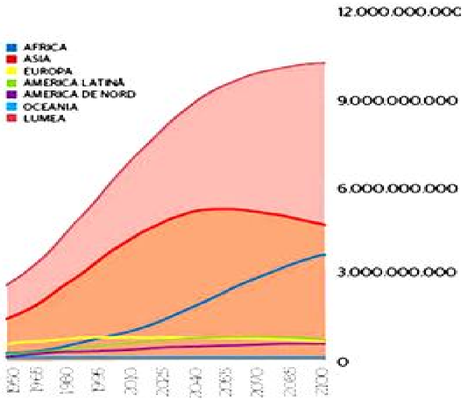

Fig. 2 – World population.

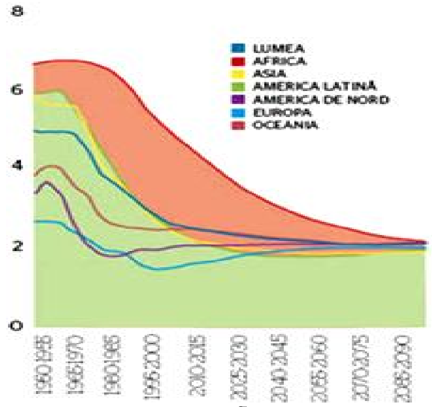

Fig. 3 – Inflation rate.

Population growth and planet's pollution are leading to Earth's inability to offer sufficient amount of resources for survival of the entire population. It is estimated that resources will decrease globally in direct proportion to population growth, according to the schedule in Fig. 4.

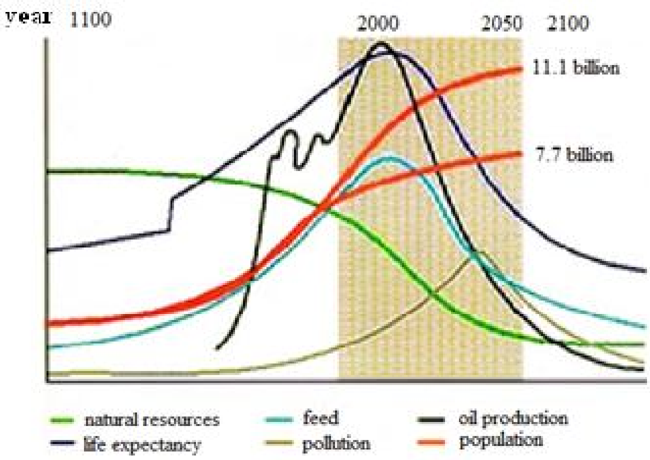

Fig. 4 – Perspectives on current economic issues.

Outside the european countries the picture is different, and primary energy demand is increasing by about 50% each decade. Overall, world energy demand is expected to increase by more than 50% from 2005 to 2030 (Fig. 5).

In agriculture, water requirement is determined by its use in irrigation, which ensures irrigation of increased agricultural areas, producing more than

2/3 of harvests and about 3/5 of cereals. Ahead, the need for water for agriculture will increase by 14%, in order to develop irrigated area by 20%.

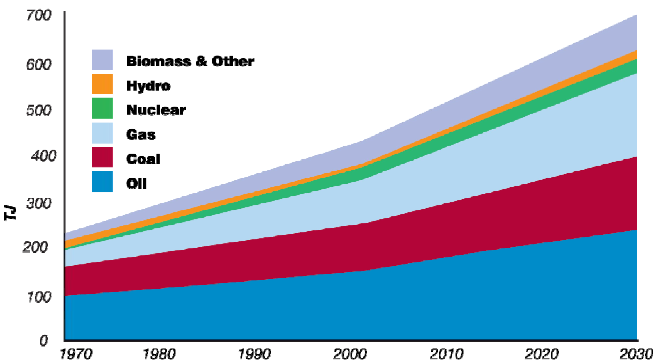

Fig. 5 – World energy demand; source: OECD/IEA World Energy Outlook, 2004.

So in the near future we believe that the possibility of waste water's capitalization in irrigation represent a solution to save fresh water for drinking water use, realising a more rational use of existing planet's water resources.

3. The Beginning of Using Waste Water in Irrigation

According to specialist archaeological studies, experts have concluded that in Babylon, Niniveh and Egypt, but also in our country, in cities like Tomis and Callatis (name of the time), houses were connected to sewage discharge channels. Jerusalem had since the time of King David large drainage channel width of 0.6 m and height of 2 m. In ancient Athens underground collectors were caryed into the rock or built in argil, which led waste water on the outskirts, where they were used to irrigation. In the Middle Ages there is a lack of concern for public health and hygiene issues, except some big cities, monasteries and fortresses (Jelea *et al*., 1967). In 1531, Bunzalau city was the first German city of that era, who after building a sewage system used waste water for irrigation, system that works until the beginning of twentieth century.

Several years later, in Poland, the areas where trees have just been planted for reforestation were irrigated. Later, the rapid growth of industry and cities, especially in England and Germany, has created accentuated contamination problems of the surface water. Thus, in England has growing natural biological treatment of waste water.

If at first waste water reuse was random, then there was observed a strong influence on vegetation due to their nutrient content. At present, waste water is used in order to be treated by soil and in future it is expected that their use will be imposed generally by the lack of clean water for irrigation. First irrigated areas with the purpose of waste water treatment where realised in England in the twentieth century to irrigate the grasslands, the fields of irrigation from Ashburton and Devon, where it was found that waste water reuse in agriculture in humid climate conditions, using soil for waste water treatment lead to obtaining an increased agricultural production.

4. Current Status of Irrigation with Waste Water

Fig. 6 shows the number of municipal water reuse schemes across different regions of the world according to field of reuse application. Applications are arranged in four main categories: agriculture, urban, industrial and mixed (multipurpose).

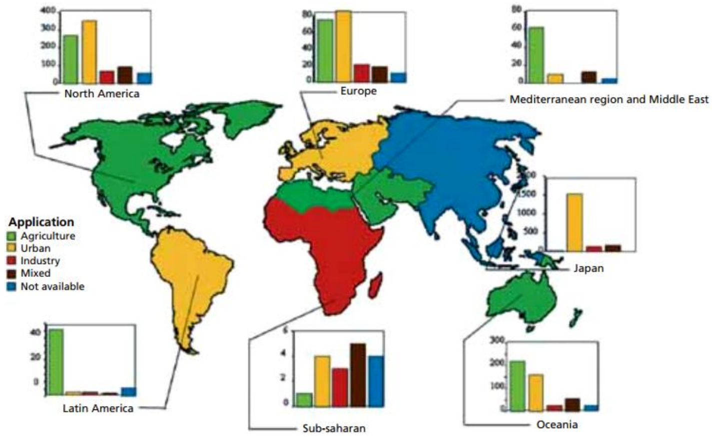

Fig. 6 – Municipal water reuse schemes.

It is estimated that within the next 50 years, more than 40% of the world's population will live in countries facing water stress or water scarcity. Growing competition between the agricultural and urban uses of high-quality freshwater supplies, particularly in arid, semi-arid and densely populated regions, will increase the pressure on this ever scarcer resource. Waste water may be a more reliable year-round source of water than other sources available to farmers, though this is dependent on the primary sources of urban water also being reliable. The value of recycled water has long been recognized by farmers not only as a water resource, but also for the nutrients it contains for plant growth and soil conditioning properties. Currently, the total land irrigated with raw or partially diluted waste water is estimated at 20 million ha in 50 countries, which represents approximately 10% of total irrigated land (FAO Waste Water Database).

In Europe, most of the reuse schemes are located in the coastal areas and islands of the semi-arid Mediterranean regions and in highly urbanized areas. Water scarcity is a common constraint in the Mediterranean region with varying precipitations, sometimes below 300...500 mm per year in southern parts of Spain, Italy, Greece, Malta and Israel. At times, water resources may fall below the chronic water scarcity level of 1,000 m^3 per inhabitant and per year. Long distances between water sources and users also create serious regional and local water shortages and water scarcity may worsen with the influx of peak summer tourists in the Mediterranean coasts and demographic growth, as well as drought and potential climate change – related impacts.

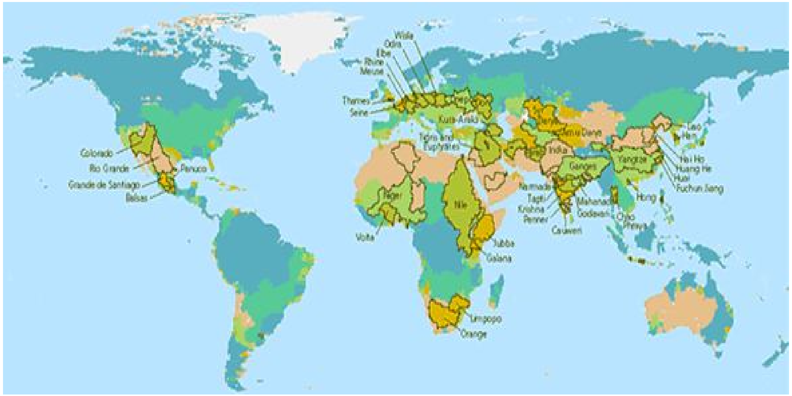

Fig. 7 – Widely practiced globally of irrigation with waste water;
source: FAO Wastewater Database.

In Romania, in 1996, there were over 60,000 ha of irrigation design with waste water from livestock, included in about 30 irrigation systems. At present, these are no longer functional (www.agir.ro).

5. Environmental Impact

Generally speaking, waste water (treated and untreated) is extensively used in agriculture because it is a rich source of nutrients and provides all the moisture necessary for crop growth. Impact from waste water on agricultural soil is mainly due to the presence of high nutrient contents (N and P), high total dissolved solids and other constituents such as heavy metals, which are added to the soil over time. Environmental concerns surrounding irrigation include the possibilities of leaching of nutrients to groundwater and accumulation of Na in the soil (Britz *et al*., 2006).

Nevertheless, a limited amount of research has shown that effluent irrigation has positive effects on soil properties including a liming effect, sometimes modest increases in soil organic matter status and substantial increases in the size and activity of the soil microbial community (Degens *et al*., 2000; Sparling *et al*., 2001).

The research made until now regarding mechanically and biologically treated waste water irrigation showed that waste water can also contain salts that may accumulate in the root zone with possible harmful impacts on soil health and crop yields. The leaching of these salts below the root zone may cause soil and groundwater pollution (Bond, 1999). Prolonged use of saline and sodium rich waste water is a potential hazard for soil as it may erode the soil structure and effect productivity. The problem of soil salinity and sodicity can be solved by the application of natural or artificial soil amendments.

Another negative factor is the presence of heavy metals from waste water affecting the food chain is addressed under soil resources. Soil usually acts as a filter and retains heavy metals in the soil matrix. The effects of these concentrations on the ecosystem may thus be reduced too.

Regarding the effect of waste water on crops after irrigation, most crops give higher than potential yields with waste water irrigation, reduce the need for chemical fertilizers, resulting in net cost savings to farmers. Crop scientists have attempted to quantify the effects of treated and untreated waste water on a number of quality and yield parameters under various agronomic scenarios (*Empirical Evidence of Impacts of Waste Water Irrigation on Crops*). An overview of these studies suggest that treated waste water can be used for producing better quality crops with higher yields than what would otherwise be possible. The use of untreated municipal waste water, as is the practice in many countries, raised a whole set of different problems. Nevertheless, the high concentration of plant food nutrients becomes an incentive for the farmers to use untreated waste water as it reduces fertilizer costs, even when the higher nutrient concentrations may not necessarily improve crop yields.

Table 1

Agricultural Crops Grown with Untreated and Treated Municipal Waste Water

Types		Examples of crops
Field crops		Barley, corn, oats, wheat
Fibre and seed crops		Cotton, flower and vegetable seeds
Vegetable crops that	can be consumed raw	Broccoli, cabbage, cautiflower, celery, chilli, pepper, green tomato, lettuce, pepper
	will be processed before consumption	Artichoke, asparagus, beans, onion, peanut, potato, sinach, squash, sugar beet, sunflower
Fodder and forage crops		Alfalfa, barley, clover, cowpea, hay, maize, pasture
Orchards and vineyards		Fruit trees, apple, avocado, citrus, lemon, peach, pistachio, plum, olive, date palms, grapevines
Nurseries		Flowers
Commercial woodlands		Conifers, eucalyptus, poplar, other trees

S o u r c e s: Asano *et al*. (2007), Jimenez & Asano (2008), Lazarova & Bahri (2005), Pescod (1992), California State Water Resources Control Board (1990).

6. Conclusions

While the world's population tripled in the 20th century, the use of renewable water resources has grown six-fold. Within the next fifty years, the world population will increase by another 40% to 50 %. This population growth – coupled with industrialization and urbanization – will result in an increasing demand for water and will have serious consequences on the environment.

Considering the presented situation regarding decreasing water resources and increasing its requirement, capitalizing solution of treated waste water in agriculture can be taken as an alternative to help reduction of water stress.

The condition to apply irrigation with waste water solution is that to adapt the technological processes in order to eliminate the hazard for health (microorganisms, bacteria, viruses, heavy metals), to fit the relevant legislation. Among these purification /treatment of waste water solutions, frequently applied is the advanced treatment (tertiary level).

Waste water use has a particular importance in terms of improvement of the structure and water permeability, with positive effects on the quality of agricultural works, water control regime, enhance of microbial life, with favourable effects on polluting phenomena and with a biostimulation role for all processes that occur in soil.

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VALORIFICAREA APELOR UZATE ÎN AGRICULTURĂ – O PERSPECTIVĂ GLOBALĂ

(Rezumat)

Rata de creştere rapidă a populației la nivel mondial, urbanizarea, schimbările climatice şi criza apei proaspete, au crescut accentuat necesarul între cererea şi oferta de apă ajungându-se astfel la niveluri alarmante, în unele părți ale lumii, lipsa apei fiind o amenințare pentru existența umană. Multe oraşe din lume în curs de dezvoltare se confruntă cu o mulțime de probleme în asigurarea alimentării cu apă, gestionarea deşeurilor solide şi lichide, precum şi securitatea alimentară a populației în creştere. Având în vedere criza globală, o alternativă pentru rezolvarea problemei deficitului de apă este reutilizarea apelor uzate în agricultură pentru irigații, dar şi în alte scopuri. În acest context, autorii subliniază importanța valorificării apelor uzate în agricultură pentru utilizarea rațională a resurselor de apă în viitor, fără riscuri asupra mediului.

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REDUCING THE IMPACT OF THE LAVAUD DAM ON THE DOWNSTREAM WATER BY MODIFYING DAM'S OPERATION

BY

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Abstract. Human construction activity has a great influence over the environment. Such constructions are dams, and the huge water accumulations behind them. The impact of these constructions over the environment can be physical or chemical. The most important environmental changes caused by dam construction are studied.

Referring especially to artificial lakes, the most frequent phenomena, occurring mainly during summer, is water stratification, and, as result, the chemical and physical structure of natural water courses is modified.

The temperature of the downstream water varies as compared to the natural status, besides, the chemicals dissolved in discharged water varies as well. This may have impact for the wild life in the river.

An example of a mitigation solution is presented, as well as a computer program for controlling the openings of a dam in order to minimize the effect of water stratification. This mitigation solution was proposed for Lavaud dam in France (within the framework of a joined EU program). Graphics of the variation of the solved chemicals and water temperature in the lake and downstream are also presented.

Key words: downstream water; environment; water reservoirs; water stratification.

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1. Introduction

Planet's freshwater resources are scarce, because 97.3% of the total water is salty while the fresh water is limited to only 2.7%. Besides, it is unevenly distributed in the world. Industrialized countries comprising only one third of world population have most of the available freshwater resources. In many areas the lack of freshwater resources is a great problem, as it happens in countries where these reserves are less than 1,000 m^3 per person.

The water reservoirs created by the construction of dams make possible the accumulation of additional water reserves in deficient countries, but they also have other purposes, such as getting electricity, hydrological regularization of water courses, etc.

At the planetary level there are about 45,000 large dams (large dams are considered those taller than 15 m) and over 800,000 small dams with an overall storage capacity of 7,000 km^3. The existing dams ensure a 70% increase in the availability of freshwater. Thus, the main reasons for building dams are: facilitating the use of available water, reduction of water level variability of different watercourses, storing water in case of crisis due to some prolonged droughts, regulation of flow for different uses, increased safety in cases of catastrophic flooding, the generation of electric power.

In terms of environmental impact must be taken into account basic elements such as the surface of the water accumulation and the degree of change in water flow, including both habitat modification and other elements specific to the ecosystem and how ecosystems are affected downstream. The impact of dams on downstream ecosystems is complex and has both social and environmental components. If the human population in areas affected by construction of a dam must be evacuated, social impact is simple, yet very drastic. The downstream impact is rather represented by a set of impacts related to the time period and volume of changes of the river level, the quality of the river bed, and the connections between hydrological conditions and flooded areas.

The impact of dams on downstream areas clearly involves substantial changes in the dynamics of some parameters and characteristics of the environment. The precise estimation of the effects of a dam construction at the time of its design is almost impossible. There is a high level of uncertainty in terms of prognosis and the type of impact for different areas and the evolution in time of the negative effects.

2. Water Stratification

The evolution of the thermal structure of a reservoir is complex. In the case of a natural lake, the weather conditions are the major component of water stratification. In the case of a dam, the destabilization of water bodies caused by volume changes in inputs or withdrawals plays an important role. In the literature, the term *water stratification* is reduced to the *thermal approach*, although the same phenomenon also concerns dissolved oxygen.

2.1. Thermal Stratification of Water

Lakes are not just water tanks uniformly mixed. They are in fact highly dynamic systems, characterized by complex processes, and a variety of subsystems that vary seasonally and according to longer cycles. Stratification of lake water is due to variations in density, caused by temperature variations. The density of water increases with decreasing temperature and reaches a maximum at about 4°C. The result is a thermal stratification; distinct layers tend to be formed during the summer months, in deep lakes. Deep waters, remote from the sun and staying cool and denser, are forming a lower layer called the *hypolimnion*. Surface waters and coastal warmed by the sun, less dense, form a surface layer called the *epilimnion*. As the summer progresses the temperature difference between layers increases. A thin intermediate layer or *thermocline* is developing, which corresponds to a rapid thermal transition. The phenomenon of stratification of lake water can prevent the dispersion of effluents from the tributaries and thus increases the concentration of pollutants near the shore. The warmer *epilimnion* contains the greatest amount of living organisms of the lake. Algae production attains its maximum near the surface, or penetrates easily the sun. The surface layer is also oxygen-rich, element that comes from the atmosphere and mixes with the water. A second zone of high productivity is immediately above the *hypolimnion*, due to upward diffusion of nutrients. Moreover, the *hypolimnion*, while rich in nutrients, is less productive because it receives only a small amount of sunlight. In some areas it may be deficient in oxygen due to the decomposition of organic matter. At the end of the autumn, surface waters are warming, become denser and sink, displacing the deep water and causing mixing or renewal of deep water, causing the mixing or renewal of the lake water as a whole. In winter, the temperature of the entire lake is close to 4°C, while the surface water cools to the freezing point, and ice may appear. As the temperature and density of deep and shallow waters vary with spring warming, another water renewal can take place. However, in most cases, the lake water remains mixed throughout the winter.

3. Mitigation Solution for the Influence of Water Stratification Phenomenon in Lavaud Lake on Downstream Waters

Generally, the aim of operating a storage lake is to ensure the consumers water needs and/or to prevent the effects of drought or flood. In the case of Lavaud dam, located in the Department of Charente (France), it is necessary to take into account the phenomenon of water stratification for its operating system. This operation system is facilitated by the fact that the dam is provided by construction with three water intakes located at different levels.

Studies on water stratification, and thus on stratification of water dissolved chemical elements, are largely conditioned by the precise knowledge of the flow rates imposed by three openings of the dam. Similarly, temperature and, generally, the quality of water discharged into the lake can be verified only in terms of a precise knowledge of the flow discharged by three openings. The flow that passes downstream the Lavaud dam can be monitored *via* a single remotely located valve. In this situation there is no information on the flow distribution through the three openings, therefore, the operation of the dam, taking into account the phenomenon of stratification, is difficult.

A mitigation solution for downstream problems caused by water stratification consists of determining the following (problem solved by two specially designed computer programs):

i) the flow rates collected by the three openings, depending on the flow discharged through the bottom outlet, in order to provide solutions to the operational problems of the dam;

ii) the flow rates as well as the openings of the three valves, made under conditions imposed on quality of evacuated water.

3.1. Location and Specifications of the Dam

The dam is located in the Lavaud Department of Charente, at the birth of the Charente River. The dam has a capacity close to 10 million m^3. The structure of flow control device consists of an intake tower with three openings (including the bottom outlet) located at 220, 215 and 211 NGF, respectively. The openings sizes are: for the two at the top 0.80 m x 0.80 m, and 1.10 m × × 0.80 m for the bottom valve. The bottom outlet duct is common with the spillway. The drain flow and return flow are regulated by two separate valves: a valve covering the range of small flow: 50 L/s at 1 m m^3/s, and a valve covering the large flow: 800 L/s to 12 m^3/s.

3.2. Management of the Dam

The Lavaud dam (Fig. 1) stores water during winter. From spring till the end of the dry season, withdrawals are carried out to support the low flow of

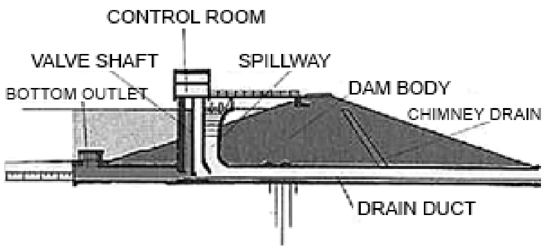

Fig. 1 – The Lavaud dam – cross section.

the Charente. For instance, in 1995, between July 20 and August 15, the highest rate of recorded withdrawals was of 2 m^3/s. The water level in the lake was at the lowest end in September. All that remains is about 2 million m^3. Depending on the year, the fill ends sooner or later, however, the observations made since 1991 indicate that in February, the bulk of the stock is almost entirely reconstituted. In late April, the dam reaches its maximum level, stabilized at around 224 m (NGF Level General of France).

a) *Dam management - imposed requirements*

During the filling period, the in stream flow will be in any case below the 1/10 of the annual average flow, or below 60 L/s or the sum of the flows entering the reservoir by Charente river and its tributaries, whichever is lower at 60 L/s.

The rate dropped from the bottom outlet or intermediate water intakes remains less than l2 m^3/s.

If no overflow discharge of the reservoir, the flow dropped on a given day may not be more than twice or less than 80% of flow released the previous day.

