BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI

Tomul LVI (LX)

Fasc. 3

HIDROTEHNICĂ

2010 **Editura POLITEHNIUM**

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
PUBLISHED BY
„GHEORGHE ASACHI" TECHNICAL UNIVERSITY OF IAŞI
Editorial Office: Bd. D. Mangeron 63, 700050, Iaşi, ROMANIA
Tel. 40-232-278683; Fax: 40-232 237666; e-mail: polytech@mail.tuiasi.ro

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tomul LVI (LX), Fasc. 3 2010

HIDROTEHNICĂ

SUMAR

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tome LVI (LX), Fasc. 3 2010

HYDROTECHNICS

CONTENTS

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

SOME ASPECTS REGARDING THE DEVELOPMENT OF TREATED WASTE WATER

BY

VIOREL TOBOLCEA, VALENTIN CREȚU and *COSMIN TOBOLCEA

Abstract. The waste water treatment for agricultural purposes in irrigation systems is defined by the set of measures and procedures used to reduce the chemical (mineral, organic) or bacteriological impurities to certain limits so that these waters should not damage the soils or crops. These waters should contribute to the increasing of production and not damage the ecosystem.

The technological diagrams of the waste water treatment plants depend on the desired quality of the effluent so that this one should play the role of regulating the necessary nutritional substances in the agricultural ecosystem.

The work presents a set of schemes for the qualitative treatment of a waste water treatment plant which supplies systems of direct/indirect irrigation, and establishes the quantity of nutrients which should result from the process.

Key words: waste water treatment plant; direct and indirect irrigation.

1. Introduction

The waste water treatment procedures and the technological schemes which determine the choice of the component parts of a waste water treatment plant are determined by the characteristics of the waste waters, by the required parameters of the effluent (depending on the destination of the treated water), its direct or indirect use (by surface watercourses) and by the characteristics of the emissary (rivers or lakes).

The quality of the waste water treatment, that is the reduction of some parts of the physical, chemical or biological components during the waste water treatment, indicates the choice of the necessary technological line of a waste water treatment plant able to produce the right balance in the nutritional substances (nutrients) of the effluent which will fit the targeted. agricultural ecosystem.

The *direct irrigation* with waste waters is the process in which the treated waste waters are directly discharged into the irrigation system. The *indirect irrigation* is defined as the process by which the treated waters are discharged into an emissary (river or lake) and then introduced in the irrigation system. The important factors to be taken into account regarding the direct irrigation are the parameters of the elements of the inlet flow and those of the irrigation system, while the indirect irrigation would be considered together with the characteristics of the emissary, its possibilities to dilute and selftreat the waste waters.

The treatment of the waste waters is accomplished by two distinct process lines:

1. The waste water treatment process line, which will target the with-holding and/or the treatment of noxious substances in non noxious products, the final product being a treated effluent.

2. The sludge treatment process line which will target the treatment and the dehydration of the retained products in the water operational line, resulting in a treated sludge.

The water process line can be made of one or more treatment stages (according to the wanted/desired/required quality of the effluent) following the possible schemes

a) primary stage;

b) primary and secondary stage;

c) primary, secondary and tertiary stage;

d) advanced primary stage, advanced secondary stage and tertiary stage.

The differentiation among the stages represents a result of the different ratios between the physical, chemical and biological processes and the sequence or overlap of these processes.

2. Waste Water Treatment in Direct Irrigations

The very complex range of substances found in waste waters can be considered a potential source of fertilizers for agriculture when the technological processes of the treatment of the waste water are so coordinated that the characteristics of the effluent should meet the soil necessary nutrient demands.

Fig. 1 presents the components of the waste water and sludge treatment scheme for direct irrigation purposes.