Conditions imposed on the setting up and operation of hydraulic dams are located and fitted out so as to reduce the disturbances caused to the river and surrounding environment.

Regarding Lake Lavaud, thanks to the studies undertaken by Christophe Guglielmin, the stratification of the water was established using an original method. The stratification for the year 1995 had the following development: June 1...June 22, no real stratification is recorded; June 29...July 12, stratification begins essentially with that of dissolved oxygen; July 20…August 23, stratification is well defined, corresponding to the warm period of the year; August 16...September 6, the studies indicate a good stratification of dissolved oxygen; the water withdrawal of August 30th indicates a return to original state in the intermediate zone reflecting the end of a state of stratification; September 13…September 27, these withdrawals characterize the absence of stratification. The stratification for year 1996 is similar.

The tracking method used to provide indications is fairly accurate but it has still significant inaccuracies since the inputs and outputs of water are not precisely known. The water inlets are positioned at levels corresponding to their density layers, carrying with them the surrounding water bodies. The water catchment mobilizes a horizontal layer of the reservoir whose height depends on the flow and thermal stratification.

To increase accuracy, *a method for calculating the flow rates* was required.

b) *The main physic-chemical parameters of water and classification of the lake*

Dam LAVAUD, like most reservoirs in temperate regions, is presumably of dimictic type. This means that it undergoes complete mixing in the fall and spring while it has stratification in summer and winter. The main indicators of water quality are: temperature, dissolved oxygen and percentage of saturated oxygen, pH, conductivity, total suspended solids (TSS) and total organic carbon (TOC); ammonium, nitrate and phosphate, the Kjeldahl Nitrogen, the BOD_5, COD and nitrite (Fig. 2). The maximum values of the main dissolved elements in Lavaud Lake are shown in Table 1.

Table 1

The Main Elements Dissolved in the Water Of Lavaud Lake with their Maximum Values, Recorded at Maximal Depths, Corresponding to the Water Discharge Level of 209 m

Element	1995 – Maximum concentration, [mg/L]	1996 – Maximum concentration, [mg/L]	Normal value mg/L
Total Fe (Fe^{2+}, Fe^{3+})	28.54	34.94	0.01...2.0
Mn^{2+}	4.25	6.77	0.01...2.2
Ortho P_3^-	0.5	0.67	0.01...14
NH_4^+	5.67	8	0.1...8
F^+	3.699	0.67	0...5
Cl^-	10.77	10.54	0.5...2
NO_2^-	0.81	0.46	0.1...2
NO_3^-	3.429	4.17	5...80
SO_4^{2-}	8.34	5.31	250

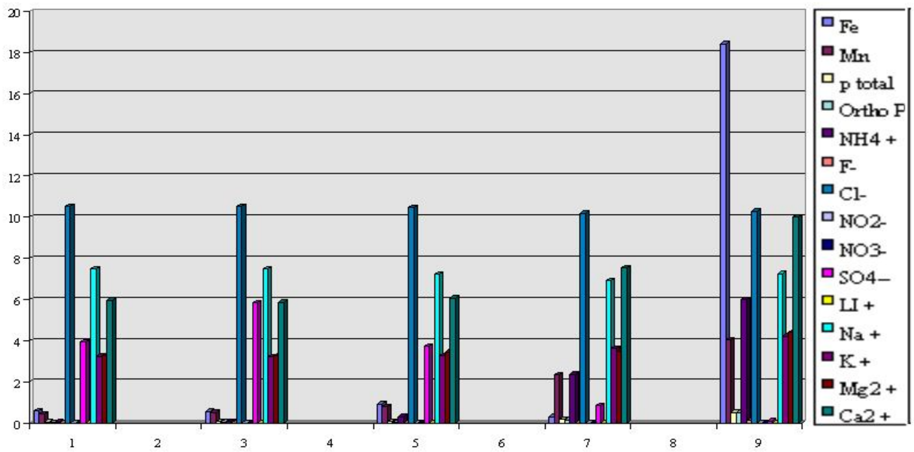

Fig. 2 – The evolution of dissolved elements in the Lavaud lake, 1996, [mg /L].

c) *Problems needed to be solved for Lavaud dam operating*

These problems have in view:

A – calculation of withdrawal rates;

B – minimization of pollutants dissolved in downstream water of a dam at an imposed temperature using Simplex method.

A. *Calculation of Withdrawal Rates*

In the case of Lavaud dam there is only one remote control valve to adjust flow rates and evacuated three water intakes located at different levels. To operate the dam taking into consideration the real stratification of water, it is necessary to know the three flow rates that pass through the openings in the situation in which the height of the openings and the value of evacuated flow is modified.

To solve this problem, we matched the expressions of flow rates that pass through the three openings, with the flow discharged through the bottom outlet, the charge for each opening being expressed in terms of the variable height of the water tower. Varying the height, at a given time, the equality of both terms of the relationship is obtained. In that moment, the appropriate values for the flows Q_1,..., Q_3 represent the flows are looking for

$$Q_{\text{bottom}} = Q_1(z) + Q_2(z) + Q_3(z), \tag{1}$$

or

$$\mu_{\text{fond}} b_{\text{fond}} h_{\text{fond}} \sqrt{2gz_{\text{fond}}} = \mu_1 b_1 h_1 \sqrt{2gz_1} + \mu_2 b_2 h_2 \sqrt{2gz_2} + \mu_3 b_3 h_3 \sqrt{2gz_3}, \tag{2}$$

where: b_i, h_i are the intakes openings; μ_1 – the flow coefficients, z_i – the variable loads + linear head-losses of the openings at a given time.

B. *Minimization of some pollutants dissolved in downstream water of a dam at an imposed temperature using Simplex method*

The operating conditions of the dam have been imposed in order to guarantee a minimum downstream flow, with respect to the quality parameters of the discharged water. The quality criteria imposed are often contradictory, because of the previously presented stratification phenomenon. For example, for a small concentration of iron dissolved in water, at the same time is required to avoid exceeding a maximum temperature for the downstream water in the river. Iron ion is found in small amounts on the surface of the lake, but the water is colder at the bottom of the lake where the iron concentration is maximal. Obviously, in this situation it is necessary to find an optimum which is framed within the imposed operating conditions.

Precisely, one must find the flow rates discharged by three (or two, in the last period of the summer) water intake openings, whilst the mixture meets these requirements. We solved this problem using the well known Simplex Optimization Methods.

4. Computer Programs for the Proposed Dams Management

To solve the first problem, the operation of the dam taking into account the real situation of water stratification, that is, to know the three flows that pass through the openings, the first computer program was designed. It calculates the flows that pass through the three openings of the tower, when one changes the water intake openings and the flows that pass through the bottom outlet. Normally, the values of the flow passing through each opening cannot be measured directly by remotely operating the bottom outlet.

The entering data are: the lake water surface lavel, the downstream flow, the height of the three openings.

The flow coefficients are considered as constants as in the code lines. For a better accuracy, their values should be verified by field measurements. As output data there were obtained the flow discharged by three (or two for low lake levels) openings.

The second program is a program that solves the problem of minimization of a certain pollutant, respecting the restrictions downstream the dam. The entering data are: water level in the lake, concentrations of the contaminant (*e.g.*, iron) in front of each opening, maximum values allowed for restriction (*e.g.*, the temperature downstream the dam).

As output data the program gives the flows that must be evacuated by the three (or two for low lake levels) openings and the minimum value of the pollutant resulted under the given conditions.

The code lines of the first program can be provided if required.

4.1. Some Results Regarding the Calculation of Flow Rates Running the Program No. 1

The program was run having as input data the flow rates evacuated by the bottom outlet during the summer of 1996. As there is no data on the dimensions of the openings for this period, several tests for different values of the openings were done. Subsequently diagrams of flow rates by three openings for the same opening of 10 cm for all outlets are presented. Note that the flow rates, which go through the catchment at the lower level, are increasing in the same time the discharged flow is higher, whilst the flows passing through outlet at a higher level is diminishing. The flow rates passing through the middle outlet remain almost constant, with a slight tendency of growing. It means that, in general, for the same opening of the catchment, mainly water at a lower level is discharged downstream the dam. That is, the quality of discharge water will be influenced by the quality of water in these layers.

The changing of the flow rates evacuated by three openings is more evident for flow rates larger than 0.5 m^3/s. At 1.35 m^3/s appears a delimitation of evacuated flows due to the too small openings of the catches. As the evacuated flow rates exceeded this value, in reality, it appears that the openings were larger.

Since running the program for openings of 0.2 m height, does not produce limitations of the withdrawal, we can say that such a situation may be similar to that existing in the summer of 1996.

Obviously an infinite number of combinations between the openings are possible, this mean that thanks to this program it is possible to know the real rates of water withdrawals, and the actual modeling of sedimentation can be possible. We recall that the results obtained using this program can become more precise if real values of the discharge coefficients are determined by direct measurements.

4.4. Some Results as Regards the Calculation of Flow Rates for a Requested Downstream Water Temperature of 15°C, and a Minimal Iron Concentration, with the Program no. 2

During the summer, the water user, situated downstream of the dam, requests that the water delivered by accumulation meet certain conditions. The most common requests are from the *Fishermen's Association* that relate especially to the temperature of water released from the lake.

A modeling for the months of July and August 1995 was carried out, for a required water temperature of 15°C, under the conditions of minimizing the total iron content. The requested flows comprised between 0.5 and 2 m^3/s. The program allows the processing of all values encountered in any real situation. Obviously, up to now, it was difficult to fulfill these demands especially since the flow discharged through each opening were unknown.

The program can be used for any demands since the optimized parameters can be modified at any demand. There are presented the data as a result of running the program, with the recommended flows and openings for the three water intakes of the tower. Regarding the year 1996, the data are more accurate, since the flows are known.

From the above, it is seen that problem of operating the lake so that its impact on existing wildlife downstream of the dam is minimal, can be solved using two computer programs. Note that starting from the adjusted value of total evacuated flow using the only remotely adjustable valve, the program No. 1 calculates the values of $Q_1,\ldots,Q_3$ flows passing through the three openings (*e.g.* of 0.1 m) of the dam's intake tower, at different elevations (Figs. 3,…, 5). This is very important because the pollutants concentration varies depending on depth, due to stratification of lake water. From Table 1 we see that at the lake bottom (209 m), the concentration of the pollutants is maximal. For example, Total Fe reaches a concentration of 34.94 mg/L, far exceeding the allowable value of 2 mg/L. As a logical consequence, one can improve the water quality discharged from the lake, if smaller flows are allowed to pass through the bottom opening, where the concentration of the pollutants is maximum. Similarly, the same can be said for another important environmental factor for wildlife that can be adjusted using the flow, namely the temperature of evacuated water. Lower values of the temperature ($12^o\ldots13^oC$) are also recorded at the lake bottom. The required optimal value for evacuated water is 15^oC, while minimizing the concentration of the pollutants. Achieving this minimum is possible using program No. 2. This gives the values of the required

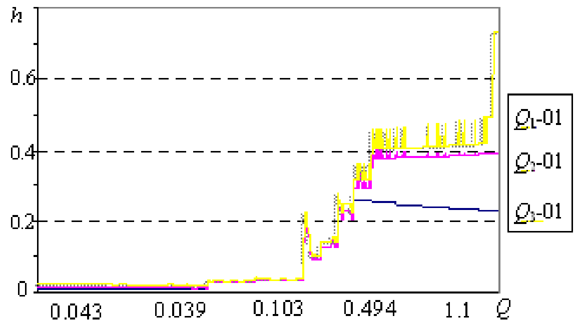

Fig. 3 – Graphic of flows, [m^3/h], passing through the three openings of the tower having h = 0.1 m, for a variable bottom flow (Summer 1996).

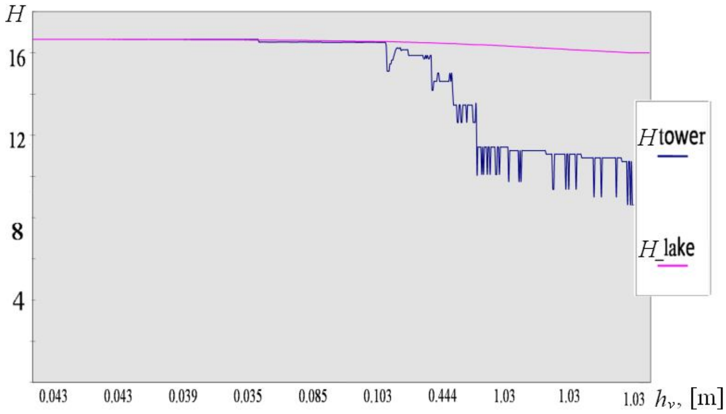

Fig. 4 – Levels in the lake (H, [m]) and in the tower for a 0.1 m opening of the catches

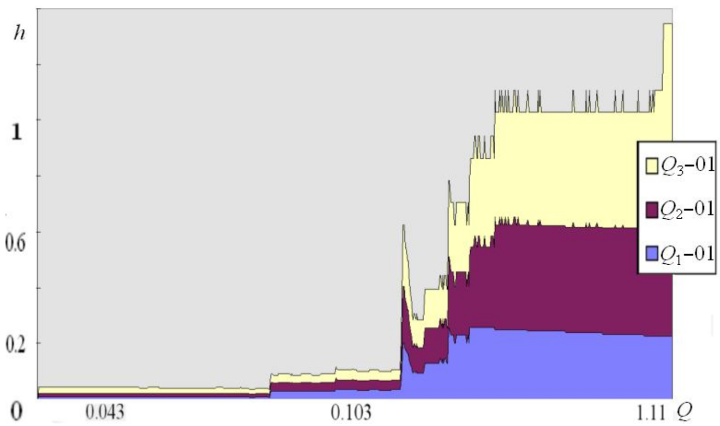

Fig. 5 – The flow (Q, [m^3/s]) distribution at a constant height of 0.10 m for each opening.

heights for the intake tower openings in July and August when stratification take place. Note that at the beginning of the period is recommended that the h_1 opening value (at the lake surface) should be maximum (about 0.25 m), and the bottom should be minimal (< 0.05 m), while the in the next period, there are no longer taken any flow through the top opening, since water level in the lake is below this elevation (Figs. 6 and 7), the height of other openings alternating

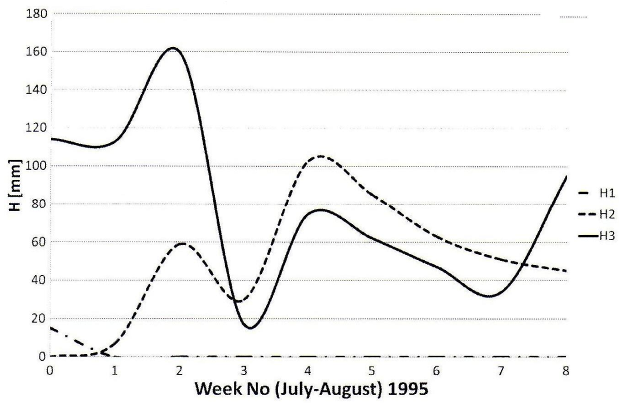

Fig. 6 – Graph of openings [m] calculated for a water demand of 15°C and minimum of total iron content (July – August, 1995).

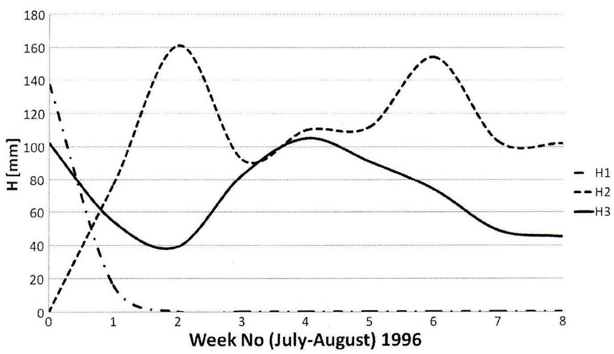

Fig. 7 – Graph of openings [m] calculated for a water demand of 15°C and minimum of total iron content (July – August, 1996).

depending on the month, in order to ensure the temperature criteria and a minimal for pollutants. The numerical values of the openings in the tower, as well as the values of pollutant element (Total Fe) for the studied two years (1995 and 1996) are presented in Tables 2 and 3. Note that the minimum concentration value achieved downstream the dam, using the proposed two programs, does not exceed the value of 20.33 in the most unfavourable month (August 1995), when the maximum concentration in the lake is 28.54 mg /L. Some measured data of the physical parameters of the lake in 1996 are graphical presented in Fig. 8.

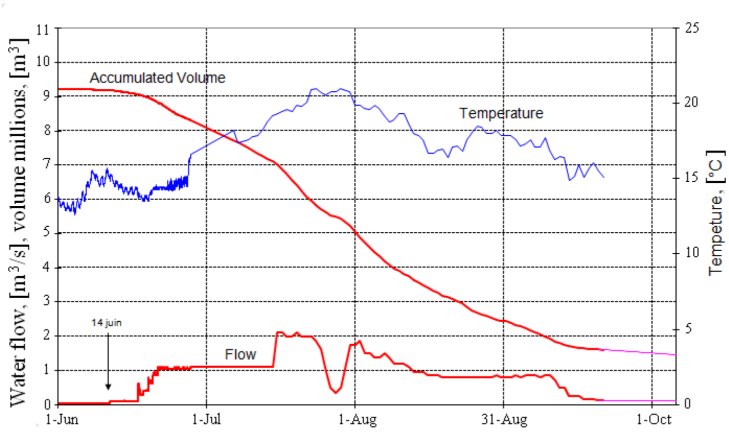

Fig. 8 – Flows, [m^3/s], and temperatures, [°C], recorded at the water surface level (summer 1996).

Table 2

Results Calculated for a Water Demand at 15℃ and Minimum Iron Content (July – August, 1995)

Date	Opening level, [m]	Lake level m	Q_t m^3/s	T °C	Total Fe mg/L	Fe min. mg/L	Q_1 m^3/s]	Q_2 m^3/s	Q_3 m^3/s	h_1 m	h_2 m	h_3 m
6.07	219	223	1	21.9	0.34	0.7	0.08			0.034		
	217			14.4	0.73			0.92			0.233	
	206.85			11.9	8.64				0			0
12.07	219	223	1	25.5	0.34	0.94	0			0		
	217			15.3	0.39			0.91			0.23	
	206.85			12	6.47				0.09			0.012
20.07	219	222	2	28	0.27	0.94	0			0		
	217			16.9	0.64			1.14			0.318	
	206.85			12.5	6.85				0.86			0.121
27.07	219	220	0.5	–	–	8.02	0			0		
	217			24.4	0.25			0.09			0.036	
	206.85			12.8	9.84				0.41			0.061
2.08	219	220	1.8	–	–	6.53	0			0		
	217			22.4	0.31			0.41			0.155	
	206.85			12.8	8.38				1.39			0.209
9.08	219	220	1.5	–	–	8.34	0			0		
	217			23.3	0.33			0.34			0.126	
	206.85			12.6	10.65				1.16			0.175
16.08	219	219	1	–	–	10.36	0			0		
	217			23.1	0.65			0.2			0.096	
	206.85			13	12.76				0.8			0.126
23.08	219	219	0.8	–	–	13.77	0			0		
	217			24.6	0.68			0.14			0.07	
	206.85			12.9	16.63				0.66			0.103
30.08	219	218	0.8	–	–	20.33	0			0		
	217			20.9	0.96			0.24			0.2	
	206.85			12.5	28.54				0.56			0.092

Since during that year the operation of the lake was done before the existence of these two programs, there was an attempt to comply with the temperature parameter by varying the discharged flow in the second half of July and early August. Note also that the operating period October – June is mainly used for recovery of the stock of accumulated water.

Table 3
Results Calculated for a Water Demand at 15°C and Minimum Iron Content (July – August, 1996)

Date	Opening level m	Lake level m	Q_t m^3/s	T °C	Total Fe mg/L	Fe min. mg/L	Q_1 m^3/s	Q_2 m^3/s	Q_3 m^3/s	h_1 m	h_2 m	h_3 m
2.07	219	222	1.11	20.4	0.13	1.6	0.46			0.272		
	217			19.4	0.58			0			0	
	206.85			11.2	2.63				0.65			0.091
9.07	219	222	1.11	18.8	0.16	5.74	0			0		
	217			18.4	0.32			0.59			0.164	
	206.85			11.2	11.8				0.52			0.074
16.07	219	221	2.12	23.4	0.08	6.62	0			0		
	217			18.9	0.15			1			0.318	
	206.85			11.5	12.43				1.12			0.162
23.07	219	221	1.99	24.5	0.24	9.05	0			0		
	217			23.1	0.26			0.58			0.183	
	206.85			11.7	12.63				1.41			0.205
30.07	219	220	1.74	23.5	0.16	12.42	0			0		
	217			22.7	0.64			0.56			0.212	
	206.85			11.3	18.08				1.18			0.177
6.08	219	219	1.37		–	13.63	0			0		
	217			22	0.43			0.46			0.221	
	206.85			11.5	20.23				0.91			0.143
13.08	219	218	0.943	–	–	14.24	0			0		
	217			20.2	0			0.36			0.302	
	206.85			11.8	23.3				0.58			0.095
20.08	219	218	0.783	–	–	16.79	0			0		
	217			23.3	0.62			0.24			0.199	
	206.85			11.4	23.8				0.55			0.089
27.08	219	217	0.783	–	–	12.04	0			0		
	217			20.2	0.59			0.28			0.2	
	206.85			12.1	18.42				0.5			0.086

5. Conclusions

Among the various impacts on the environment produced by artificial lakes is water stratification. It occurs mainly during summer, and as result, the chemical and physical structure of the lake water and of the downstream water as well, is modified. Also, the temperature of the downstream water varies as compared to the natural status. This may have impact for the existing wild life in the river.

We are proposing a solution for minimizing the effect of water stratification consisting of an operating method based on the use of two special conceived programs. Although the solution was proposed particularly for Lavaud dam in France (within the framework of a joined EU program) this specially designed software package may be used for any similar artificial lakes.

The use of these two programs made possible an environmental friendly way of management for the Lavaud dam.

The first program within this package makes possible an accurate application of the water stratification modeled for Lavaud dam because it provides the real values of the flow rates at each opening.

The second program enables the management of water quality downstream the Lavaud dam, as a response to a corresponding request.

The examples of running the programs allow the reconstruction of the real cases of dam operating during the years 1995 and 1996. This facilitates eventual calibrations of the programs by tuning the flow coefficients to match the already measured data.

The use of these two programs should be interactive, based on real field-data. Running the programs for real situations *prior* to1995 is not possible due to the lack of data.

Graphics of the variation of the dissolved chemicals and water temperature in the lake and downstream the lake are also presented.

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REDUCEREA IMPACTULUI BRAJULUI LAVAUD ASUPRA CURSULUI DE APĂ DIN AVAL, PRIN MODIFICAREA EXPLOATĂRII BARAJULUI

(Rezumat)

Construcţiile realizate de catre om exercită o mare influenţă asupra mediului înconjurător. Printre aceste construcţii se numără şi barajele, care creează în amonte

acumulări uriaşe de apă. Impactul acestor construcții asupra mediului poate fi fizic sau chimic. Se prezintă unele din cele mai importante modificări ale mediului înconjurător cauzate de construcția barajelor.

Dacă ne referim în special la lacurile de acumulare, fenomenul cel mai frecvent care apare, în principal, în timpul verii, este stratificarea apei, şi ca urmare, modificarea structurii chimice şi fizice a cursului de apă natural.

Temperatura apei din aval variază față de starea naturală, în plus, substanțele chimice dizolvate în apă variază în acelaşi mod. Acest lucru poate avea un impact negativ asupra viețuitoarelor din mediul acvatic.

Se propune o soluție de atenuare a acestui fenomen, precum şi un program de calculator pentru controlul deschiderii evacuatorilor unui baraj, în scopul de a minimiza efectul de stratificare al apei. Această soluție de atenuare a fost propusă pentru barajul Lavaud, Franța (în cadrul unui program de cooperare european). Sunt prezentate de asemenea, grafice de variație ale substanțelor chimice dizolvate precum şi ale temperaturii apei din lac şi din aval de acesta.

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RESTORATION OF A LANDFILL. A CASE STUDY: ANTON LANDFILL IN BELGIUM

BY

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Abstract. In this paper are described and motivated the necessary interventions on a landfill in the province of Namur, Belgium. The reason is that wastes, mainly from the city of Brussels, was deposited directly on rock without ensuring proper sealing at the dump base and side and without any special precautions. Serious risk of explosion caused by methane produced by decomposing waste, many questions about the stability of the dump itself, and significant cracks in the underlying rock unable to prevent leachates from seeping into the Black Lake and from there into Meuse River, increased the danger of the situation, not only in terms of the environment, but also with regard to public health.

Key words: landfill; engineering works; safety; environmental.

1. Introduction

Waste management comprises the set of activities, measures and regulations on waste, including those pertaining to the waste impact on the environment and related economic issues (Cismaru & Gabor, 2004). The

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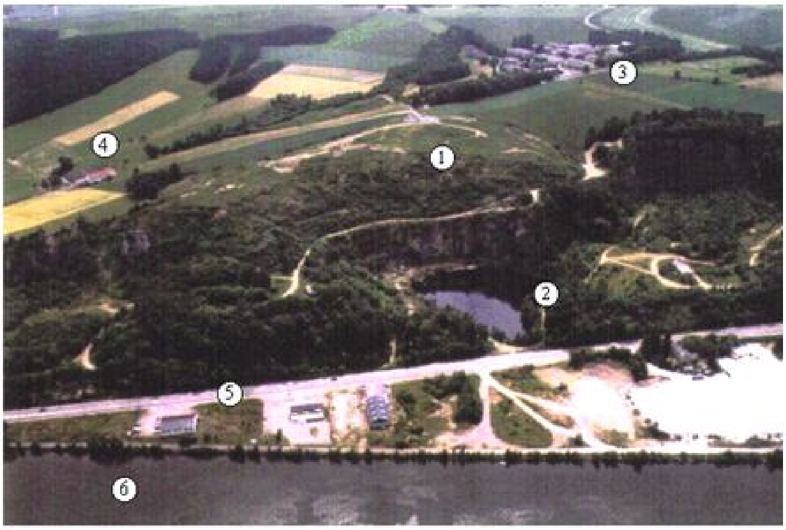
domestic dump is very heterogeneous, its composition showing significant variation from one locality to another, subject to season, urban development and civilization degree, living standard, food profile.

One of the general objectives of waste management is storing it in environmentally friendly landfills (only the post-treatment waste). Another important objective is monitoring the existing landfills (considered as unmonitored repositories) that were instated long time ago, looking out for maintaining their safety (Găzdaru, 2002; Wehry & Orlescu, 2000).

2. Analysed Location

The Anton landfill is located in Namur province, Commune of Andenne, Bonneville area, South from the national route 90, between Huy and Namur (Belgium). The waste dump fills in the two cavities of a former chalk quarry, existing on the hill side, outside the city of Meuse (Fig. 1).



1. Anton landfill.	4. Farm Ansias.
2. Black Lake.	5. Highway $N^0$90.
3. Institute Saint-Lambert.	6. Meuse River.

Fig. 1 – Aerial view of the Anton landfill *prior* to the implementation of the biogas production network.

Around 1 million m^2 of domestic waste and dredging mud were stored there between 1981 and 1985. The dump of about 30…40 m height lies on a surface of approximately 5 ha. On the North side it forms a 30…40 m height self-standing ramp above a shore. At its base, there is a lake with a surface of 0.6 ha and a 50,000 m^2 volume. For fifteen years, this lake has been collecting the discharges and overflows of waste leachates seeping through the multiple cracks of the chalk rock.

A downflow system implemented ever since the quarry exploitation was active, maintains an almost constant water level, regardless of the climate conditions. This actually means that all the leachates get into Meuse River.

3. Reason for the Analysis Performed

Anton dump (Fig. 2) – the former Moreau quarry – appeared in 1981, when the site was initially exploited for the storage of municipal solid waste of Andenne city and the dredging mud remaining after a dam construction over the Meuse river. Its increase accelerated starting from July 1983, after the exploitation permit was granted by the permanent delegation of Namur province.

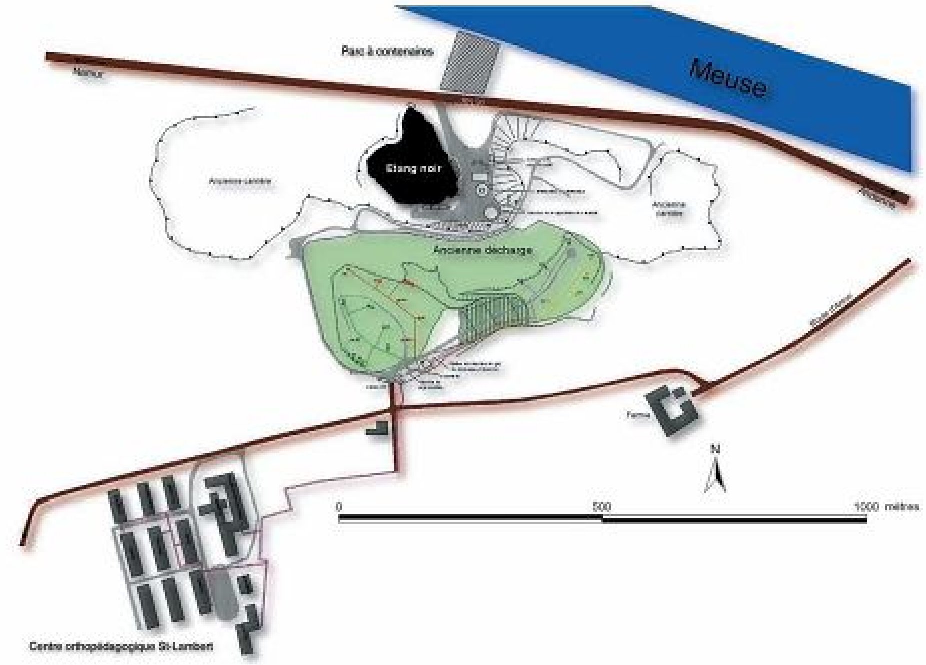


Fig. 2 – Current map of the Anton waste repository.

This permit enabled the discharge area expansion and mainly to imbed the domestic waste except for toxic waste. This permit was also a granted subject to strict requirements, provided that a proper sealing should be made at the dump base and sides. It appears that none of these requirements was met (www.spaque.be).

The waste coming mainly from the congested city of Brussels was discharged even directly on the rock without any precautionary measures. At the end, the dump was covered by a layer of muddy rocky ground, which was permeable and less than a meter thick.

In a few years Anton site became a real pollution hot spot, affecting the air, underground water and surface water beneath the dump.

The high risk of explosion caused by the methane produced by the decomposition of waste, the concern weather the dump was sufficiently stable, as well as the significant cracks in the underlying rock, unable to prevent leachates from seeping into the water, increased the danger of this situation, non only for the environment but also for the public health.

Starting from 1991, following the many awareness campaigns, the Minister of Environment for the Walloon region authorized Spaque company to research on the site and take the necessary emergency measures (www.spaque.be).

In 1992, after the research was published, Anton dump was classified as one of the four priority sites that needed restoration, along with Mellery, Florzé and Cronfestu.

One of the first emergency measures consisted in conducting an additional hydrologic analysis in order to assess the pollution risks following the discharge caused by supply wells in the drinkable water of Saint-Lambert Institute, located at less than 300 m upstream the site. Many marking tests and a long-term pumping test support the fact that there was no contamination of the underground water serving this facility.

At the beginning of 1993, a measuring drill with a capacity of 250 m^2/h was installed at the front of the dump in view of burning the biogas which was already temporarily collected, and also in order to make an estimate of the biogas resource available.

This initial system shortly proved to be unable to absorb all the gas seeps. That is why by the end of 1995, new works started for completing and improving the network for Anton dump degasification. The many civil engineering operations aimed to set up a more adaptable structure that should facilitate the rain water flow (Recycling International, 2011; www.spaque.be).

At the end of the second stage of works, a 500 m^2/h drill was set up in December 1996. This new equipment worked continuously for two years and a half, when various analyses were made to assess the potential for biogas production and modification of specifications, in order to enable the use of its energetic value.

In February 1999 a call for tender was issued at European level, for making a valuable use of the biogas energy, using the cogeneration principle. A cogeneration module made up of an electric generator set and a heat recovery system was installed on the site and brought into service by the end of September 1999. From that moment on, the electricity produced from the biogas contained by the Anton dump was partially used for self-supply, and the remaining part was injected in the public network of Liège Electricity Association (ALE).

A new biogas extraction system and a higher-capacity drill replaced the previous ones, in order to improve extraction and exhaust of gas seeps.

In 2000, preliminary works were developed to prevent the leachates seepage and to restore the area designated for the waste water treatment plants. A thermal energy equipment was set up inside the dump, consisting of an embedded piping network and a central heating station, supplying Saint-Lambert Institute with hot water, as produced by recovering the heat from exhausted gas and cooling of the cogeneration module (Environment & Technique, 2011; www.spaque.be).

The next stages of the restoration, planned for 2001, were building and bringing into service of the equipments for leachates treatment and draining of the lake water, still a hostile environment for any life form.

4. Presentation of Measures/Actions Proposed for the Restoration

4.1. Biogas Extraction and Use

The biogas extraction network (Fig. 3) includes a set of 5 aerial collectors, connected to:

a) 17 degasification wells, each of 1 m diameter, drilled in the waste mass at an average depth of 26 m;

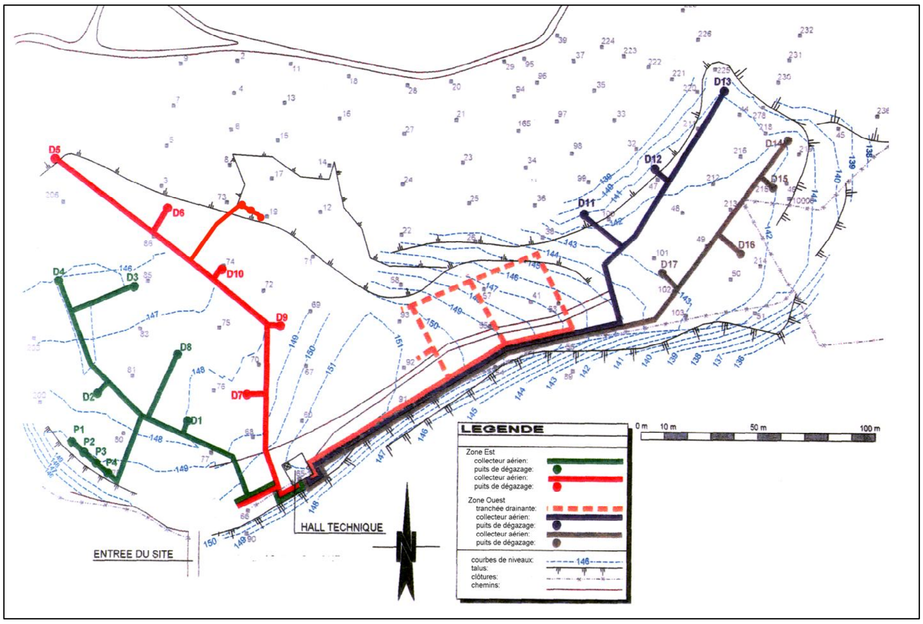


Fig. 3 – Map of the biogas extraction network at Anton dump.

b) 3 surface drains, installed in an area where the waste depth is lower (5…8 m);

c) 4 micro-wells for biogas extraction;

d) 3 existing natural manholes.

To maintain the network efficiency certain wells were provided with pumps enabling the leachates exhaust. Actually leachate accumulation in the wells reduces the available heating value of wells, and, subsequently, their effectiveness in extracting the biogas.

This biogas is collected and transported through the cogeneration module by using two gas turbines able to create over 100 mbar depression into the network, and thus intake the waste- generated biogas (Figs. 4 and 5). By the end of 1999, the gas quantity recovered was estimated at about 400 N.m^3/h, with a methane concentration between 40% and 45%.

Fig. 4 – The cogeneration system: inside view.

Fig. 5 – The cogeneration system: outside view.

Most part of this volume is burnt in an engine with a rated capacity of 1,280 kW; that means it is capable to absorb up to 320 m^3/h of biogas, producing heat and electric energy. The alternator causing the drive shaft to spin enables to produce 470 kW electric energy. After using approximately 85% of it to fuel various existing systems on site, the energy is resold to ALE and redistributed through the network. A double heat exchanger installed on the engine cooling circuit, above the exhaust gas portal, enables to retrieve 620 kW energy, as calories.

These volumes are distributed by an embedded pipe network to the SPAQuE offices onsite, as well as to the 9 main facilities of Saint-Lambert Institute, located at less than 300 m distance from the dump. Here, a second series of heat exchangers enables to use the energy for heating the facilities or for producing sanitary hot water for showering and washing purposes.

This device represents an investment of approximately 300,000 € and enables to significantly reduce the heating cost for Saint-Lambert Institute. According to the latest estimate, in the next ten years, this project will cover up to 75% of the forecast heating needs and 100% of the sanitary water need. Moreover, it represents a unique pilot experience, as nowhere else in Wallonia was the waste generated biogas used to simultaneously produce heat and electric energy.

Overall, around 146 million m^2 of biogas have been exhausted by the domestic waste from the dump. Unfortunately, the most part of the biogas volatilized over the first years of the dump existence. Still, there is a volume of 20 million m^2 of biogas available to be recovered and properly used over the next fifteen years. Therefore, this type of restoration needs effective long-term management.

4.2. Leachates Extraction and Treatment

With regard to the waters, much effort has been made on analysis and testing. Nineteen piezometers were drilled and many analysis campaigns have been performed; all of them proved the advanced degree of pollution caused by Anton dump.

The leachates continue to permeate at a speed of 2…5 m^3/h. At a very high level they still contain significant organic loads, exceeding 2,000 … 3,000 mg DCO/L. Less than 10% of them are biodegradable, as the BOD/COD (biological/ chemical oxygen demand) report was not in favour of implementing the biological treatment procedure. Similarly to other old dumps, this is caused by the overload of humiferous compounds (humic and fulvic acids) existing in leachates. The typical brown colour of the latter is a more than clear indicator.

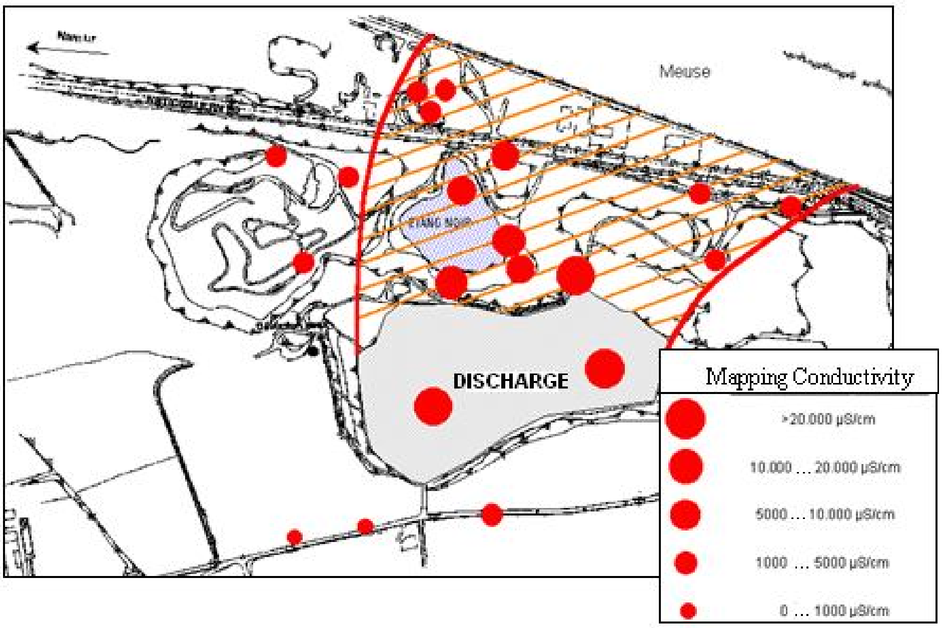


Fig. 6 – Conductivity map – pollution spread.

Another important element – the leachates taken from the core of domestic waste have a strong ammoniacal nitrogen concentration. At Anton, this can reach 1 … 2 g/L. In an unusual way, the waters around the cliff very often have concentrations of nitric azote, thus revealing an intense nitrification. When reaching the Black Lake, these effluents are extremely diluted and mix up with the underground and rain waters, so that DCO does not reach an average of 700 mg O_2/L, having a 150 mg N/L ammoniacal nitrogen concentration.

The underground waters are obviously polluted by the waters discharged from the dump, as proven by the tests made on the upstream wells (Fig. 6). However, the pollution hot spot has a limited area, and is spreading neither to the West nor to the East, being confined to the areas underneath the dump. The discharge of this water is following entirely N-NE direction before discharging into the underground waters of Meuse, which is the natural discharge.

It is worth mentioning that no pollution of underground waters was noticed upstream the dump. A long-term pumping test made on a drinkable water supply well of Saint-Lambert Institute did not reveal any inversion of the piezometric gradient; on the contrary, it tends to discharge the polluted waters towards Meuse. In this case we witness a progressive dilution of polluting waste, as those are getting near the river, thanks to their mixing up with these waters that are always in a higher proportion compared to polluted underground waters.

Fig. 7 – Raw leachates treatment station – aerial view.

At the end, two types of waste waters need to be treated: the black lake waters on the one hand, and the raw leachates generated by the dump on the other hand. Both contain a significant organic load, resistant to any type of biodegradation, showing an intensely brown colour and a high content of ammoniacal nitrogen; the first type of waters are two or three times more diluted than the latter.

Another difference is that the treatment for the black lake waters can be on a short-term, aiming to drain 50,000 m^2 of waters. On the contrary, the raw leachates are relatively permanent, calling for the implementation of a treatment station that will need to function in the next fifteen – twenty years.

Raw leachates treatment implies two stages namely

a) A biological nitrification/denitrification stage by using a membrane bioreactor, designed to reduce the significant azote concentration in the dump discharge.

b) A physical-chemical stage, by means of two absorption columns with active carbon filter, in order to remove the resistant DCO, responsible for the strong colouring of waters.

Treatment of the black lake waters is calculated on the same principle as the physical-chemical treatment of leachates (Fig. 7), taking into account also that the two active carbon columns are protected by sand filters, to prevent clogging.

4.3. Ensuring the Ramp Stability

A network of over 120 hubs and two drift indicators were placed inside the dump in order to assess the risks for waste runoff towards Meuse.

Ground surveys initially made on a monthly basis, and currently resumed every six months, revealed valuable information about the waste settling dynamics, but also on the ramp stability and safety.

Subsequently, a landfall towards Meuse is very unlikely; most of the waste mass, spread on approximately 40 m distance, does not show any signs of horizontal movements. Only insignificant low-intensity movements have been recorded; these do not exceed 1.20 m in 15 years, until the end of the dump exploitation. It is important to ensure that these movements will continue to be isolated and occur exclusively on the waste surface layer.

Quite the opposite, the settlings are far more important. These record an average velocity of 1.5 cm per year / m of waste and their levels are far from being constant, as confirmed by the iso-settling curves displayed in Fig. 8. This phenomenon is extremely noticeable in certain areas of the dump, as the variable settling levels have created some cracks through which biogas is often exhausted.

To avoid such seeps affecting the air quality and the degasification network performance, the compacting and sealing of cracks are performed on a permanent basis by using waterproof argyle, such as betonite.

These settlings, that can reach 40% of the initial waste depth in certain areas during the dump existence, show a decreasing speed over time. This slowing down will accelerate the dump maturation degree, as the waste gets into a progressive stabilization state.

In 2004 and 2005 several measurements were made every three months on the hubs placed onsite for the settlings monitoring.

The data enabled to make some forecasts, using various settling estimation methods.

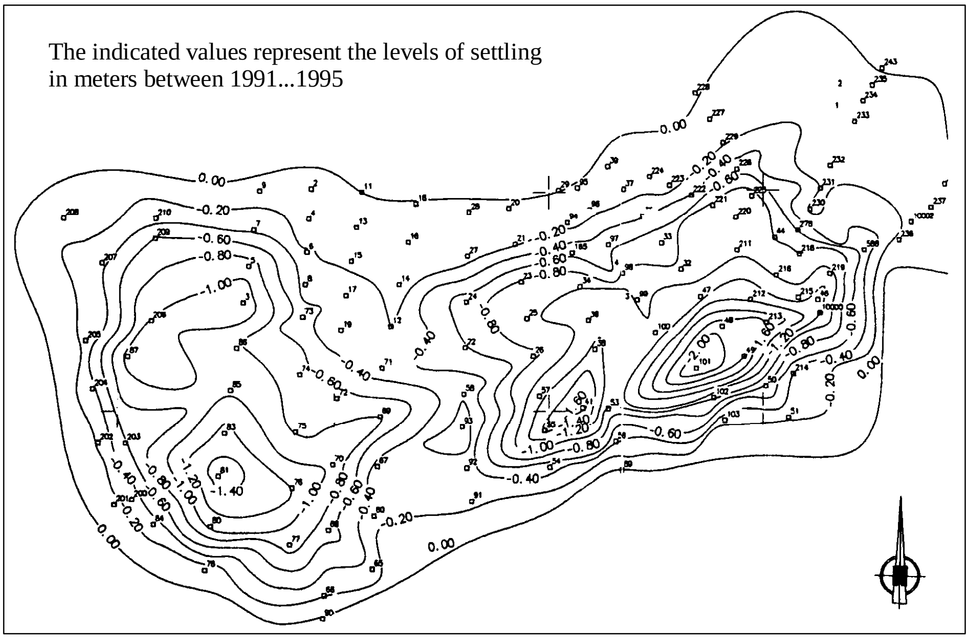


Fig. 8 – Variation of waste settling at Anton dump between 1991…1995.