The global balance of the fertilizing mineral substances on the line: Public Sewage Network (PSN) – Waste Water Treatment Plant (WWTP) – Irrigation System (IS) – Agricultural Ecosystem (AE) [1], [2] is

(1) $$SM_{ef} + SM_{n} = SM_{inf}\text{ , [mg/L]},$$

(2) $$\mathrm{SM}_{\mathrm{ef}} = \mathrm{SM}_{\mathrm{si}}\,,$$

(3) $$\mathrm{SMT}_n = \mathrm{SM} + \mathrm{SOM},$$

(4) $$\mathrm{SO}_{\mathrm{inf}} = \mathrm{SOM}_n + \mathrm{SO}_n + \mathrm{SOV} + \mathrm{SOM}_{\mathrm{ef}} + \mathrm{SO}_{\mathrm{ef}}\,,\ \ [\mathrm{mg/L}],$$

where: SM/MS represents mineral substance, SO – organic substance, SOM – mineral organic substance, SMT – total mineral substance, SOV – volatile organic substance, emanated from waste water or sludge; the types of the emanations varies according to the type of the biological process involved (aerobic, anoxic – aerobic on the water operational line and anaerobic on the sludge operational line) (Fig. 1).

The balance of the volatile substances out of the organic substances groups should be done taking into account the blown gases (air) in the waste water, the gas emissions CO_2,N_2, CH_4, H_2S, etc., and also the gas emissions resulted from the sludge treatment process, in the form of gas fuels as follows

(5) $$\Sigma(QC)_{\mathrm{input}} = \Sigma(\,QC)_{\mathrm{output}}\,,$$

so that

(6) $$Q_{\mathrm{inf}}C_{\mathrm{inf}} + Q_aC_a = Q_{\mathrm{ef}}C_{\mathrm{ef}} + Q_nC_n + Q_{gc}C_{gc} + Q_gC_g\,.$$

Nutrient quantities in the specific sections can be determined as follows:

a) Section 1 – nutrient quantities at the inlet of the WWTP (influent – G_{inf})

(7) $$G_{\mathrm{inf1}} = Q_{\mathrm{inf}}\mathrm{SM}_{\mathrm{inf}}\,,\ [\mathrm{kg/day}],$$

(8) $$G_{\mathrm{inf2}} = Q_{\mathrm{inf}}\mathrm{SO}_{\mathrm{inf}}\,,\ [\mathrm{kg/day}].$$

b) Section 2 – nutrient quantities at the outlet of the W.W.T.P.(effluent – G_{ef}):

(9) $$G_{\mathrm{ef1}} = Q_{\mathrm{ef}}\mathrm{SM}_{\mathrm{ef}}\,,\ [\mathrm{kg/day}],$$

(10) $$G_{\mathrm{ef2}} = Q_{\mathrm{ef}}\mathrm{SO}_{\mathrm{ef}}\,,\ [\mathrm{kg/day}].$$

c) Section 3 – necessary nutrient quantities for establishing of the ecological balance of the agricultural ecosystem

(11) $$G_{EA}^{1} = G_{SI1} = G_{ef1}, \text{ [kg/day]},$$

(12) $$G_{EA}^{2} = G_{SI2} = G_{ef2}, \text{ [kg/day]}.$$

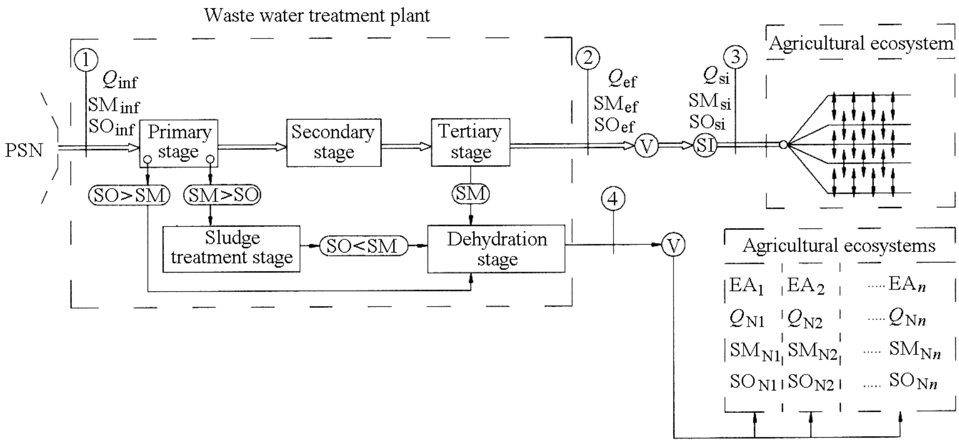


Fig. 1 – Waste water and sludge treatment flow scheme for a WWTP for direct irrigation system: Q is the flow; SM – fertilizing mineral substances; SO – organic substances; inf – influent (inlet flow); ef – effluent (outlet flow); SI – system of irrigations; S/N – sludge; EA – agricultural ecosystem; V/U – use (valuation); PSN – public sewage network.