5. Conclusions

The measures proposed for the restoration of Anton landfill (Fig. 9) aimed to protect the environment by the following proceedings: building and bringing into service of the equipment necessary for leachates treatment and draining of the lake water, still inadequate for any life form; biogas extraction and proper use; ensuring the ramp stability.

The degasification network installation required expenses of approximately 750,000 €, representing less than a half of the amount necessary for large diameter well drilling. Another 500,000 € were necessary to perform the site leveling works (reconstruction of the surface shapes).

Approximately 1 million € were also necessary to supply and install the technical systems such as drills, cogeneration module, heat distribution network and automated (remote) system for biogas extraction management.

The remaining amount was used for funding many analyses and works performed onsite, and for monitoring the discharge (checking the ramp stability and water quality, monitoring the settlings, testing the biogas and smoke emissions).

One last installation of almost 2 million € is necessary in order to ensure the leachates treatment and black lake waters draining.

The total value of analyses, works and investments achieved at Anton dump was estimated to around 5 million €.

Fig. 9 – Current aerial view of Anton landfill.

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REABILITAREA UNUI DEPOZIT DE DEŞEURI. STUDIU DE CAZ: DEPOZITUL ANTON DIN BELGIA

(Rezumat)

Sunt descrise şi motivate intervenţiile ce au fost necesare pe un depozit de deşeuri din provincia Namur, Belgia. Justificarea constă în faptul că deşeurile, provenind în principal din aglomeraţia oraşului Bruxelles, au fost depozitate direct pe rocă fără a asigura o etanşeitate adecvată la baza şi pe lateralele haldei, şi fără nici o altă măsură de precauţie specială.

Riscurile grave de explozie cauzate de metanul produs prin descompunerea deşeurilor, numeroasele semne de întrebare legate de stabilitatea haldei în sine, precum şi fisurile semnificative ale rocii subiacente, incapabile să rețină levigatele ce se infiltrează in iazul „Etang Noir” (Lacul Negru) şi de acolo mai departe spre râul Meuse, sporeau periculozitatea situației, nu numai din punct de vedere al mediului, ci şi în ceea ce priveşte sănătatea publică.

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ON THE CONCEPTS OF RIVERS ARRANGEMENTS TO FLOODS

BY

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Abstract. In the first part of the paper are presented some European and national principles on the arrangement of the water courses to the flood, for allowance their destructive effects.

There are presented and analysed the previous and new concepts of rivers arrangement, with examples on hydrotechnical arrangement from Banat catchment area.

In this paper the need to introduce the concept of "efficiency of new solutions in time" is emphasized. By monitoring the behavior in time of these works, can be appreciated their implementation opportunity, both from technical and economical points of view.

Are taking into account, both the big/medium catchments with high degree of the arrangement and small catchments.

In the final part of the paper is presented a case study regarding Bega River arrangement to decrease the destructive effect to floods, with presentation of the current situations and proposed works (regulation and damming of the Bega River and its tributaries).

The paper finishes with the discussion and conclusions on the approach mode of some arrangements, by transition from current state (previous concept of arrangement) to the proposed (new concepts).

Key words: aquatic biodiversity; dessattenuation; discharge; flood; wetland.

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1. Introduction

Social and political conflicts have occurred in many parts of the world due to the lack of access to drinking water for more than 1.1 million people, to the lack of access to safe sanitation systems to more than 2.4 million and to constant degradation of aquatic ecosystems. In the 21st century is a major challenge for the international community to apply the principles of sustainable development, the equity and the democratic governance in water management and the scientific community should participate in this debate, with experts from various fields.

Throughout the 20th century, the principle of nature domination has led to a productive approach of water management. For surface water, the main strategies based on providing water supply from public money to finance large hydroenergetic constructions led to an inappropriate use of resources.

It is necessary that the "precautionary principle" should be introduced in practice as all elements generating the crisis mentioned before, are supplemented with "climate change" that will likely increase pressure on water resources. Special attention should be given to the choice and implementation of rehabilitation strategies of normal ecological status of aquatic ecosystems as an alternative to traditional solutions of large hydraulic building constructions.

Floods are natural phenomena that have been marking the development of human society, being the most geographically widespread disasters around the world and also the largest producer of damage and casualties.

Over time mankind has tried to fight these relentless natural phenomena throughout various means. As the technological process progressed, new methods and ways to fight floods have been found. Until the late twentieth century the most appropriate ways of combating floods seemed to be the hydro-technical structures.

Negative consequences that these constructions had on river flows, as well as the changing modality of floods production, have led to the development of new planning concepts of facilitating the rivers, and they will be analysed in this paper.

2. Material and Methods

2.1. Old Concepts of Facilitating Rivers

Hydraulic structures including barrages – reservoirs, dams, derivatives, etc., are works that can run both for the use of water resources for various purposes, but also to combat the destructive effects of water. By achieving this purpose it is aimed at the use of water for: drinking and industrial water supply, electric energy production, irrigation, flood mitigation, defense works and drainage water, transport development, fishing and water sports, improving microclimate and environment.

The existent papers in speciality literature are used in singular goal (meeting a goal) and complex/multiple (to satisfy many uses and objectives).

The first attempts of devising overall hydraulic works were projected and prepared with by different Romanian engineers with their own measures. Among these can be mentioned the studies for damming the Danube floodplain by Professor Anghel Saligny and studies of a masterly channel from Siret for the irrigation of Bărăgan by Professor Alexandru Davidescu. Although these studies did not deal with the overall problem of river basins by the size of studied territories and the complexity of the issues addressed, they exceeded the projects, covering the solving of local problems.

After the Second World War it was initiated the National Electrification Development Plan of the country. The Plan reviewed all types of power plants, but paid a particular attention to hydroelectric plants. In developing the hydro energetic part of the electrification plan, the most qualified professionals in Romania participated. The objective of the plan was the electrification, and so, the development of water resources for multiple purposes was not systematically taken into account. However, for some projects included in the electrification plan, other advantages of the arrangement were highlighted.

In the period 1959...1962 there were developed river basin management plans and the layout of Waters in Romania.

Content standards have ensured the development of various plans on hydrographic basins, so that a summary of the provisions of the plan per country could be made.

From the methodological point of view the most important advances were:

a) Calculations of water management in which methods for determining the water requirement were established, especially water for irrigation taking into account climatic conditions. Further methods of calculating the balance between water availability and requirements settled, the results were then interpreted and statistically required, volumes reservoirs were determined. Mathematical models were developed for water management calculations and electronic computers were employed. With that end in view, the computers from the Institute of Atomic Physics were used, electronic computers first made in Romania and in fact the only existing in the country at that time. In 1960 the use of electronic computers was generally at an early stage in most countries. Romania was the first country to regulate the use of mathematical models as a standard method applicable in all water management studies.

b) Economic efficiency calculation in which a methodology to determine the ratio of the cost of the water and the benefits realized was the basic criterion for selection and timing of the water works. An objective economic criterion was needed to eliminate arbitrary political decisions in choosing the constructions.

The national planning of water management was to be a synthesis of river basin development plans, analysing links between their proposals and developing a general program for water management measures.

The development plan included proposals to achieve a series of works, mainly about water management namely

a) reservoirs leading to a redistribution of water resources in time, retaining excess of water during rainy periods, to supplement flows during dry periods;

b) derivatives that modify the territorial distribution of water resources by transferring flows from water-rich areas to the poorer ones.

For protection against flooding, the development plan envisaged a series of works of embankment correlated with lakes to retain flood flows and, in some cases, derivatives that could lead flood flows in areas that do not cause damage. Furthermore, the plan aimed systematic arrangement of floodplains, avoiding the placement of important objectives in areas that could be affected by flood waves. Finally, although at that time there was not yet a highly developed economy, the development plan envisaged measures to protect water quality through both treatment plants and the rational placement of economic objectives, which enabled successive use of water resources to multiple employments (River Basin Management Plans – National Report, 2004).

In 1975 instead of an update of the National Plan it was preferred the development of "framework schemes of watershed". The difference is not just the title. Management plans were seen as an instrument of state policy underlying the water management that does not relate to the actions of a single department, but to include all branches of the national economy which had interests in water use by analysing correlations between them and the actions of coordination necessary for coherent development. In contrast, the schemes of arrangement had a much more limited purpose, to develop an investment plan for the National Water Council. Replacing the National Plan with the framework schemes was a major step back from the previous period. This measure emphasized the investments extent, but minimized other water management activities. This view has been proved disastrous in 1989 when the investments were practically ceased.

The concept of framework schemes provided to the water management a passive role, to respond to economic demands of different industries, but eliminating any tendency to show other branches the measures that can lead to a rational water management. Concepts related to systematization of floodplains, rational use of land, the creation of protection zones around lakes, to reserving sites, were abandoned. As a result, industrial objectives and new districts of the city were located in floodplains, works hard to protect by embankment. Water quality was neglected because treatment plants were the responsibility of different ministries, which were considered of secondary importance being unproductive. Saving water, which was a priority regarding the geographic situation of the country in the management plan, was not considered.

One area consistently hampered was the management of water quality. Unlike the period of development plans of drafting from 1959...1962, the rapid industrial development, unaccompanied by a corresponding development of waste water treatment plants or other water quality protection measures, resulted in an alarming increase of watercourses pollution (Plan of Water Arrangement, 1962).

Immediately after 1989, all water management works were stopped. Some of them were resumed and completed in the coming years, many of them were never completed. In planning, it justifies the resumption of development plans, under which it ought to define the role of various units in achieving effective water management.

Thus, in planning water management it was maintained the concept of planning framework schemes that limited studies to analyse the investments. Thus, the Water Law approved on September 25, 1996 also included a number of specific elements of a central planned economy but incompatible with a market economy.

2.2 Banat Hydrotehnical Arrangements

Hydraulic works started in Banat during the first half of the eighteenth century and continued throughout the next century, intended to maintain free navigation of water courses by recovering and protecting agricultural land from frequent floods.

The Banat hydrographical network is very extensive, comprising in addition to big rivers: Danube, Tisa and Mureş which were natural borders of the province, the internal secondary rivers Timiş Bega Aranca, Birda, Bârzava, Caraş and Nera, many of them with navigation possibilities. The density of watercourses, their sinuous beds, slow water flow in plains area, frequent rains and heavy snow in mountainous areas bordering the river which formed the rivers collecting basin, made the waters flow frequently from their channel and flood large areas.

Besides the four large wetlands along the rivers Mureş, Bega, Timiş, Bârzava and Pogăniş there were swamp terrains. Their surfaces extended especially during rainy seasons, covering large agricultural areas with water, making land cultivation considerably difficult.

The history of Banat hydrotechnical networks of arrangement executed during the eighteenth century and nineteenth century distinguished three main stages namely

1. The first stage includes major works performed during the eighteenth century and early nineteenth century, when most constructions were performed under the guidance of funds and central authorities from Vienna.

2. The second stage corresponds to the works performed during the nineteenth century after the revolution of 1848-1849 and to the establishment, in 1871, of the “Society for Timiş-Bega Waters Regularization”

3. The third phase includes the activity of this society until 1912, when major works were carried out.

The first stage includes drainage works and dams – shaping the river's hydrographical network. The second stage includes navigation improvement and transforming Bega in a navigable thoroughfare and the third stage, the consolidation and strengthening of dams built in Banat.

2.3. New Concepts in River Planning

The new concept in river planning is based on sustainable development principles deriving from the idea that "water is a legacy which needs to be protected, preserved and treated as such". The Water Framework Directive and the Directive on Flood Risk Assessment and Management promotes a new concept in river planning, its main objectives being flood risk reduction and conservation of aquatic biodiversity.

The new planning strategy starts from the idea that rivers and their corridors form complex ecosystems which include the adjacent land, flora, fauna and the waterways. These ecosystems rely on the behaviour of watercourses for which the discharge, sediment transport, water temperature and other variables have a well-defined role. In the event these variables change compared to the natural existing values, the balance is disturbed. This is why river development through engineering works should aim to maintain the global dynamic balance of watercourses in time and space.

The damming of watercourses on long river sections has led not only to a decrease in aquatic biodiversity but also to the dessattenuation of peak discharge. Moreover, changes in climate will cause an increase of water levels over time which will lead to the need for dams to be over raised. The constant increase of the water level will raise the pressure exercised on dams, and the frequency in generating gaps, also, the risk of flooding.

Depending on intervention methods, the planning measures distinguish themselves as being structural and non-structural.

The structural planning measures are as follows: repositioning the embankments; reopening meanders, restoring the natural course for regularization riverbeds, creating buffer zones, wetland development.

a.1) Embankments are structural measures taken for flood protection implemented in accordance with the old concepts of defence against flooding. Any embankment produces a change in the natural flow regime of a water body. In addition to the positive effects it has on flood protection and damage decrease, embankments also cause negative effects such as a swirl on the upstream region creating a growth in levels and flow rates, an increased speed in flood waves translation, a modified behaviour of the solid river flow, but also changes in the structure and the lithology texture of the main riverbed, the specific soil, flora and fauna.

It has been concluded that in addition to the flood dessattenuation effect of the dams, there is also a longitudinal barrier to be added within the ecosystems with the purpose to modify them.

In case of continuous lines of flood protection, in case of river sectors constrained by embankments, restoring the old route plan features of a body of water is considered necessary, especially in the case of high water.

a.2) The reopening of meanders is practised in order to bring a body of water that has been modified by cutting one or more meanders with the purpose of regulating the bed to the best state possible, provided the old meandering river beds have been preserved (Fig. 1). The aim of such a measure is to restore the minor riverbed, replenish the aquifers in the major bed and reduce the stream velocity in the minor riverbed.

Fig. 1 – Banat map 1723-1725 – Dry marsh , Ilandza and Alibunar
(Archive: Banat Water Basin Administration).

a.3) Restoring natural course in the case of recalibrated and rectified riverbeds. The recalibration of a watercourse aims to increase the capacity of discharge evacuation in the minor riverbed, hence changing it on the transversal as well as the longitudinal. By shortening the riverbed route the slope becomes bigger and thus a deepening of the riverbed bottom and a decrease of the water levels. Mass cutting the river bends leads to the implementation of expensive shore defence works. Any modification of the river route outline is followed by a modification of the riverbed cross section, from a natural profile to a heavily modified a.4**)** Creating buffer zones; a buffer zone is an area with vegetation, usually trees and shrubs, and other species of plants, situated alongside a water course which is designed to maintain the integrity of river functions, reducing pollution, providing food and habitat and thermal protection for fish and other species. Buffer zones filter the sediments and nutrients and also have a role in stabilizing slopes.

a.5) Wetlands development. Wetlands are stretches of puddles, swamps, whose sources are natural or artificial waters of a permanent or temporary nature. Wetlands are natural water storage reservoirs during the flooding they represent a specific habitat for the fauna population and can help maintain the quality of water. Several techniques of restoring the ecosystems by removing clogged sediments are known to help in the rehabilitation of these areas. These works aim to increase the depth and volume of lakes by increasing fish production, removing nutrient rich sediments, toxic matters and by combating the excessive abundance of aquatic pants.

b) The non-structural development measures are: remodelling the banks with vegetation – thermal management, grazing management, biological consolidations.

b.1) Remodelling the banks with vegetation – thermal management. Due to low cost and ecological efficiency, remodelling the riverbanks and lakes with vegetation is one of the most common renaturation (revitalization) measures.

b.2) Grazing management is a very efficient non-structural measure especially when it is cumulated with other structural or non-structural measures. It is implemented where grazing has a negative impact on vegetation and water quality or where it contributes to versants instability.

Fig. 2 – Regulation of watercourse (River Vecht).

b.3) Biological consolidations. Studies in the last century show that a practical method of adequate protection of banks is to consolidate green. Riverbank protection of biological methods (Fig.2) provides an organic link between water and major bed, with no interruption data structural works.

Studies in the last century show that an adequate practical method to protect the banks is the ecological consolidation. Biological methods to protect the banks ensure an organic link between the water and main riverbank without the existence of interruption such as in the case of structural measures.

3. Experimental

3.1. Developing the Bega River in the Curtea – Leucuşeşti Sector

The necessity that led to the making of this study aroses as a result of frequent exceeding flood quotas (almost on a yearly basis) in the River Bega valley, on the sector situated between the villages Leucuşeşti and Curtea, causing material damages.

Flooded areas vary from year to year both in intensity and in placement due to the fact that floods occur because of both the Bega River and its tributaries, which have no transport capacity and flood the valley terrains after exiting the high area.

Carrying out measures of protection against floods on the Bega River and its tributaries on the Leucuşeşti – Curtea sector is deemed as timely and necessary.

Two options have been analysed in the Bega River development scheme. These options were analysed and separated into two solutions as regards to the continuity of flood defence lines.

Solution A pertains to the protection of the premises by creating mounds, concrete parapets and landfills systematized with 1:10 slopes (on small agricultural premises ensured at 10%) which fully dedicate themselves to agricultural production.

Solution B is different from solution *A* in that the systematized landfill sites are made with a 3 m wide canopy which is completely removed from agricultural production, thus ensuring the continuity of the flood defence line during high waters and the access to current maintenance and exploitation works.

The advantages and disadvantages of the explored solutions are the followings:

S o l u t i o n *A*: it’s more economical compared to solution *B*; it permanently occupies a 6.9l ha smaller agricultural surface; it doesn't ensure the continuity of the defence line, the landfill rendered in the agricultural circuit isn't a part of the exploitation organ.

S o l u t i o n *B*: it permanently occupies an agricultural surface bigger than the one in solution *A*; it requires an additional volume of earthwork for the placement of the canopy on riverbed sections where excavations don't compensate the minimum necessary volume in landfill; has the advantage of ensuring the continuity of the flood defence line, the canopy of the systematized landfill being permanently discontinued from agricultural production and delivered to the rightful beneficiary of the regularization works. Current maintenance (fixes, additions to project shares, etc.) and satisfactory exploitation in normal conditions as well as during high water is thus ensured.

Fig. 3 – The consolidation of right bank, downstream of Curtea locality.

4. Discussion. Conclusions

Floods represent a natural phenomenon that cannot be prevented. However human activities contribute to the probability and the magnitude of the negative impact of floods. Given that most river basins in Europe are common, a joint action at Community level will bring considerable added value and will improve the overall level of flood protection.

Given the potential for loss of life, economic and environmental assets, Europe's commitment to feasible growth could be severely affected unless appropriate measures are taken.

Combining environmental measures with some technical (biological) measures and developing a detailed economic analysis of the process of water management requires the involvement of multidisciplinary personnel. Bioengineering techniques and technologies arise precisely from the overlap of structural and non-structural renaturation measures; a superposition made by taking into consideration, besides the technical and ecological conditions, the economical ones as well. All thought at local scale but on a broader framework of basin planning.

The negative consequences of inadequate development of watercourses as well as the change in the way floods are produced have led to the elaboration of a development concept generically called *more space for rivers*. This new concept involves the harmonization of social and economic requirements such as water supply, protection against floods and others with ecological requirements. Through this the continuity of the river and its link to the floodable valley must be ensured in order to create habitats (wetlands) for the conservation of flora and the aquatic fauna and to attenuate floods and nutrient retention. This way, the river can manifest its mobility and adapt to perturbing external pressures and maintain its self-functioning conditions (Şerban & Gălie, 2006).

The transition from the old hydrographic basins development concepts to the implementation of the new concepts requires research and a significant period of monitoring the behaviours in time, which cannot be neglected.

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ASUPRA CONCEPTELOR DE AMENAJARE A CURSURILOR DE APĂ LA INUNDAŢII

(Rezumat)

In prima parte a lucrării sunt prezentate unele principii naţionale şi europene cu privire la amenajarea cursurilor de apă la inundaţii, pentru diminuarea efectelor distructive a acestora**.**

Sunt prezentate şi analizate vechile şi noile concepte de amenajare a cursurilor de apă, cu exemple de lucrări hidrotehnice din spaţiul hidrografic Banat.

In lucrare se pune accent pe necesitatea de a introduce conceptul de „eficienţă în timp a noilor soluţii”. Oportunitatea implementări acestora poate fi apreciată prin monitorizarea comportării în timp a acestor lucrări, atât tehnic cât şi economic.

Sunt luate în considerare, atât bazinele hidrografice mari / medii cu un grad ridicat de amenajare, cât şi bazinele mici.

În partea de final a lucrării se prezintă un studiu de caz cu privire la amenajarea râului Bega pentru diminuarea efectului distructiv la inundaţii, cu prezentarea situaţiilor

actuale şi a lucrărilor propuse (regularizări şi îndiguiri pe râul Bega şi afluenții săi).

Lucrarea se încheie cu discuții şi concluzii despre modul de abordare a unor amenajări, prin trecerea de la soluțiile actuale (conceptul anterior de amenajare) la cele propuse (prin concepte noi).

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ON THE INSUFFICIENCY IN CONSTRUCTIONS SAFETY, DUE TO THE FIRES INCREASE, NOWADAYS

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Abstract. The paper is based on the finding that the fires have increased alarmingly in the last years, as magnitude and frequency, becoming a severe danger to the safety of constructions, environmental and human life. This issue must become a priority for specialists and decisional forums, because the long term impact of the fire on the constructions of noncombustible materials is not deciphered and the design methods are deficient in expressing quantitatively accurate of parameters of the fire present forms. In spite of major advances in the fire computation and modeling, however, to foresee the quantitative response of the construction under the loads from today’s fires is almost utopian. We take into account the diversification of sources of fire, the lack of data on the behavior of concrete with polymer additives and of other new materials.

The post-fire management of the damaged construction is a problem poor in studies and norms. It is very important to survey in time a post-fire rehabilitated building, but this issue, in Romania, is neglected or treated superficially.

Key words: fire resistance; destruction potential; post-fire management.

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1. The Fires, Major Traumatic Cause of the Constructions Degradations

In the past centuries, the earthquakes, wars, fire and ignorance severely affected the Romanian architectural heritage. The constructions history of this territory notes that, from these four causes traumatic, the fires have produced the most frequently and devastating degradations. For example, the city of Iaşi was mostly destroyed by the fire in July 19, 1827 (Iorga, 1905).

The fires are complex phenomena both in terms of causes and effects. They occur in peacetime, but also during armed conflicts or, more recently, during terrorist acts (World Trade Centre collapse, 2001), for other reasons and with very different scale, but with the same serious effects on buildings. For instance, during the Second World War, in the Iaşi County, were destroyed, by bombing and fires, many economic, strategic, social and cultural buildings, some being irrecoverable.

In the recent years, worldwide, the scale and frequency of fires have grown alarmingly, becoming a severe threat to the natural environment and for the safety and, even, for the life of constructions. Although, at present, the methods and means of studying the building materials behavior have achieved a high performance (DTA and TG; XRD; PM and SEM; Hg porosimetry), however the long term impact of fires on the structures made of concrete, reinforced concrete, masonry, stone or other noncombustible materials is not yet deciphered. Furthermore, the design methods are deficient in the ability to express, quantitatively and realistically, the parameters of current forms of fire.

2. Building Characteristics Undermined by Fires

To establish the post-fire management for buildings damaged by fire, must be known the complex evolution of the "fire" phenomenon and the behavior of materials exposed at fire.

The fire produces physical, chemical and mineralogical changes in the materials of the building structure. After the fire, these materials will find themselves in a hostile environment that will enhance their damage and will further reduce the safe operation of the structure. Concretes, ceramics, rocks behave differently to fire, because the crystals contained in these materials have different thermal properties, to which are added the degradation processes to which they are exposed. It is noteworthy that all building materials from rocks, at high temperatures, irreversibly lose their properties. Consequently, the constructions made from these materials, especially those load-bearing, must be subjected to a resistance expertise that will decide the restoration, strengthening or demolition.

2.1. Characteristics and Evolution of Fires

The fire is revealed through a complex combustion process, initiated by a well-defined cause, its evolution is indefinite and, more, including many physical and chemical phenomena (combustion, heat transfer, flames training, exchange of gases with the environment, structural changes in building materials and load-bearing elements, etc.). The thermal, chemical, biological and electromagnetic agents resulting from fire, act on the buildings, facilities and users, and so can produce many negative effects: deformations, reducing resistance, instability, collapse, burns, poisoning, trauma, panic, etc. (Calotă, 1990).

The combustion is an exothermic chemical process, resulted by the combustible material oxidation and, usually, is accompanied by light. To be a combustion process, the simultaneous presence of four elements, which form the “fire tetrahedron”, is mandatory (Fig. 1): combustible substance (material), substance to keep the burning (oxygen, fluorine, and sulfur), ignition source (temperature), and chemical reactions (Biondo, 1987). The combustible materials are thermodynamics sources and they have the ability to combine very rapidly with oxygen, through exothermic chemical reactions. In the fuel material, there are certain oxygen combinations, which are stable at ambient temperature but, at elevated temperatures, they are avid for the air oxygen, to form peroxides, which helps the ignition. The oxidation is done only by the atomic oxygen.

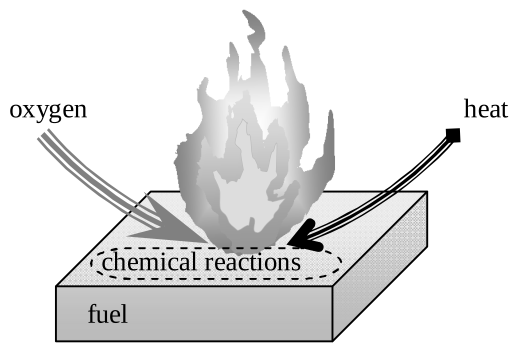

Fig. 1 – Fire tetrahedron.

The fire resistance for design a new building or for post-fire decision at a damaged building, should be examined and selected rigorously, because no two identical fires. The explanation is that the development of any fire is randomly, because it depends on the temporal variation of fire parameters. The safety of the construction, users and the environment is severely diminished by the numerous combustion products. These are various, depending on the fuel composition and combustion evolution, namely: flames (the visible part of the combustion), heat (transmitted by conduction, convection, and radiation), hot gases (H_2O, CO, NO_x, SO_2, CO_2, O_2, N_2), smoke (dispersion, in air, of carbon fine particles and other solids and liquids, as products of incomplete burning), solid waste (ash, slag).

The effects of fire (primary or repeat) on the construction significantly depend on the burning rate of the materials. The burning rate of combustible materials is influenced by the temperature at which the first reaction occurs, the chemistry and concentration of combustible substances, the moisture of environment and fuel, environment ventilation, ambient air pressure, the ratio between the free surface and volume of combustible material. Depending on the burning rate, the combustion may be: slow (oxidation is slowly, without flame, heat generated is small), rapid (oxidation occurs with subsonic speed, great amount of heat and light), instantaneous (oxidation occurs with supersonic speed, explosions).

A construction is degraded differently by fires, if they occur inside or external.

2.2. The Construction Degradation by Compartment Fires and by External Fires

The compartment can represent any confined space that controls the ultimate air supply and thermal environment of the fire (Quintière, 2006), these factors, governing the fire evolution. The compartment fires spread, usually, vertically. The fires occurring in aboveground buildings (room fires) and underground fires (enclosure fires) belong to in this category.

The compartment fires evolve over time in three distinct phases: smoldering, burning active, extinguish (Fig. 2, *apud* Gemeniuc & Florea, 2007) and each phase take place in its own shapes, depending on numerous intrinsic and extrinsic factors. In each stage, the fire action on the construction materials, on the structural elements, and upon the construction overall has different forms. These actions accumulate, which leads to the acceleration of the construction degradation by the effects superposition.

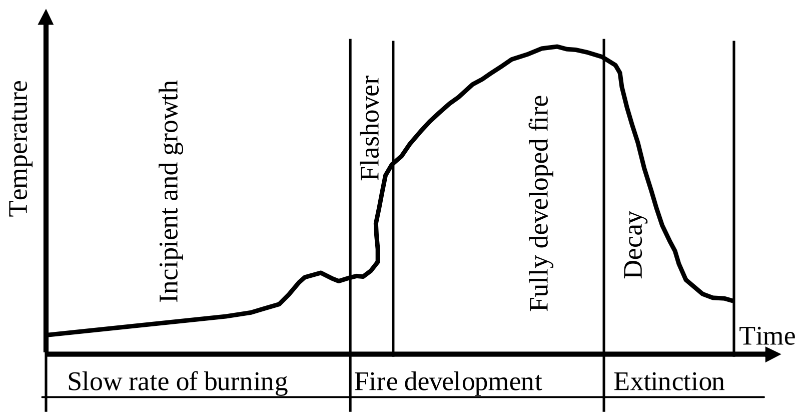

Fig. 2 – The evolution of a compartment fire.

The burning becomes active and strong but the temperature varies greatly in time and space. The heat transfer is mainly by radiation through the layer of hot gases and smoke accumulated in the compartment ceiling. The construction materials in the area reach the ignition temperature and thus the fire spreads.

Depending on the oxygen amount in enclosure, the burning can take different aspects, as

a) Flash-over, when there is enough oxygen into compartment, then the fire develops suddenly, with massive release of energy, like an explosion, the temperature reaching 1,000°C. The thermal stress on structural elements is very important, so be taken into account as accurately as possible to study the fire resistance (Gemeniuc & Florea, 2007).

b) Spontaneous extinction, when the air ambient became poor in oxygen.

c) Back-draft, when, during regression (point b)), there is a sharp intake of fresh air, similar to the flashover, with the rapid increase in temperature and massive generation of smoke.

Unless (b)), the phenomenon reaches its climax, when, in compartment, all combustible materials burn, the temperature reaches the peak (up to 1,200°C). The heat transfer is mainly through radiation, so, the danger of fire spreading to adjoining areas becomes huge. The incombustible materials of the load-bearing structure are particularly affected by the fire, reaching even to collapse: walls crack and dislodge, cracks widen, beams collapsing, floors have large deformations.

The regression and extinguishing stage expresses the fuel exhaustion, the temperature drops, but remains high for a long time, continuing to destroy the structural elements.

The external fire propagation is horizontally, due to the configuration of the land, air currents created by fire and wind. At ground level the fire spreads in a circle, and in case of unevenness land, fire spreads toward the top of the slope. External fire can get inside the building, through the combustible roof, doors, and windows and when the wind direction favours the burning particles transport. The wildfires have become a serious issue in many parts of the world (*e.g*. Western USA, 2012), destroying the natural environment, the built environment, the goods, endangering human life.

3. Insufficient Safety Operation of Construction, under Conditions of Fire and Post-Fire

The construction safety and stability under fire and post-fire expresses the sum and the consequence of the behavior at high temperatures and burning of the used materials, of the construction elements capacity to limit the fire spread, and of the load-bearing capacity of the static system adopted.

3.1. Fire Effects upon Incombustible Materials of the Load-Bearing Structure

Prima facie, the construction elements made of incombustible materials seems that they will behave perfectly under fire conditions. In fact, under high temperatures and fire, the thermal and mechanical properties of incombustible material are changing, which leads to lower mechanical strength and to degradation, even at collapse.

The main thermo-physical properties are: the thermal conductivity (depends on the porosity and structure of the material, the ambient humidity and temperature), specific heat, thermal capacity (change with temperature), density, thermal expansion, refractory character, and thermal inertia. The mechanical properties involved in fire behavior of materials are: strength, hardness, elasticity, plasticity.

The stone fire behavior is governed by thermal expansion and mineralogical composition. The thermal expansion is characterized by two parameters, namely: residual deformation after heating-cooling cycle and coefficient of linear expansion. The predominant phenomenon of the siliceous rocks destruction is the inter-granular fracture, because these have a great and sudden thermal expansion, even below 600°C. The carbonate rocks behavior, at low temperatures, is governed by the anisotropic expansion of calcite, but at high temperatures, the behavior expresses the decarbonation process, with sudden expansion and cracking. After this damage by fire and after a post-impact time to keep the normal temperature, a second phase of destruction follows, caused by the water used to fight fire, the proximate rain and atmospheric humidity, namely the increasing of volume and porosity occurs. For this reason is not allowed to use water for the fire fighting at the constructions of limestone.

At high temperatures (600°…800°C), the strength of most stones is seriously affected and, if thermal shock occurs, the stone can disintegrate.

When mixed with water, the Portland cement hardens as cement stone and develops structures with high mechanical resistance. At high temperatures of fire, from cement stone, all types of water (free, bound physically, and chemically bound) are eliminated, leading to the structural damage and to the strength loss.

The concretes and mortars are artificial conglomerates obtained after the hardening of homogeneous mix of cement, aggregate and water. Their thermal properties depend on the cement amount, W/C ratio, aggregate granulosity, etc. At high temperatures, the concrete components will behave differently, because every have own expansion coefficients and this fact leads to the occurrence and growth of cracks, and, finally, to the concrete thermal destroy (Gemeniuc & Florea, 2007; Olaru, 2007). At 400…500°C, after 5…15 min., is concrete blast, which is manifested by rapid detachment of pieces of material from the heated surfaces of concrete, with specific noises. The cause is a wide dilatation of the gases and water vapour coming from the bound moisture. From 500° to 600°C, the concrete becomes brittle, but at 1,200°C, the concrete sintering occurs, accompanied by the forming of fissured surfaces.

The ceramic materials, as bricks, are obtained by burning shaped forms, made from a mixture of clay, water and additives. The quality and duration of firing ensures the durability and longevity of brick. During burning, the product porosity is reduced, and between particles appear developed links, through partial melting and/or calcination of amorphous constituents. This manufacturing process makes that repeated fires do not have a significant impact on physical and mechanical properties of bricks.

3.2. Fire Resistance of Structural Elements

The fire resistance of building elements is expressed by time from the burning start until signs that the bearing capacity, by the heat insulation capacity, and the tightness were lost, by the material reached the critical temperature. Regulations in most European countries established three fundamental criteria for the fire resistance of building elements: criterion *R* – resistance and stability (for beams, slabs, columns, tie, walls), criterion *I* – thermal insulation (for floors) criterion *E* – tightness.

In fire conditions, the structural elements take on additional loads, which can cause the partial or full destruction of the construction. The fire unfavourable factors are high temperature, sudden changes in temperature, gases pressure, dynamic loads arising from fall of components destroyed, and dynamic loads from extinguishing water.

3.3. The Overall Structural Behavior of Constructions to Fires

The stone constructions perform well in fire due to their massiveness, but only up to 900°C.

The clay brick construction behaves well up to 700°…900°C for several hours, without visible signs of damage, but the silicate brick buildings reduce their strength at half, at above 700°C.

The reinforced concrete constructions have their own specific behavior, to fire (Florea & Rapisca, 1998). The behavior is satisfactory up to approx. 300°C. An element partially exposed to fire heat unevenly and, therefore, the exfoliation occurs. The process also takes place at the concrete–reinforcement contact, and so the concrete–reinforcement adhesion is canceled. Increasing the coating thickness will increase the duration of heating of the armature, and will mitigate a quickly decrease of its resistance. Briefly, the reinforced concrete behaves well at high but short-lived fire.

The collapse, from fire, of the elements or of the entire structure made of reinforced concrete, may occur due to many causes: the steel reaches the critical temperature (about 550°C), the coating comes off completely or in part, the adhesion is canceled due to the unequal expansion between steel and concrete, the avulsion of the anchored bars, followed by the sudden fall of the element, the steel quickly corrosion, the concrete explosion.

4. Assessment of Destruction Potential. Post-Fire Management

The construction fire safety is, nowadays, a global, complex and risk issue. Recent tragic events have attracted the worldwide attention (Mont Blanc tunnel fire, 1999; World Trade Center, USA, 2001) on the critical events that are possible to occur in industrial plants, in large public buildings or inside transport facilities. That is why, prevention measures, active protection measures, and passive protective measures must be implemented.

Forecasting opportunities of destruction and degradation are so low because so numerous and diverse factors that contribute involved parties: fire, construction, and environment. Some hopes of estimating could be for the first fire on the constructions. But, for buildings subjected to repeated fires, historic fires, the problem is too difficult to solve, yet.

New materials, larger and more complex constructions can lead to more severe fires, and to many features of construction fire, so that the increased hazards are difficult to predict.

The modern fire research, the fire safety design, and risk assessment of constructions are based on Computational Fluid Dynamics (Ciambelli *et al.*, 2008).

The post-fire management to recover the safety in operation of a damaged construction is a difficult issue to generalized and poor in studies and regulations; however, certainly, there are only two steps to do, namely the structural diagnosis and structural therapy. The safety level of post-fire construction must be investigated by a team of structural engineers, architects, hydro-geologists, installation engineers, specialists in Building Physics. The expertise results underlying the decision to eliminate the causes that led to structural insufficiency, to restore the bearing capacity and other operational safety requirements. After applying the therapeutic interventions and after the sufficient restoring in the operational safety of the building that suffered fires, it is necessary to follow its behavior in time. Note that this very important point is neglected or treated superficially.

To express quantitatively the fire reaction of the noncombustible building materials represents a difficult, but achievable under laboratory conditions, but, to prognosticate the quantitative response of the bearing elements and/or entire construction to the loads of today's fire is a utopia. There are researches for the constructions exhibited at the first fire, but the calculations are bushy and include many coefficients measured in lab tests on materials, or on structural models, rarely for the entire construction, so that the results are far from reality. For the constructions subjected to repeated fires, the problem is too difficult, yet. We have in view the fact that the ignition sources have diversified (electrical, chemical, explosions, terrorist acts), the spread velocity has increased due to porous materials flammable used in auxiliary elements, and that the data on the behavior in time of concretes and mortars with polymer additives are lacking.

The management post-fire to recover the operational safety of the damaged construction is a problem poor in studies and norms. We should been emphasize that the rehabilitated building post-fire must be surveyed in time, but this very important question, in Romania, is neglected or treated superficially.

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ASUPRA INSUFICIENŢEI SIGURANŢEI ÎN EXPLOATARE A CONSTRUCŢIILOR, CAUZATĂ DE ACTUALA CREŞTERE A FRECVENŢEI ŞI MĂRIMII INCENDIILOR

(Rezumat)

Se analizează statusul actual al incendiilor produse asupra construcţiilor şi se sintetizează principalele probleme privind siguranţa în exploatare a construcţiei expuse, posibil sau probabil, la foc.

Incendiile au crescut în ultimii ani, ca amploare şi frecvenţă, devenind un grav pericol pentru siguranţa şi, chiar, existenţa construcţiilor.

Impactul pe termen lung, al incendiilor, asupra construcţiilor din materiale necombustibile, nu este descifrat şi metodele de proiectare sunt deficitare în exprimarea

cantitativă reală a parametrilor actualelor forme de incendii, de aceea problema trebuie să devină o prioritate pentru specialişti şi pentru forurile decizionale.

Construcțiile realizate din materiale necombustibile (piatră naturală, betoane, cărămidă) nu se comportă ireproşabil cum s-ar părea, ci, dimpotrivă, temperaturile înalte şi focul modifică proprietățile termice şi mecanice ale acestor materiale, ceea ce duce la degradare, chiar la colaps. Analiza comportării la incendiu a construcțiilor din piatră, cărămidă, beton armat, confirmă complexitatea răspunsului structurii portante la multitudinea factorilor intrinseci şi extrinseci.

Exprimarea cantitativă a comportării la foc a materialelor de construcții necombustibile este o problemă dificilă, dar realizabilă în condițiile de laborator actuale. Însă, a prognoza răspunsul cantitativ al elementelor de rezistență şi/sau al construcției în ansamblu, la solicitările din incendiile actuale este o utopie. Pentru construcțiile expuse la primul incendiu, există propuneri, dar cu coeficienți apreciați din testele pe materiale sau pe modele de elemente structurale, mai rar pentru ansamblul construcției, încât rezultatele sunt departe de realitate. Pentru construcțiile supuse la incendii repetate, problema este, încă, mult prea dificilă, având în vedere diversificarea surselor de foc (electrice, chimice, explozii, acte teroriste), mărirea vitezei de propagare din cauza materialelor poroase inflamabile din elementele auxiliare, lipsa datelor despre comportarea în timp a betoanelor şi mortarelor cu aditivi polimerici.

O altă problemă dificil de generalizat şi deficitară în studii şi norme, este managementul post-incendiu pentru recuperarea siguranței în exploatare a construcției degradate. Se subliniază că urmărirea în timp a construcției reabilitate post-incendiu, în România, se neglijează sau se tratează superficial.

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ORGANIC WASTES – A RENEWABLE ENERGY SOURCE AND LONG TERM DEVELOPMENT SOLUTION

BY

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Abstract. Very large organic waste quantities form the organic sludge resulted from waste water treatment plants, or from agricultural and zootechnical, farms have demanded new treatment/mineralization concepts, the resulting biogas being turned into electric or thermal energy, by conversion.

The paper outlines an example for an urban area in Botoşani County, with remarkable results in the producing of renewable energy. The implementation of the project focuses on the sustainability of the area development, as well as on conceptual development.

Key words: organic waste; organic sludge; electric or thermal energy.

1. Introduction

Biogas plants make use of natural processes in order to produce gas, that is where "biogas" term comes from.

Biogas is the result of organic substances decomposition during an anaerobic process in absence of light. "Organic" substances are exclusively made up of carbohydrates, proteins and fats. Microorganisms are directly responsible for decomposition, these enhancing substance transfers at certain temperature and pH values.

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Decomposition follows more steps, beginning with complex molecules (polymers) division in smaller units (monomers), followed by fermentation and, finally, by the formation of gas mixture made up of methane (CH_4), carbon dioxide (CO_2) and certain gas traces as nitrogen, hydrogen sulfide, ammonia, thus, the technical biogas, analogous to the fossil one, turns to *energetic usable fuel*.

Biogas plants are often met not only in agriculture, but also in waste management. Consequently, among raw materials we can spot economical fertilizers (*e.g*. mash dung, garbage), as well as raw materials from crops (as corn silage), wastes from agriculture (wastes from agriculture), as well as organic wastes (as leftovers, wastes resulting from food preparation, fats), also sludge resulted from waste water treatment processes.

At present, the majority of biodegradable wastes are transported to inconsistent dumps and landfills, contributing to the formation of storage gas, a danger for the workers and inhabitants in the area, with greenhouse effects.

In Botoşani County there are four inconsistent deposits, and approximately 168 dumps. Inconsistent deposits are of various sizes. The deposit in Botoşani is the biggest, 13.75 ha, and will be closed in 2012. The deposits in Dorohoi (2.06 ha), Darabani (1.93 ha) and Săveni (1.87 ha) do not have an environmental permit. All these inconsistent deposits ought to be closed by 2016.

Table 1 presents an overview on the existing inconsistent deposits in Botoşani.

Table 1

Inconsistent Deposits in Botoşani

Deposits in Botoşani	Quantity of deposited wastes			Expected capacity m^3	Available capacity m^3	Expected surface ha	Year of closure
	2009 t/year	2010 t/year	2011 t/year				
Botoşani	42,388	39,551	45,835	1,700,000	593,090	13.75	2012
Dorohoi	27,544	21,273	23,457	500,000	183,550	2.06	2012
Darabani	3,930	2,945	1,808	50,000	30,150	1.93	2014
Săveni	3,600	920	1,267	60,000	7,000	1.87	2016
Total	77,462	64,689	72,366	2,310,000	813,790	19.61	

The creation of a complex installation for the production of gas for CHP (combined heat and power) has to take into account the multiple raw materials to be used in the process. Renewable energy sources for the production of biological energy in Vlăsineşti will originate in biomass – vegetable wastes respectively, and manure (including the sludge from waste waters treatment plants).

Biogas will originate in biomass and manure/sludge. Anaerobic fermentation of this raw material mixture takes place in a mesophilic environment, at 37^{o}C, producing

a) biogas which turns into CHP;

b) an agricultural fertilizer of good quality, to be further used as fertilizer on agricultural lands, with a remarkable regenerative capacity of humus.

2. Paperwork Necessity and Opportunity

Cogeneration, or CHP (Fig. 1) represents the use of a heat engine or a power station to simultaneously generate both electric energy and useful heat. It is one of the most common forms of energy recycling. Cogeneration technology is mainly characterized by energetic efficiency and reduced fuel consumption (Cismaru, 2004, Negulescu, 2006).