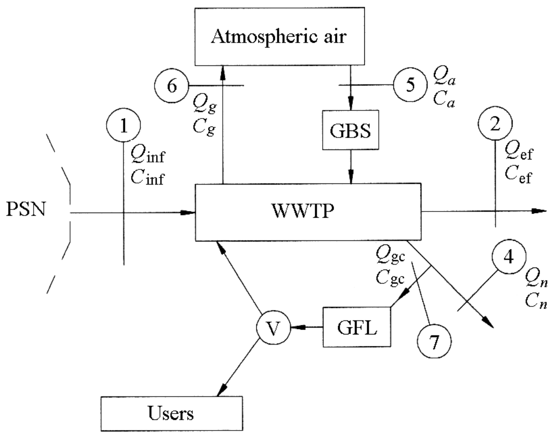


Fig. 2 – A general flow scheme of gas and other organic volatile substances: C – concentrations; S – sludge; a – atmospheric air; g – various gases; GF – gas fuel; GFL – gas fuel line; GBS – gas blowers; 1,2,…,7 – characteristic sections.

d) Section 4 – unnecessary nutrient quantities for the agricultural ecosystem with irrigation system, which will be used in other agricultural ecosystems. (EA_1 , EA_2 ,..., EA_n)

(13) $$G_{N1} = Q_N SM_N \text{, [kg/day]},$$

(14) $$G_{N2} = Q_N SO_N \text{, [kg/day]}.$$

3. Waste Water Treatment in Indirect Irrigations

The indirect irrigation represents the use of the treated waste water in indirectly irrigations, after being flushed into an emissary, a surface water. After a certain water course of the mixed waters, these are used in an irrigation system for a certain agricultural ecosystem, as in Fig. 3 [3], [4].

If the discharged elements in the emissary satisfy the needs of the agricultural ecosystem we would destroy the emissary ecosystem by water nourishment with phosphorous and nitrogen. (eutrophication). That is why the nutritious elements in the water flow are transferred to the sludge flow.

The water flow, the emissary, can be a surface water as rivers, springs, or natural/artificial lakes with the following flows: $Q_{em} < Q_{ef}$, $Q_{em} = Q_{ef}$ or $Q_{em} > Q_{ef}$.

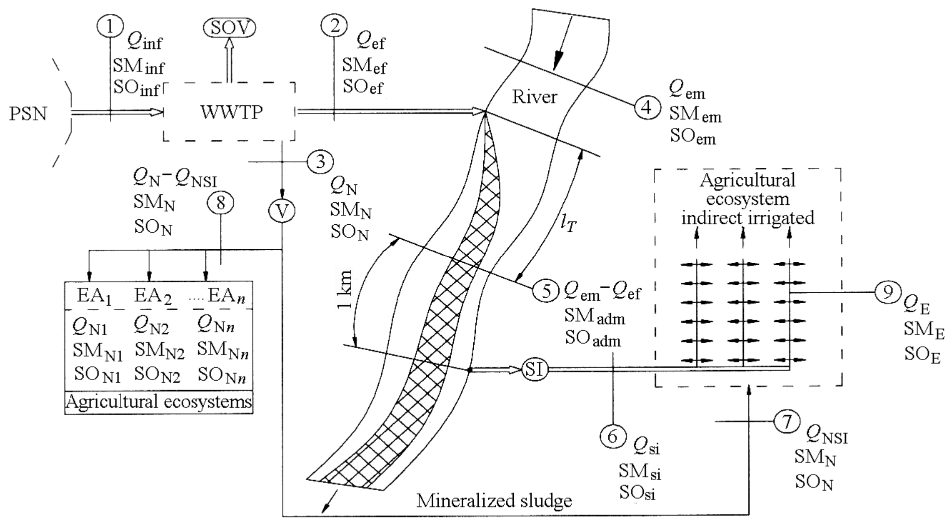


Fig. 3 – The scheme of the water and sludge treatment line for a WWTP which serves an indirect irrigation system (IS/SI); PSN – public sewage network; IS – irrigation system; em – emissary; adm – admissible; *S* – sludge; *V* – values; l_T – the length of the watercourse.