The main advantages this paper evidentiate are the folloings :

a) substantial advantages represented by the production of highly efficient CHP;

b) helps substantial saving of non renewable sources and use them efficiently;

c) equipments depreciation, mounting and installation being performed in a shorter time compared to any other equipments;

d) can be used separately (with no connection to the national network) or simultaneously (connected to the network);

e) 50% less contaminants in the air, 70% cheaper energy;

f) can be used in industrial field, hospitals, hotels, commercial centers and a lot more;

g) by using biogas, the CHP installations are suitable for waste water plants, in agriculture and dumps.

The process develops in anaerobic conditions and can be followed in four stages:

Stage 0	*Stage 1*	*Stage 2*	*Stage 3*	*Stage 4*
input	hydrolysis	acidification	acetification	Methano genesis
carbohydrates	sugars	carbonic acids	acetic acid	methane
fats	fatty acids	alcohols	hydrogen	CO_2
proteins	amino acids	hydrogen	CO_2	
		CO_2		
		ammonia		

At the first stage anaerobic bacteria use enzymes in order to decompose organic substances with a large number of molecules, as proteins, carbohydrates, cellulose and fats in organic compounds with a small number of molecules.

During the second stage, the acid which forms the bacteria continues the process of decomposition in organic acids, carbon dioxide, hydrogen sulfide and ammonia. Acid bacteria form acetate, carbon dioxide and hydrogen during the third stage (acet genesis).

The fourth stage (methano genesis) involves the specific bacteria that creates methane, producing methane, carbon dioxide and alkaline water.

Bacteria can digest any biological material, except sold biological fuels which contain a large quantity of lignite, as wood.

Methane bacteria needs longer reproduction period than bacteria in acidification phase. This way, fermentation speed and proportion depend upon methane bacteria metabolism. Furthermore methane bacteria needs acid bacteria metabolism, these being symbiotic bacteria, thus, the necessary environmental conditions for the developing of both bacteria being absolutely imperative in order to ensure a continuous flux.

The targeted energy to be obtained from the biogas plant is of 181,589 kWh/year. This value will satisfy the energetic needs of public institutions and the consumption of the technological installations.

The heat resulted from the plant will be used for the building heating, preparation of hot water and for technological purposes.

The electric energy resulted from the plant (181,589 kWh/year) will be used for consumption namely

a) in the technological flux for energetic consumption of equipments – 16,508 kWh/year.

b) for the local public institutions: hall, hospital, police, schools, kinder-gardens, libraries – 165,081 kWh/year.

3. Determination of the Necessary Biogas Quantity for CHP

The calculation has taken into account the following aspects:

a) the needed energy for Vlăsinești administrative units and for the lighting;

b) the needed quantity of biogas for CHP;

c) the necessary raw materials (quantitatively and qualitatively) for the production of biogas;

d) raw materials network to be introduced in the biogas plant, taking into account the following requirements:

– C/N ratio between 15…30;

– over 90% humidity for the mixture (92%…94%);

– pH between 6.8…7.3;

– no inhibiting substances for microorganisms.

For the determination of the total amount of biogas necessary for electric energy production, we considered that for a kWh, 1m^3 of biogas is consumed. The necessity of biogas is presented in Table 2.

A necessary quantity of biogas was established for the production of heat for the internal consumption of the biogas plant (an approximation of 15% of the necessary quantity for the public institutions). The resulting heat is strictly used for the technological flux of the biogas production and capitalization (Table 3) (Dima, 1982, Tobolcea, 2004).

Table 2
Biogas Necessity for Electric Energy per Month

Month	Jan.	Feb.	Mar.	Apr.	May	June	July
Biogas, [m^3] – public institutions	6,511	7,523	6,085	6,450	7,955	7,041	15,775
Biogas, [cm] – plant	651	752	609	645	796	704	1,578
Total	7,162	8,275	6,694	7,095	8,751	7,745	17,353

Month	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Biogas, [m^3] – public institutions	34,072	34,885	11,088	9,822	17,874	165,081
Biogas, [cm] – plant	3,407	3,489	1,109	982	1,787	16,508
Total	37,479	38,374	12,197	10,804	19,661	181,589

Table 3
Biogas Necessary for Heat Production

Month	Ian.	Feb.	Mar.	Apr.	May	June	July
Biogas, [m^3] – cogeneration plant	64,032	64,032	8,352	8,352	8,352	8,352	8,352
Month	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Biogas, [m^3] – cogeneration plant	8,352	8,352	8,352	64,032	64,032	322,944	

The total quantity of biogas for CHP is presented in Table 4.

Table 4
Total Biogas Necessary

Month	Ian.	Feb.	Mar.	Apr.	May	June	July
Biogas, [m^3] – public institutions	7,162	8,275	6,694	7,095	8,751	7,745	1,7353
Biogas, [m^3], plant	64,032	64,032	8,352	8,352	8,352	8,352	8,352
Total	71,194	72,307	15,046	15,447	17,103	16,097	25,705

Month	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Biogas, [m^3] – public institutions	37,479	38,374	12,197	10,804	19,661	181,589
Biogas, [m^3] – plant	8,352	8,352	8,352	64,032	64,032	322,944
Total	45,831	46,726	20,549	74,836	83,693	~500,000

It results that Total Biogas Necessary/year is 500,000 m^3.

The complete installation is made up of the following technological elements (Fig. 2):

a) biomass catchment;
b) collection and mixing tank;
c) fermentation tank;
d) room for maneuver;

e) thickeners for sludge fermentation tank/digestor;
f) sludge water pumping station (supernatant);
g) cogeneration plant;
h) gas meter;
i) biogas burner for destruction if necessary;
j) mechanical dewatering plant for fermented sludge.
Of all these we will only choose to present CHP.

4. Cogeneration Station for CHP

CHP/cogeneration plant turns the biogas produced in the two digesters into heat and electric energy.

Produced electric energy will be used for lightening of streets and for the public institutions in Vlăsineşti, while produced heat will be used by heat exchangers from sludge digesters and for heating in general (administrative building, etc.), (U.S. Env. Prot. Agen. 1991, New Alchemy Inst., Newsleter – Spring, 1993).

Cogeneration/CHP plant is placed in the hall together with the sludge mechanical dewatering plant.

The mechanical equipment is made up of a combined heat and electric energy plant including biogas pre-treatment, connection and integration in the heating system and in the energy supply system (Fig. 1).

Fig. 1 – Cogeneration station for CHP.

Cogeneration plant is made up of the following components:

a) a biogas motor with the following characteristics: 1,330 m^3 biogas and 164 kW electric power, including biogas purification and dewatering, pressure device;

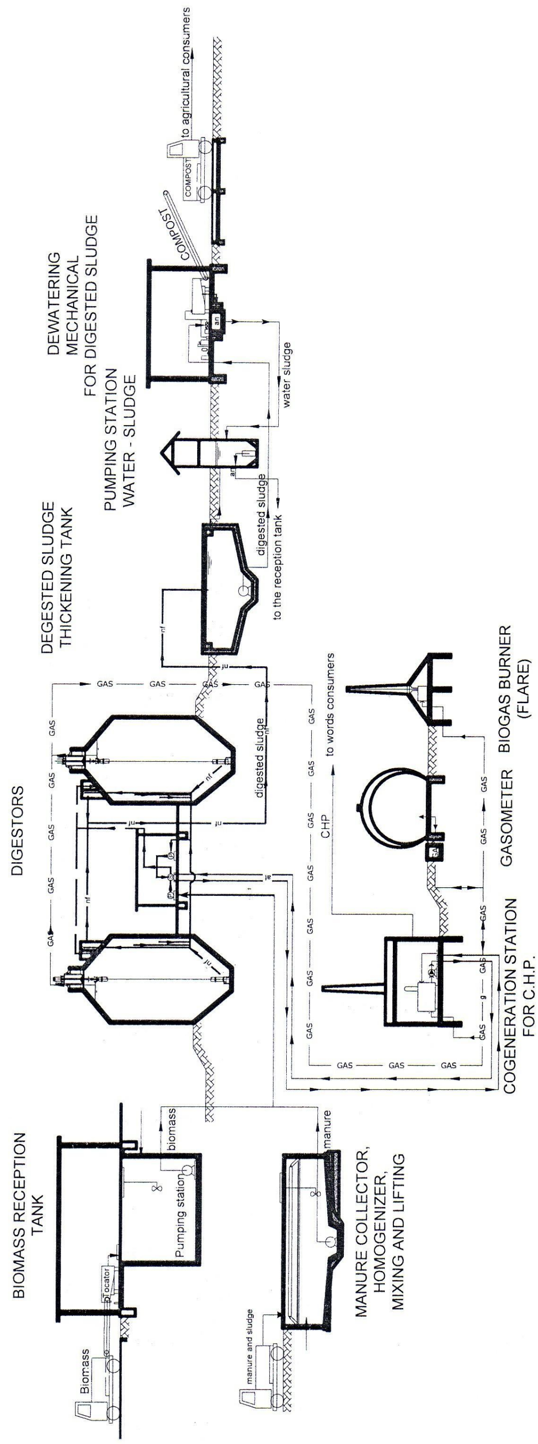

Fig. 2 – Technological flux for CHP.

Table 5
Monthly Recipes for Biogas Plant

Raw material	Jan.	Feb.	Mar.	Apr.	May	June
Biogas necessary m^3/day	2,373	2,410	502	515	570	537
Green grass, weight parts/tons				1/0.99	1/1.10	1/1.04
Corns stalks, weight parts/tons	1/0.65	1/0.66	1/0.14			
Inhabitants, weight parts/tons	0.5/0.18	0.5/0.18	1.5/0.11	2/0.16	2/0.17	2/0.16
Sheep manure, weight parts/tons	1/4.75	1/4.82				
Cattle manure, weight parts/tons	5/42.38	5/43.04	4/4.17	7/12.88	7/14.25	7/13.43
Pork slurry, weight parts/tons	0.5/1.98	0.5/2.01	0.5/0.42			
Poultry manure, weight parts/tons	2/3.71	2/3.77	3/1.18			
C/N report (limit 15…30)	26	26	25	26	26	26
Average dry substance, [%]	25.43	25.43	26.28	15.40	15.40	15.40
Water necessary, parts	22	22	23	9	9	9
Raw material	July	Aug.	Sept.	Oct.	Nov.	Dec.
Biogas necessary, m^3/day	857	1,528	1,558	685	2,495	2,790
Green grass, weight parts/tons	1/1.65	0.5/1.47	0.5/1.50			
Corns stalks, weight parts/tons				1/0.19	1.5/1.02	2/1.52
Inhabitants, weight parts/tons	1/0.13	0.5/0.12	0.5/0.12	1.5/0.16	0.5/0.19	0.5/0.21
Sheep manure, weight parts/tons					1/4.99	1/5.58
Cattle manure, weight parts/tons	8/24.49	6.5/35.47	6.5/36.17	2.5/6.12	4.5/40.10	4.5/44.84
Pork slurry, weight parts/tons		0.5/1.27	0.5/1.30	1/1.14	0.5/2.08	0.5/2.32
Poultry manure, weight parts/tons		2/2.39	2/2.44	4/2.14	2/3.90	1.5/3.27
C/N report (limit 15…30)	25	23	23	23	27	29
Average dry substance, [%]	14.80	17.08	17.08	27.60	29.10	32.10
Water necessary, parts	9	11	11	25	26	30

b) hot water boiler (insulated) – $V = 2$ m^3;

c) liquid fuel boiler and biogas for heating during primers of digesters and when biogas production is fragmented during cold seasons. This boiler starts working in order to supplement heat at peak hours, when it will use diesel as fuel.

Biogas engine was chosen according the following data:

a) biogas production: 1,400 m^3/day;

b) biogas production for calculation: $0.95 \times 1,400 = 1,330$ m^3/day;

c) specific energy (heat and electric energy): 6.4 kWh/m^3 biogas;

d) energy production (heat and electricity): 6.4 kWh/m^3 x 1,330 m^3/day = = 8,512 kWh/day;

e) electric energy production: 40% × 8,512 kWh/day = 3,405 kWh/day = = 142 kW;

f) cogenerator capacity is considered electric energy: 142 × 1.15 = = 164 kW.

As the biogas necessary varies substantially during the year (reaching maximum levels during the cold seasons) and due to the fact that certain raw materials, essential for the production of biogas (that is biomass), are not available during the whole year, there is no recipe for a biogas plant, each month has a specific recipe for the mixture, according to the need. Recipes are presented in Table 5.

5. Conclusions

The implementation of such a complete installation for the processing of renewable wastes, the production of heat and electricity in Vlăsineşti, Botoşani County, will surely impact environment positively, as well as the health of its inhabitants.

Biogas plant implementation has the following detailed effects:

a) improvement of waste sustainable development with a view to make the waste management system more efficient;

b) improvement of life standard and reducing disease risk for the inhabitants;

c) providing information and educating the targeted population regarding the importance of waste capitalization for the protection of the environment, by large awareness and promotion campaigns;

d) increase of local incomes by a good waste management;

e) substantial advantages created by the production of energy in highly efficient cogeneration;

f) it helps the substantial saving of non renewable resources and to the maximization of their use;

g) depreciation for equipments, montage and installation can be done in a shorter time than in the case of other equipments;

h) can be used in isolation, with no connection to the national network, or simultaneously with it (connected to the network);

i) 50% less emissions, 70% cheaper energy;

j) can be used in industry, hospitals, swimming pools and Spa centers, commercial centers and other;

k) biogas cogeneration plants are suitable for waste water plants, in agriculture and landfills.

The use of certain materials, considered wastes, for energy production cannot be a good idea, also taking into consideration the costs of depositing. Furthermore, biogas is a good alternative if we take into consideration the environment protection, price increase for the conventional energy and the ever increasing demands for an adequate management of renewable wastes.

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DEŞEURI ORGANICE – SURSĂ DE ENERGIE REGENERABILĂ ŞI DEZVOLTAREA DURABILĂ

(Rezumat)

Cantitatea foarte mare de deşeuri organice provenite din nămolul organic al stațiilor de epurare, sau de la fermele agrozootehnice, a creat concepte de tratare (mineralizare) a acestora şi biogazul rezultat să fie folosit prin conversie în energie electrică sau termică.

Se prezintă un exemplu pentru o aglomerare urbană din județul Botoşani, cu rezultate deosebite în domeniul energiei regenerabile. Dezvoltarea durabilă a zonei şi a conceptelor este un deziderat al implementării proiectului.

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ECOSYSTEM SERVICES – A NECESSITY FOR SUSTAINABLE DEVELOPMENT

BY

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Abstract. The interest in the ecosystem services concept is growing rapidly because of him potential to contribute in sustainable development. It is a tool to emphasize the importance of nature and its conservation too. Along with rise of interest it was made a classification of these in four categories and has appeared some researches which can evaluate this kind of services.

Paper describes the concept, the classification of ecosystem services and takes some evaluated examples of these.

Key words: ecosystem services; sustainable development; wetlands.

1. Introduction

The definition of the concept began in 1970 in the *Study of Critical Environmental Problem*, where were discussed about environmental services that would decline if there were a "decline in ecosystem function". This concept starts to be used for emphasize the importance for conservation and protection of nature by quantification of ecosystem services.

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2. Discussions, Concepts and Examples about Ecosystem Service

The ecosystem service is defined as *the benefit to humans resulting from ecosystem function and processes* (ARD, 2007).

Table 1
The Main Services that are Performed by Natural Environment (Including Wetlands Ecosystem)

Kind of services	Details	Examples
Regulation services	Describe the capacity of ecosystems to regulate the essential ecological process and life support systems on Earth.	Regulation of carbon dioxide (CO_2) and oxygen (O_2) concentration from atmosphere. Storage and recycling organic matter, nutrients. Maintenance of migration and nursery habitats. Maintenance of biological and genetic diversity. Regulation of runoff and groundwater recharge, etc.
Carrier services	Describe the space or suitable substrate needed for the leadership of human activities such as living, cultivation, recreation. Examples include soil and rainfall for growing crops.	Providing space and suitable substrate for: human habitation and indigenous settlements. Cultivation. Energy conservation. Recreation and tourism. Nature protection.
Production services	Describe the resources provided by nature, including food, raw materials for industrial use and genetic raw material. Example would include production of clean water for drinking and wood for building.	Oxygen, water (for drinking, irrigation, industry, etc.). Food and nutrition drinks. Genetic resources. Medicinal resources. Raw materials for closing and household fabrics. Raw materials for building, construction and industrial use, etc.
Information services	Describe the role played by natural ecosystems in the maintenance of mental health by providing cognitive development, spiritual inspiration, and scientific appreciation of the word. Example would include wilderness areas and historical landscapes.	Aesthetic information. Spiritual and religious information. Cultural and artistic inspiration. Scientific and educational information, etc.

Why this concept? Ecosystem services represent a new idea in human's efforts to properly value and conserve nature. There are researches which quantified the economical importance of ecosystem services. This is very important for consciousness the economic importance and the necessity to protect nature (conservation of ecosystems and renaturation or ecological reconstruction in case of anthropogenic changes). Processes from natural ecosystem and their functions must be conserved or must be recovered because of their contribution to the sustainable development and their irreplaceable value for livelihood and food security, economic growth, etc.

It is important to following and understand the relationship between ecosystem services and biological diversity. Biological diversity is the variety and variability of species, the genes they contain and the ecosystems they create. The diversity at all of these levels creates and maintains ecological processes and functions, which are the source of ecosystem services. Biodiversity is not itself some kind of ecosystem service, but rather the source of all ecosystem services (WWF, 2006).

For an easier evaluating of ecosystem service these were classified in four types (Table 1) (Keddy, 2010).

There are made researches to evaluate the benefits provided by nature to humans by measuring the many services it provides.

Table 2
Economic Value of the Pantanal Wetland Millions of 1994 US Dollars/year) (Keddy, 2012)

Service	Value
Water supply	5,322.58
Disturbance regulation	4,703.61
Waste treatment	1,359.64
Cultural	1,144.49
Water regulation	1,019.82
Nutrient recycling	498.21
Recreation	423.64
Habitat/refugies	285.04
Raw materials	202.03
Gas regulation	181.31
Erosion control	170.70
Food production	143.76
Climate regulation	120.50
Soil formation	60.22
Pollination	33.03
Biological control	30.39
Genetic resources	22.15
Total	15,721.12

The value of wetland services on the Lower Danube River is of 250…1,354 Euro/ha/yr (their role in flood management was not included)

(Martini, 2012). Here is an example from Pantanal wetland, which illustrates the types of services and their values (Table 2), evaluated by WWF (World Wide Fund for Nature) (Keddy, 2012). The Pantanal is one of the world’s largest wetlands (Fig.1).

a

b

Fig. 1 – *a* – The extent of the Pantanal in Brazil, Bolivia, and Paraguay; *b* – Danube River.

We can observe the importance of wetland in water supply, disturbance regulation, waste water treatment, etc.

A study made by WWF for 89 wetlands conclude that the two most valuable services wetlands provide are: recreation opportunities and amenities (median value of 492 $ ha/yr) and flood control and storm buffering (median value of 464 $ ha/yr). The most conservative estimate was that 63 million hectares of global wetlands provide services valued at 3.4 billion $ per year (Keddy, 2010; WWF, 2006).

If we study more carefully these values, we can conclude that when humans manipulate wetlands by draining for agriculture use, many services were simultaneously changed with unknown consequences.

3. Conclusions

The concept concerning ecosystem services is an important tool for nature protection, conservation and restoration. In this way, for any anthropogenic change in ecosystem must be done research to see the impact of works on ecosystem functions and processes; For anthropogenic or disappeared ecosystems must to provide new solution for ecological rehabilitation and, respectively, reconstruction of old ecosystems to take advantages for a sustainable development.

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SERVICIILE ECOSISTEMICE – O NECESITATE PENTRU O DEZVOLTARE DURABILĂ

(Rezumat)

Interesul față de conceptul *serviciile de ecosistem* a crescut rapid, datorită aportului la dezvoltarea durabilă: este un instrument ce evidențiază importanța naturii şi contribuie la conservarea acesteia. Odată cu dezvoltarea acestui concept ecologic, serviciile de ecosistem au fost clasificate în patru categorii şi s-au fundamentat metode care pot evalua/cuantifica aceste tipuri de servicii.

Lucrarea descrie acest concept, clasifică şi exemplifică serviciile de ecosistem.

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STUDIES ON POLLUTION MADE BY THE INDUSTRIAL WASTE DUMPS

BY

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Abstract. This study presents the method of monitoring the dumps of wastes resulting from the iron and steel industry and their impact on the environment. The case study carried out at a metallurgical group of enterprises emphasizes the negative impact of the waste dumps on the environment. The monitoring was performed on the following fields: the wastes storage in the environment, the operation of the dump, the impact on the environment, etc. The analysis carried out referred to the dumps running and the ones in conservation. The present paper analyses also the new regulations regarding the environmental agents monitoring and the ecologic reconstruction of the area.

Key words: dump; industrial waste; monitoring; environment; ecologic reconstruction.

1. Introduction

Pollution is a process by which the biotic and non-biotic environments are altered but which affects also the values created by the human society being caused by human activities. Furthermore, contamination may also involve an

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environmental degradation caused by natural agents. One of the 13 domains regulated by the environmental IQ is represented by the vast and complex domain of "waste management" which comprises specific regulations regarding industrial waste dumps.

Industrial waste dumps must be endowed with control and measurement equipment in order to measure the parameters considered in the analysis. The behavior in time of the running dump should be monitored following the new regulations adopted in the field. Due to the high construction, operation and monitoring costs of a controlled waste dump both during its filling and during its conservation, a cost–profit analysis is expedient. This analysis will represent a criterion in selecting the storage area and the construction solution of the dump. According to the provisions in force in the European Union the storage prices should cover the closure, operation and monitoring costs for a period of minimum 50 years after the dumps closure.

2. Induced Pollution by the Industrial Waste Dumps

Important quantities of waste more or less toxic, depending on their nature, which cause big problems in what regards their processing and storage, result from the industrial processes carried out within the S.C. ARCELOR MITTAL S.A., Galați. Their valorization was performed periodically, the useful substances being recovered and used for other purposes. In many cases these wastes were deposited in inadequate conditions, without previously preparing the ground; the wind and rains often transported these wastes to large areas and infested the underground waters and the surface waters, the environment being thus seriously damaged.

The slag dump analysed is located in the Western side of the metallurgical group of enterprises and neighbors Mălina Bog to the North and the exploitation road of Sendreni Mayoralty to the East. The location of the dump starts at an altitude of 10,00 m on a table land situated between Cătușa and Mălina Valleys and the farm lands of the localities Smârdan and Movileni.

The dump occupies a surface of approx. 110 ha. The average height of the dump is of approx. 50 m. The height varies surface-wise depending on the dump exploitation degree. In some sectors of the dump holes were formed due to the slag exploitation. The surrounding land, situated outside the perimeter approved for storage, is partially and even totally covered with wastes.

The dump, which is situated in the Western part of the unit, first occupied the Eastern side of Mălina Lake and advanced towards other directions covered with water. The advance was horizontally oriented, but also with a continuous slope and if in the beginning the elevation marks were 40 m…46 m height they reached 60 m in the unloading faces area.

The construction of the slag dump started in 1968. The wastes resulting from the technological process of the Metallurgical Group of Enterprises Galați (Fig. 1) were stored there.

The execution project based on which the waste dump was built is no longer available.

Fig. 1 – The industrial waste dump in operation phase.

The analysis carried out within the dump for five years pointed out the following risk situations:

a) There is no natural or artificial waterproofing.

b) The waste dump has no drainage system for the leachate collection and treatment.

c) There are no collecting channels for meteoric water.

d) The waste dump has no gas collection and disposal system.

e) The dump slopes are instable.

f) Meteoric waters infiltrated into the dump are not collected and drained through an appropriate drainage system.

g) The subsurface waters are polluted by uncontrolled infiltrations from the waste dump.

h) The access in the dump is free, etc.

The metallurgical group's operation is in direct relation with the evacuation and storage of the wastes. Due to the quality parameters but also from technical-economical reasons the wastes cannot be revaluated.

The wastes have been stored there for a lot of time and this is why a relief currently called *slag dump* appeared next to the unit.

36.0 mil. tones of blast furnace slag and approx. 14.0 mil. tones of steel plant slag were deposited on the slag dump location during the 1968…2006 period. They were stored on the surface of the dump on a more or less selective basis. Initially the surface of the deposit was smaller but by successive deposits the actual surface exceeded the designed one. Despite this, there have not been taken neither waterproofing measures for the extended base of the dump nor measures meant to ensure the leachate draining and disposal system.

3 mil. tones of blast furnace slag, 1.50 mil. tones of steel plant slag and 600,000 tones of other wastes have been deposited in the dump during 2003…2006 years. An estimated share of the stockpiled materials is shown below:

a) blast furnace slag – approx. 47%;

b) steel plant slag – approx. 30%;

c) refractory wastes and other – approx. 23%.

The volumetric density of stockpiled material has an average of approx. 2,100 kg/m^3.

The industrial wastes dump and the technological processes carried out on site do not generate residual waters. The used water resulting from the slag granulation is collected by the sewage system of the metallurgical group.

The meteoric waters infiltrating into the material stored infiltrate into the soil too where from they get into the ground water and then into the emissary (Mălina Bog). At the same time the waters draining on the dump slope determine its erosion, whereupon they draw off into Mălina Bog. Part of this water is absorbed by the mass of the dump or by the soil in the adjacent area. The infiltrated water influences the quality of the subsurface water and of the water in Mălina Bog.

Mălina Sud sludge bed, situated in the Southern part of the dump, helps the used waters from the blast furnace and steel plant slag taken over by C8 collector discharge in Mălina Bog.

Since there is no draining and collecting system of the leachate generated by the percolation of the dump by the meteoric waters, the slag dump through its position influences both the quality of the subsurface water and the emissary (Mălina Bog).

Because the storage and distribution surface of the industrial wastes has exceeded the Western bounds of the dump, the escarpment of the dump registered some landslips between 2004 and 2005. This phenomenon generated silting processes and even the obstructing of the sewer in Mălina Nord area.

In order to deposit the wastes in the slag bank the automotive transport is used for the blast furnace and steel plant slag. In order to deposit the refractory and industrial wastes, the railway transport is used. The blast furnace non-granulated slag, cooled and solidified, is transported and deposited in the slag dump on platforms, a new stage being thus created the access being possible on the previously deposited wastes.

The truck unloading face is situated in the N-W side, on the marginal line of the slope. The bank slope is consolidated only by the compaction exercised by the trucks weight. The waste trucks are side-tracked, blocked and then dumped. When the slope has achieved its back angle and the wastes no longer slip towards the base, a dozer compaction is performed and the infrastructure towards the area of the new slope is prepared (Fig. 2).

The infrastructure of the new unloading railway face is made of various types of wastes with different granulations. This procedure is adopted because the effect of the slope upon loading is unknown and slide surfaces may appear.

It is worth mentioning that in the access area where the wastes transport is realized by railway, the storage was not selective. Various types of materials and wastes are met in this area.

Fig. 2 – Unloading face for the industrial wastes.

Presently the wastes storage is done on a surface of 84 ha, with the recommendation that the present limit of the dump should be observed.

The waste storage dumps are hydrotechnical constructive structures which involve some special technical-economical and social aspects, such as

a) ensuring the stability and preventing the possible accidents which may take place by the industrial wastes displacement as well as by their forming structure breaking;

b) collecting the surface and subsurface waters with their treatment where necessary;

c) preventing the contamination of the environment with substances carried off from the dumps;

d) the reintegration of the land used for deposits into the economic and ecologic circuit.

The existent legislation on which governs the design, the operation and closure (abandon or conservation) of the dumps (waste bank) is very vast, the most important being

a) GUO *244*/2000 amended and completed with the Law *466*/2001 regarding the safety of the dams.

b) Law *426*/2001 for the approval of the Government Urgent Ordinance no. *78*/2000, regarding waste regime.

c) The Order of the Minister of Waters and Environment Protection no. *1147*/2002 for the approval of the Technical Standard Regarding Wastes

Storage – the construction, running, monitoring and closure of the waste dumps.

d) The Order *867*/2002 of the Minister of Waters and Environment Protection regarding the definition of the criteria that wastes must fulfill in order to appear on the national list of accepted wastes from each class of waste dumps;

e) The Decision *162*/2002 of the Government regarding the wastes storage.

The existent environment legislation regarding the construction, monitoring and closure of the waste dumps, includes specific recommendations concerning the necessary data and information for each stage of the dump life cycle.

3. Results of the Environment Agents Monitoring

The technological monitoring is carried out during the entire operation duration of the dump and is essential for its good running. Thus the risk of accidents and destruction of the waterproofing bed is reduced. The working order of all the dump components should be permanently controlled: the access road and the one in the precincts, the condition of the existent endowments, the degree of settlement and the stability of the dump, the control of the waste entrances (consignment notes, making the conformity analyses), etc. (Fig 4).

Fig. 3 – The pollution of the Malina Valley.

For a strict supervision of the wastes bank running the strict monitoring of the liquid, gas and solid emissions is necessary. Its object is to check if the emissions comply with the competent authorities' requirements (the environment authorization, the water utilization authorization).

The monitoring process of the subsurface waters is carried out for the following parameters: pH, suspensions, fixed residue, CCOCr, chlorides, sulphates, nitrates, ammonium, Fe, Ca, Mg, phenols, cyanides, Cr, Zn, Mn, Pb, Ni. Each month samples are taken from the observation drillings executed on the site and in the neighborhood. The samples are analysed and the results are compared with the values imposed by the existent standards and norms.

Fig. 4 – The industrial waste dump in operation phase.

In order to monitor the underground water, two drillings executed down to the depth of 21.0 m are used.

The quality of the environmental agents from the influence area of the wastes dump is controlled having in view

a) the registration of the meteorological data obtained from the local weather station on a monthly basis in order to establish the quantity of precipitations, the temperature and the prevailing direction of the wind;

b) determining the concentrations of the specific markers in the environmental air from the dump influence area (sedimentation powders – monthly, aerosols – monthly samples);

c) determining the noise level during the operations which require blasting and during the wastes unloading and ecologization works (two quarterly determinations);

d) determining the specific concentration of pollutants in the soil from the dump influence area (pH, SO_4, Cd, Mn, Pb; four samples taken from the four cardinal points per semester).

Due to the nature of the wastes and the storage technology used, the material which makes the structure of the slag dump is very inhomogeneous, both physically and chemically. On the other hand, the dump has impressive dimensions both in horizontal and vertical plane. Therefore, a characterization of its physical-chemical composition by lab analyses would take a lot of time and the conclusions would be irrelevant and uncertain. Consequently, it seemed expedient to take samples from the material stored, the wastes being characterized by the analyses performed by the producer.

The soil samples were taken from the neighboring area next to the bank from four points (two samples for every one: a surface one and one 30 cm deep) situated approximately on the four cardinal directions with respect to the dump. The dump position as well as the predominant wind direction in the area was considered. The choice of the four sampling points allows the analysis of the polluting effect of the dump activity on the soil.

Considering the nature and the chemical composition of the wastes deposited and the recommendations in annex 3.1 to the MAPPM Order *184*/1997, the lab analysis of the soil samples aimed to determine the heavy metals (Pb, Cd and Mn), sulphates and pH concentration.

In order to value the wastes dump contamination effect, the results of the analyses, performed on the soil samples taken from the East side of the location in June July 2006, are presented in Table 1.

Table 1
Contamination Effect of the Wastes Dump

Soil sample code	Determined parameters				
	pH	Cd mg/kg	Mn mg/kg	Pb mg/kg	SO_4^{2-} mg/kg
Less sensitive possessions (inside the metallurgical unit)					
E/ (surface)	8.18	1.42	1,370	53.2	460.2
E / (30 cm)	8.20	1.58	1,399	46.7	880.2
Normal values (Ord. *756*/1997)	–	1	900	20	–
Alert threshold (Ord. *756*/1997)	–	5	2,000	250	5,000
Intervention threshold (Ord. 756/1997)	–	10	4,000	1,000	50,000
Less sensitive possessions (outside the metallurgical unit)					
E/ (surface)	8.26	1.61	1,270	38.2	601.4
E / (30 cm)	8.22	1.83	1,184	37.5	909.8
Normal values (Ord. *756*/1997)	–	1	900	20	–
Alert threshold (Ord. *756*/1997)	–	3	1,500	50	2,000
Intervention threshold (Ord. *756*/1997)	–	5	2,500	100	10,000

From the analysis of the data results that the soil samples have a pH value quarter as 8.0, what confers to the soil in the area an alkaline character. The concentration of the lead in all the analysed samples exceeds the normal values without exceeding however the intervention threshold for the sensitive utilities.

Considering the position of the sampling points with respect to the slag dump and the predominant direction of the wind the negative effect of its activity on the soil is obvious.

Presently S.C. MITTAL STEEL S.A. manages selectively the slag wastes. Distinct areas for wastes storage were arranged. In the following period, the utmost utilization of the wastes will be achieved by the excavation and processing of the slag in the dump, without affecting however the stability and safety of the dump. The wastes which cannot be valuated shall be stored in a distinct area in a controlled and selective manner, according to the technology.

During 2005…2006 years the granulation of the blast furnace slag was done up to more than 70% of the slag quantity produced so that no slag would be stored in the dump.

4. The Post Closure Monitoring and the Ecological Reconstruction

In order to comply with the environment protection requirements regarding the closure of the slag dump, the following measures should be taken:

a) the final coverage of the dump under safety conditions considering the previous land utility and the landscape framing;

b) monitoring the emissions into the environment after the actual closure of the dump for minimum four years until the complete stabilization of the wastes.

The layers of the covering system must ensure

a) the stabilization of the wastes;

b) the subsequent use of the land;

c) waterproofing layer;

d) layer for collecting and disposing the rain waters;

e) vegetal soil layer.

According to the legal provisions, the dump operator is obliged to ensure the post-closure monitoring for the period established by the competent environment authority (minimum three years). The post-closure monitoring system shall be performed for four years and shall comprise the meteorological data, the concentrations of pollutants in the soil, underground water and air, together with a careful monitoring of the subsurface water quality parameters. At the same time, topographical studies on the stability of the slag dump shall be performed by using the landmarks mounted on the dump platform and on the slope.

After turning to good account part of the slag dump, ecologization technologies shall be applied for the volume remained unvalued after extracting the iron. The works include putting back the slag dump into the forest circuit and shall be done by stages.

The ecological reconstruction of the wastes dump shall be considered completed based on some evaluation criteria regarding

a) the quality of the environment agents;

b) the wastes settling;

c) possibilities of subsequently using the ecologically rebuilt land.

The subsequent use of the location shall be done considering the specific conditions and restrictions imposed by the existence of the covered dump depending on the stability of the land and the degree of risk it may present for the environment and human health.

5. Conclusions

1. In order to make the industrial waste dumps safe the regulations in the field correlated with the European law provisions shall be observed.

2. The slag dumps resulting from the metallurgical and siderurgical groups require special attention due to the components included. They influence significantly the stability and circulation of the surface and subsurface waters.

3. The dump safing must be carried out during the operation stage by adopting some measures meant to allow a controlled expansion and super elevation of the dump but without affecting and polluting the environment of the location. The research carried out in this case study indicates various contamination stages of the surface and subsurface waters.

4. During the operation and conservation stage the permanent monitoring of the parameters specific to the dump as well as of the location environment should be performed in order to reduce to a minimum the environmental contamination.

5. Both during the dump operation and conservation stage the location area should undergo an ecologization.

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STUDIO ASUPRA POLUĂRII CREATE DE CĂTRE HALDELE DE DEŞEURI INDUSTRIALE

(Rezumat)

Se prezintă metoda de monitorizare a haldelor de deşeuri provenite din industria fierului şi oţelului şi impactul acestora asupra mediului. Studiul de caz efectuat la un grup metalurgic de întreprinderi subliniază impactul negativ al haldelor de steril asupra mediului. Monitorizarea a fost efectuată pe următoarele domenii: depozitarea deşeurilor în mediul înconjurător, exploatarea haldei, impactul asupra mediului etc. Analiza a fost efectuată la depozitele funcţionale menţionate şi la cele în conservare. Lucrarea de faţă analizează, de asemenea, noile reglementări privind monitorizarea factorilor de mediu şi reconstrucţia ecologică a zonei.

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RIVER WATER INTAKE WITH AUTOMATIC AND INDEPENDENT OPERATION

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Abstract. River water intakes must satisfy some condition for correct functioning: a) to provide servitude discharge; b) to insure fish ladder minimum discharge; c) to divide small discharge into minimum discharge for fish ladder (and/or servitude discharge) and intake discharge (the rest); d) to protect structure at flooding.

Usually these functions are provided by gates operation.

This paper describes a water intake with diversion dam which operate automatic (without operator intervention) and independently (no energy consumption).

Key words: broad crested weir; large orifice discharge; river water intake.

1. Introduction

Water intakes are essential components of the diversion dams that are component parts of a micro hydroelectric power plant. These are typically done without water accumulation (run off river); for this reason, the water intake works with great water levels variation in the forebay. In order to calculate the water intake opening, it is recommended that a calculation scheme similar to

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that for the broad crested weir be used (Răzvan, 1961, 1989) or large orifice discharge (Harvey, 2011)

2. Material, Methods and Case-Studies Presentation

The following calculations are refered to the Tarcău captation.

2.1. Intake Dimensions for Low Water Level

C a l c u l a t i o n s t e p s (Fig.1):

a) Set height, h_n, from running conditions: height of the discharge towards the compensation reservoir should be under the height of the water intake discharge by at least the amount necessary to balance out the losses in the hydraulic circuit thus far. Also, the height should be low enough to allow the water levels during floods (verification discharge). These are determined by trial.

b) Calculation of the contracted depth based on the relation

$$h = h_n - k_{cr}h_{cr},$$

where $k_{cr} = 0.3\dfrac{k'-1.3}{3.22k'-3.65}$, $k' = \dfrac{h_n}{h_{cr}}$, $h_{cr} = \sqrt[3]{\dfrac{q^2}{g}} = \sqrt[3]{\dfrac{Q^2}{b^2 g}}$ – the critical depth.

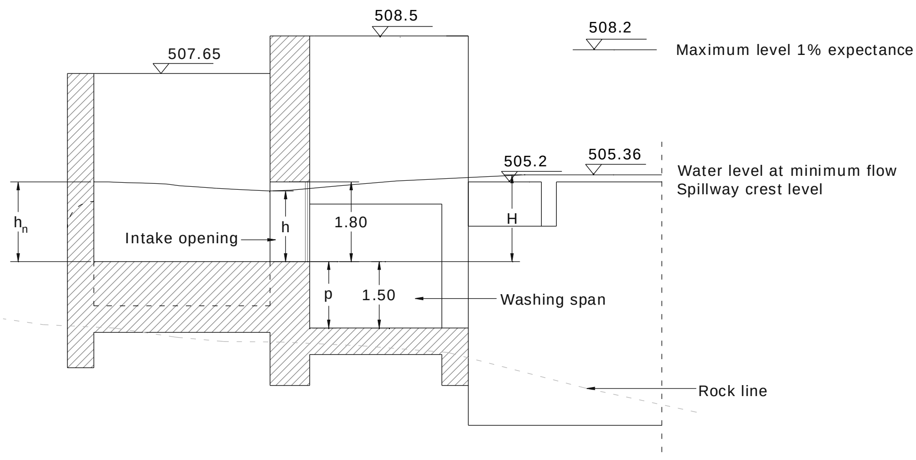

Fig. 1 – Section of the Tarcău captation; low water level.

c) calculation of the speed correction coefficient

$$\varphi_n = \varphi - \frac{0.013}{m^3}\sqrt{\frac{h_n}{H} - 0.8},$$

with

$$m = 0.32 + 0.01\frac{3H - p}{0.46H + 0.75p}$$

– the discharge coefficient. φ is taken from chart (Table 12.5, Cioc, 1983)

The discharge through the intake opening is the powerplant's installed discharge

$$Q = \varepsilon b \varphi_n h \sqrt{2g(H-h)}\ ,$$

where: Q is the discharge through the intake opening; b – the width of the opening; φ_n is the correction coefficient of water speed.

The lateral contraction coefficient is

$$\varepsilon = 1 - \frac{a}{\sqrt[3]{0.2 + p/H}}\sqrt[4]{\frac{b}{B}}\left(1 - \frac{b}{B}\right),$$

where: a = 0.19 is a coefficient for the crest and vertical edges; b/B = 0.2 – ratio between the witdh of the opening and the width of the river upstream (under 0.2 which is the limit value); with p/H = 1 we have ε = 0.89.

For instance, for Tarcău downstream:

Q_i = 5 m^3/s – the installed discharge;

b = 2 × 2 m = 4 m (two openings of 2 m each) width of the intake opening

$$h_{\mathrm{cr}} = \sqrt[3]{\frac{Q^2}{b^2 g}} = \sqrt[3]{\frac{5^2}{4^2 \times 9.81}} = 0.54 \text{ m.}$$

Discharge is submerged ($h_n > h_{\mathrm{cr}}$)

$$k' = \frac{h_n}{h_{\mathrm{cr}}} = \frac{1.8}{0.54} = 3.33\,.$$

As regards the value of h_n the following comments may be performed. In the considered case

a) The river discharge is the minimum discharge which ensures the installed discharge in the powerplant. Consequently $Q_{\min} = Q_i + Q_s$, where: Q_i = = 5 m^3/s – installed discharge of the hydroelectric plant; Q_s = 0.55 m^3/s – servitude discharge.

Using this value, the water level in the forebay is calculated (by adding the overfall wave to the weir crest, in this case 16 cm).

b) After passing through the intake opening and the grit, the water flows into the compensation reservoir. This spillway's height is chosen while keeping in mind that water needs to be able to pass through the grit and into the reservoir under installed discharge conditions. The water level over the spillway has to be greater than the height of the weir crest.The loss of energy during the passing through the grit is negligible.

c) According to Fig. 1 we have $h_n = 1.8$ m and

$$k_{cr} = 0.3\frac{k'-1.3}{3.22k'-3.65} = 0.3\frac{3.33-1.3}{3.22\times3.33-3.65} = 0.082.$$

It results the contracted depth

$$h = h_n - k_{cr}h_{cr} = 1.8 - 0.082 \times 0.54 = 1.75 \text{ m};$$

$$m = 0.32 + 0.01\frac{3H-p}{0.46H+0.75p} = 0.32 + 0.01\frac{3\times1.96-1.5}{0.46\times1.96+0.75\times1.5} = 0.34.$$

From chart 12.5 (Mateescu, 1961) we have $\varphi = 0.961$ and consequently

$$\varphi_n = \varphi - \frac{0.013}{m^3}\sqrt{\frac{h_n}{H}-0.8} = 0.961 - \frac{0.013}{0.34^3}\sqrt{\frac{1.8}{1.96}-0.8} = 0.847.$$

As regards *H,* from the water level in the dam, we must subtract the losses caused by the grit transition, the intake opening shape or the lid niche. All these account for 10 cm. Therefore we have $H = 1.96 - 0.1 = 1.86$ m.

The discharge that can pass through the opening is

$$Q = \varepsilon b\varphi_n h\sqrt{2g(H-h)} =$$
$$= 0.89\times4\times0.847\times1.75\sqrt{2\times9.81\times(1.86-1.75)} = 7.75 \text{ m}^3/\text{s}.$$

Taking into consideration an obstruction of 25% in the grill, we arrive at $Q = 5.8$ m^3/s. This is the flow capacity of the opening in the described conditions. The discharge is regulated by the spillway between the grit and the compensation reservoir.

2.2. Calculation of the Opening of the Intake for High Water Levels

During floods, water can touch, as height, 3 m over the weir crest. The scenario that consider a broad crested weir is no longer valuable for calculations. For this situation, the access to the intake needs to associate with a greater opening.

An orifice is an opening with a closed perimeter, through which water discharges. If the perimeter of discharge is not closed, because the opening is partly filled, the orifice becomes a weir. The orifice discharge is submerged if the downstream water level is above the upper edge of the orifice. Otherwise the orifice is unsubmerged.

For the aformentioned situation, we are considering the opening to be a large submerged rectangular orifice (Fig. 2). The corresponding eq. is

$$Q = \mu bh\sqrt{2gH} ,$$

where μ = 0.6 is a contraction coefficient of water flush, b = 4 m – width of the opening, h = 1.8 m – height of the opening, H = 0.85 m – the water level difference between the forebay and the desander at maximum flow (1%).

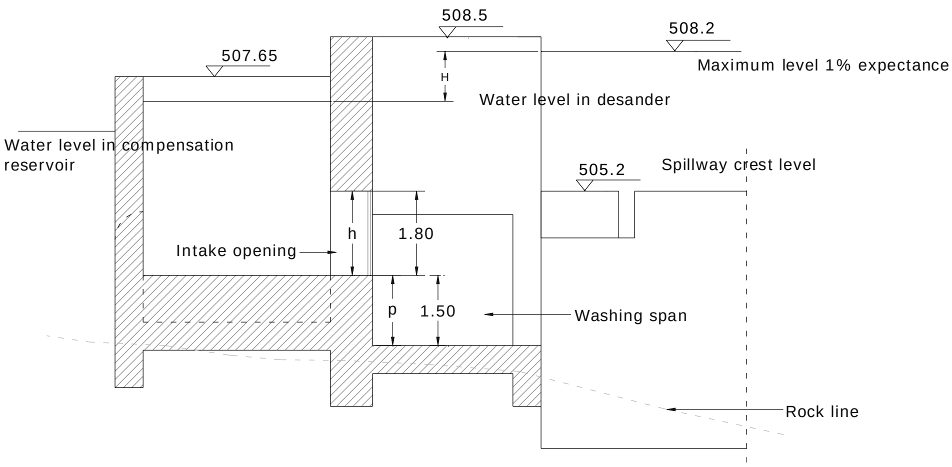

Fig. 2 – Section of the Tarcău capitation; maximum water level.

For small discharges (Q_i + Q_s = 5.5 m^3/s), H = 0.16 m from which we subtract losses caused by the grit transition, the intake opening shape or the lid niche, same as in the previous scenario, and again we evaluate those at 10 cm.

a) Discharge in the intake opening during low river flow rates (and grill with 25% clogging).

In this case, the contraction is incomplete (Mateescu, 1961) and the μ_p coefficient is

$$\mu_p = (1 + 0.13p)\mu = \left(1 + 0.13\frac{4 + 3.6}{8 + 7.2}\right)0.6 = 0.64 ,$$

where p is the ratio between the perimeter where the contraction is absent and the complete contour. It results that

$$Q = 0.75 \times 0.64 \times 4 \times 1.8\sqrt{2 \times 9.81 \times 0.06} = 3.74 \text{ m}^3/\text{s}.$$

Discharge in the intake opening at maximum flow rate (and grill with 25% clogging) is

$$Q = 0.75 \times 0.6 \times 4 \times 1.8\sqrt{2 \times 9.81 \times 0.85} = 13.2 \text{ m}^3/\text{s}.$$

We can see that the discharge calculated for the large orifice hypothesis is smaller than the one in the broad crested weir hypothesis, at the moment when the orifice section is covered. This phenomenon is similar to water flowing through channels where the hydraulic optimum depends, among others, on the ratio between the cross-section and the watered perimeter.

A 5 cm rise in water level, causes a 5 m^3/s discharge overtop in intake opening.

3. Results and Discussion

The differences between the discharges obtained in the two described scenarios must be adjusted. One way to regulate the weir's functions is described below.

The full circuit of the water in the weir is constituted by: a) water intake opening (Fig. 5), b) grit catcher (Fig. 4), c) compensation reservoir (Fig. 3), d) adduction.

Fig. 3 – 3-D wiew of Tarcău diversion dam (operation at low vater level).

From the weir to the grit, water passes through the intake opening. The variation in water flow levels between the two scenarios requires separate calculation assumptions which, in turn, generate different results. Adjustment of the discharge is obtained through the spillway situated between the grit catcher

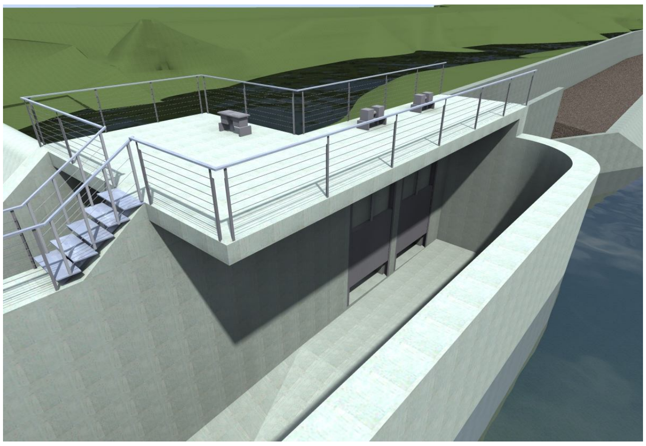

Fig. 4 – View of desand accession.

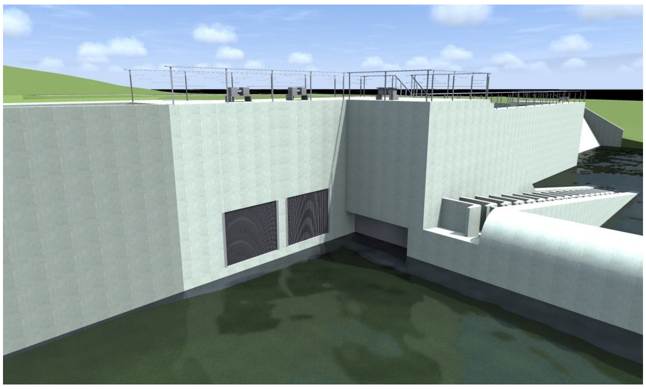

Fig. 5 – View of intake intrance (fish ladder without water).

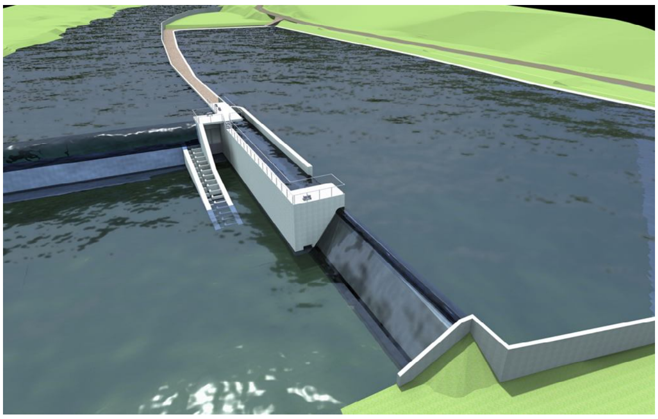

Fig. 6 – Tarcău diversion dam at maximum water level (operation without human intervention).

catcher (desander) and the compesantion reservoir. From this reservoir, the water flows into the adduction, but only in a certain amount determined by the diameter of the adduction During floods, water flows into the reservoir faster than it is leaving it (through the adduction). The surplus needs to be spilled back into the river (Fig. 6).

4. Conclusions

The dimensioning of the hydraulic circuit will be performed as follows:

a) The fish ladder is built to accomodate the servitude discharge, with the water level at the weir crest (floor of the fish ladder is lower than the acces to the reservoir).

b) The water intake opening is sized to be submerged according to Q_i, the minimum discharge in the first scenario. The maximum discharge through the intake during flood levels is obtained considering the opening as a submerged rectangular orifice.

c) The spillway between the grit and the reservoir as well as the grit walls are sized according to the flood discharge levels.

d) The spillway between the reservoir and the stream is sized by the difference between the discharge levels of the flood and the adduction capacity.

This proceedings ensures

a) at low water levels (lower than $Q_i + Q_s$) the water flow is used for the fish ladder and the rest is milled;

b) at levels exceeding $Q_i + Q_s$ the water levels rise in the reservoir, thus increasing the discharge in the adduction;

c) at maximum levels, the water circuit through the intake, reservoir, adduction and back into the river is adjusted by the proper dimensiong of the system's components and no intervention is required.

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PRIZĂ DE APĂ CU FUNCȚIONARE AUTOMATĂ ŞI INDEPENDENTĂ

(Rezumat)

Prizele de apă trebuie să satisfacă anumite condiții pentru o funcționare corectă şi anume

a) să asigure debitul de servitute;

b) să asigure funcționarea scării de pești la debitul de servitute;

c) să asigure întâi funcționarea scării de pești şi apoi captarea apei;

d) să protejeze structura la inundații (debite mari).

De obicei aceste funcțtii se asigură prin manevrarea unor stavile.

Se descrie o priză de apă a unei captări cu prag deversor, care operează automat (fără intervenția vreunui operator) şi independent (fără consum de energie). Aceasta funționare este asigurată prin dimensionarea obiectelor captării astfel încât

a) la debite mici apa curge pe scara de pești, accesul în captare este permis numai după depăşirea debitului de servitute;

b) la debite mari nivelul în deznisipator şi în bazinul compensator nu poate depăşi nivelul dorit prin dimensionarea adecvată a deversoarelor.

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ASPECTS OF EARTHQUAKE RISK MANAGEMENT IN BUCHAREST

BY

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Abstract. The list of vulnerable buildings that are built in downtown of Bucharest before 1940 and identified as with most risk value of collapse in a earthquake (comparable to the one in 1977) includes 115 fragile buildings, with medium and high height (March 2001). In fact, the list is more impressive when taking into account all categories of buildings, regardless of height regime. A brief analysis leads to the observation that many of these buildings have ground floor retail space, so there is a secondary vulnerability – for people – important, which increases the risk for people exposed to elements, especially in the event of an earthquake daytime.

Key words: vulnerability; list; scale; collaps; fragility.

1. Introduction

In human history, earthquakes are known from ancient times. During the prehistoric eras, people found shelter in caves or hills, thus property damage and fatalities caused by earthquakes were minimal.

With housing developments created by man, damage caused by earthquakes has gained ever higher extension.

The oldest information about earthquakes, dates from the eighteenth century BC. Since the twentieth century witnesses an increase in the number of

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cities, thus after the Second World War there is a development increasing more of them, so that, in case of earthquake, damages has increased dramatically. And the damage increases with the increasing number of victims.

The death toll due to collapse of structures during earthquakes and sometimes their number increases due to fire and flooding after earthquake.

2. Material and Method

Existing seismic design code requirements concerning seismic action on the building is a very complex phenomenon so that the support base motion is chaotic, the earth's surface where the first arriving: longitudinal waves, giving rise to oscillations of the vertical, transverse waves after arriving surface waves, which make construction condition of oscillation and horizontal direction. Overall movement of the structure is the result of oscillatory movements in vertical, horizontal and twisting. Elements: beams, columns, floors, walls, can vary individually.

Phenomenon research on building seismic phenomena sought to separate their importance so that those with secondary weight bearing on the stability and resistance elements can be neglected in a first approximation.

Current methods for calculating seismic action on construction of buildings are set on dynamic calculation. The best known method considers the inertial forces acting deduced in computing dynamic and static. Seismic design of buildings, seismic forces applied by static actions, are satisfactory.

Evaluation of the seismic action of inertia forces using modal analysis – spectral, calling the acceleration response spectrum. This amount is subject to a number of factors out of which some belong to the earthquake, some land and building respectively (Dimoiu, 1999)

Design codes usually express the acceleration response spectrum through a product form.

$$\frac{S_a}{g} = \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5\alpha_6\alpha_7\alpha_8, \tag{1}$$

where: α_1 is the seismic zone factor or scale MSK seismic intensity coefficient and the ratio of maximum acceleration ever recorded in the site and the gravitational acceleration.

α_2 – Dynamic seismic coefficient determined on a probabilistic view of the component during the earthquake and the maximum probability, being exceeded.

α_3 – The soil factor that increases or decreases depending on the stiffness shake land (land hard, compact ground, soft ground, sandy soil, etc.), the oscillation period of the land, the groundwater level. The land may be involved in influencing their own oscillatory movement building.

α_4 – Damping factor that reduces the dynamic effect of seismic action: codes usually give acceleration spectrum for 5%, the fraction of critical damping, but this does not applied to all construction materials and systems.

α_5 – Reduction factor due to seismic bearing capacity reserves of the structure. This factor is given by the degree of static indeterminacy and reserve absorption (dissipation) of seismic energy by plastic behaviour of structural components. In Fig. 1 there are easily identified these reserves. The simple portal is three times statically indeterminate. If one accepts the sequential formation of plastic hinges in Figs. 1 *b*, *c*, *d*, due to seismic force, *S*, in the phase structure can be exploited, it provides safety. Formation of a mechanism partially or totally (Fig. 1) leads the structure to collapse. Because of these reservations, the design seismic forces are determined lower than actual ones. Rules are used to reduce the coefficient of mutual value, respectively.

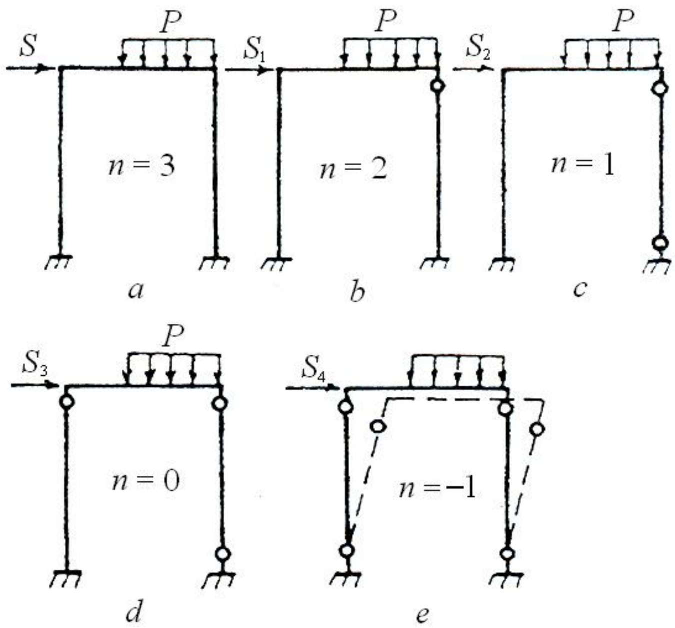

Fig.1 – Sequential degradation of static indeterminacy.

α_6 – Accepted risk factor for construction or rather that the expected damage. If damage estimated by calculation is too high, the risk factor increases the seismic force and the recovery period.

α_7 – The important factor class of construction, taking into account human values and building materials are housed and its damaging consequences. Since important factor has the same effect (increased seismic forces) by the risk factor, many rules are associated.

α_8 – Reduction resistance factor of materials used in the supports.

3. Results and Discussions

Current design codes for various countries adapt this set of factors to the specific knowledge area and the volume collected for each factor separately, which means that not all these factors can be found explicitly in the expression design spectrum.

Earthquakes continue to kill thousands of people and to destroy hundreds of thousands of shelters. Within second's time, they destroy infrastructure developed over decades. Up to a certain point, we have the means and knowledge to prevent the phenomenon. But unfortunately we cannot do this because unsafe buildings are tolerated. In this context, we analyse the reason why are unable to stop the phenomenon – both in engineering and socio-cultural perspectives and in economics. We analyse the problems together because they both are related in terms of seismic risk reduction.

Zero tolerance of unsafe buildings is a clear technical definition and a clear implementation strategy. From a technical standpoint, there were analysed common concepts/terminology; we use to describe engineering buildings safer and procedures they use to convince us and the builders that do what is right. However, note that there are many paradoxes (*e.g.* conflicts between expectations) in the usual procedures and explanations when trying to define safety. This was due to the fact that the interpretation varies according to peoples and cultures. It is clear that the definition of security depends on how we define risk and if we are prepared to accept it.

In terms of implementation it seems there are many myths and errors of logic in our concepts. A good seismic design standard imposed by legal means would solve the problem, but when it develops a strategy to create safer buildings, one overlooks the fact that safety is a socio-cultural and economic problem. This is because different cultures perceive and interpret risk in very different ways, and so are economic reasons for building unsafe construction although people are aware they live in unsafe houses.

"Why tolerate unsafe buildings due to earthquake?". This is an opportunity to analyse the fundamentals of why we were not able to do what we know to be safe for us or more important, why accept such unsafe buildings. Although the question is simple, it raises many complex issues and conflicts, technical and socio-economic/cultural frameworks.

The question "Why tolerate unsafe buildings due to earthquakes?". One assumes that we know what "safety" is. But really, what is "safe"? By definition, any building that meets current safety standards of buildings is "safe". However, how confident are the requirements defined by these standards which are constantly changing? Then uncertainty is associated with the working tools we use to analyse and create a building or construction materials we use. If you are unsure of requirements, how can we assure the safety of other buildings? We say that these documents are based on a reasonable or acceptable risk level by consensus. Words like "reasonable" and "acceptable" indicates objective rather subjective than objective.

To move to buildings with seismic means implementing something new and that means change. Hence, it would arise the following question: why are we not able to change? This question is more difficult and complex in terms of human nature. We need to analyse in depth human nature and reality perspective. They depend on cultural background, geography, accepting fate, approach and, more important, life philosophy. These issues have been raised over time. The question which was always is "Why are we so reluctant to change?". But it's only inertia that works against change, or is more than that?

It is universally accepted that safety during earthquakes is an engineering problem which can be solved by implementing proper engineering concepts through legal means. Once it comes to change, thinking is involved. To shift your thinking, risk communication and assistance are required. Necessary communication skills and negotiation are needed. Change, even if accepted, cannot be implemented for free. It takes money and the flow of cash. These problems make buildings resistant to earthquakes than an engineering multidisciplinary topic. Of course, in terms of historical earthquake engineering which was driven by safety engineers interested in earthquakes, and, in the last 50 years its horizons were greatly expanded. However, there are still gaps that prevented virtually earthquake-safe building construction, and yet we tolerate buildings which one says they are unsafe.

Problems are multilateral – from the definition of a safe building to approaches adopted for implementation. This is full of paradoxes.

By definition, any building that meets current standards is a safe building. The word "current" means that standards can be changed, and indicate that we are not sure of the standards. In the past 70 years, seismic engineering standards have changed at least six times (most often increasing demands on the structure, and almost implying that buildings built by previous standards are less secure. So the building was safe until yesterday, they could be declared unsafe, the following day because of new standards and their requirements. We cannot do anything with these buildings, their structure or how to use them. You cannot do anything in either the current seismic risk, which is the same. Definition, interpretation, or our knowledge and acceptance levels, are those that temporary structure, so they could be designed taking into account earthquakes of the last 25 years, but what would happen if an earthquake of moderate intensity would be on Sunday, when people crowded the stores shopping. Although we predicted as low risk, the consequences would be serious. So the question is not just temporary or permanent, it is rather a matter of magnitude of consequences.

As early acceptance of a building is safe or unsafe based on "acceptable risk" rational, which is a paradox in itself. It is uncertain whether they should be "acceptable risk" or "desired level of safety". How should we define the acceptable level of risk? How much risk is too high? Who should define the ceiling? Is it accepted that society should define this? Should it be reflected in the societal perspective? However, it is easy to define in the abstract which is a corporation or a company perspective, but difficult to fix specific ones. Acceptable risk perspective would differ depending on the position of a member of the company in society. So the question is “Who sets this perspective, a politician, a building owner or tenant, insurer or reinsurer, an expert?” in society, there are extremes: one can say that one does not tolerate any level of “risk” and other such says “If it happens, let it happen”. The dilemma is, “Where is the balance and how to decide?”.

At least the engineering community is accepted as the acceptable level of seismic safety of buildings is generally defined by our standards and seismic design standards in particular, because they are based on the unanimous approval of experts. However, these documents present expert opinion rather than society. Seismic safety problem is a public one which provides public safety justification for government action in terms of seismic risk. Buget allocation for the implementation of seismic safety will always highlight a major gap between commitment and action. It is matter of political risk, confusion, lack of understanding, or priorities? Another question would be, also, even if the budget is allocated and political environment created, we can afford to have claims of zero risk, or does it exist?

Definition of a building seismically safe point based on its evaluation in accordance with design code crust movements are similar to movements in a particular earthquake, any period when there was. Codes combined effect of all possible earthquakes in the region. However, a single earthquake will have elements of all earthquakes. And there is always likely to be outdated prediction. Means that we plan for something we do not know exactly. Moreover, the codes do not define the most negative scenario.

How do we estimate the seismic risk of a building? What we actually do is to build an analytical model with materials and structure, tasks and other parameters based on previous experiences? In this process we try to simplify a lot of models. We are unsure as regards the properties of materials, their content, even burden (including dead or alive). Of course, there was human error. We use thinking to predict the performance of a building or, conversely, trying to interpret whether the building complies with the standards samples? The next moment, we opt to use sophisticated analysis, trying to do right, but forget the enormous approximations included in seismic design and analysis. Another source of uncertainty and inaccuracy is discussed by Priestley (1993) in his anniversary book.

4. Conclusions

All these analysis must then pass through the filter thinking and engineering analysis. It is not incorrect, but once the human mind is under the question, it appears the subjectivity. So it is possible that although the building is declared unsafe earlier, it has been regarded safe by another professional. Or *vice versa*, even in the same load conditions. It is difficult to state the effect the assumptions we make on the results of any analysis have. Because of this uncertainty, it is extremely difficult to appreciate that building is safe and what is uncertain. After each earthquake, we see things and learn unexpected lessons. Learning lessons is not wrong, but also implies that our knowledge is incomplete. So, our predictions about the safety or uncertainty are uncertain.

It seems that there are many missing parts of the puzzle building earthquake safety. If these pieces are not found and fit in the puzzle, we continue to tolerate earthquake risk buildings. You must accept the fact that buildings can reduce the risk tolerance, however, cannot continue in the same way linking and a perception that there is no ultimate truth in this field. They identified the following measures to reduce tolerance to seismic risk buildings:

1. C o m m u n i c a t i o n: Lack of an interface between people and technology that could be complemented by communication. Communication on many aspects of risk minimizes it and put an end to user awareness, being the key to reducing tolerance to unsafe buildings.

2. R e s e a r c h: For better communication, thorough research on risk perception, awareness and communication should remove the problem and break the barriers of communication.

3. R o l e:You must change the engineering and researchers protective role in promoters. They can create the interface between people and technology. To do this, you need to know communitarian perception and importance of communication.

4. R e w a r d and p u n i s h m e n t: It wants to provide incentives for those who want to strengthen their buildings or to minimize risk in case of earthquakes – accompanied by a legal system.

5. V i a b l e t e c h n o l o g y: There are many gray areas in the aim to improve safety. They should be investigated and solved.

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ASPECTE ASUPRA MANAGEMENTULUI RISCULUI LA CUTREMURE ÎN BUCUREŞTI

(Rezumat)

Lista de construcții vulnerabile si care sunt construite in centrul Bucureştiului înainte de 1940 și identificate ca fiind cu cea mai mare valoare la risc de prăbușire într-

un cutremur (comparabil cu cel din 1977) include 115 clădiri fragile, cu înălțime medie și mare (martie 2001). De fapt, lista este mult mai impresionantă atunci când se iau în considerare toate categoriile de construcții, indiferent de regimul de înălțime. O analiză scurtă conduce la observația că multe dintre aceste clădiri au spațiu de retail la parter, astfel încât nu există o vulnerabilitate secundară importantă - pentru oameni, care creste riscul pentru persoanele expuse la elemente, mai ales în cazul unui cutremur in timpul zilei.