The nutrient quantities characteristic to different sections can be calculated as follows [5], [6]:

a) Section 1 – the quantities of nutrients at the inlet of the WWTP of the public sewage network (G_{inf})

$$G_{inf1} = Q_{inf}\mathrm{SM}_{inf}\,,\ [\text{kg/day}], \tag{15}$$

$$G_{inf2} = Q_{inf}\mathrm{SO}_{inf}\,,\ [\text{kg/day}]. \tag{16}$$

b) Section 2 – the quantities of the nutrients in the effluent, the treated waste water of the WWTP (G_{ef})

$$G_{ef1} = Q_{ef}\mathrm{SM}_{ef}\,,\ [\text{kg/day}], \tag{17}$$

$$G_{ef2} = Q_{ef}\mathrm{SO}_{ef} = Q_{ef}\,(\mathrm{SO}_{inf} - \mathrm{SMN} - \mathrm{SON} - \mathrm{SOV} - \mathrm{SM}_{ef}),\ [\text{kg/day}]. \tag{18}$$

c) Section 3 – the quantities of the nutrients in the mineralized sludge of the WWTP (G_{N})

$$G_{N1} = Q_{N}\mathrm{SM}_{N}\quad,\ [\text{kg/day}], \tag{19}$$

$$G_{N2} = Q_{N}\mathrm{SO}_{N}\,,\ [\text{kg/day}]. \tag{20}$$

d) Section 4 – the quantities of nutrients in the emissary upstream the waste water discharge (G_{em})

$$G_{em1} = Q_{em}\mathrm{SM}_{em}\,,\ [\text{kg/day}], \tag{21}$$

$$G_{em2} = Q_{em}\mathrm{SO}_{em}\,,\ [\text{kg/day}]. \tag{22}$$

e) Section 5 – the quantities of nutrients in the control section (G_{adm})

$$G_{adm1} = (a\,Q_{em} + Q_{ef})\,\mathrm{SM}_{adm}\,,\ [\text{kg/day}], \tag{23}$$

$$G_{adm2} = (aQ_{em} + Q_{ef})\mathrm{SO}_{adm}\,,\ [\text{kg/day}]. \tag{24}$$

f) Section 6 – the quantities of nutrients retrieved from the emissary by the irrigation system (G_{si})

$$G_{si1} = Q_{si}\mathrm{SM}_{si} = Q_{si}\mathrm{SM}_{adm}\,,\ [\text{kg/day}], \tag{25}$$

$$G_{si2} = Q_{si}\mathrm{SO}_{si} = Q_{si}\mathrm{SO}_{adm}\,,\ [\text{kg/day}]. \tag{26}$$

g) Section 7 – the quantities of nutrients from the mineralized sludge (G_{Nsi})

(27) $$G_{\mathrm{Nsi1}} = Q_{\mathrm{Nsi}}\mathrm{SM_N}\,,\ [\mathrm{kg/day}],$$

(28) $$G_{\mathrm{Nsi2}} = Q_{\mathrm{Nsi}}\mathrm{SO_N}\,,\ [\mathrm{kg/day}].$$

h) Section 8 – the quantities of nutrients of the WWTP sludge which can be used in other agricultural ecosystems not endowed with irrigation systems ($G_{\mathrm{EA}n}$)

(29) $$G_{\mathrm{EA}n} = \sum_{i=1}^{n} G_{\mathrm{EA}i} = G_{\mathrm{EA1}} + G_{\mathrm{EA2}} + ... + G_{\mathrm{EA}n}\,,\ [\mathrm{kg/day}],$$

(30) $$\mathrm{G}_{\mathrm{EA}n} = \mathrm{G_N} - G_{\mathrm{N}si}\,,\ [\mathrm{kg/day}],$$

(31) $$G^{1}_{\mathrm{EA}n} = (Q_{\mathrm{N}} - Q_{\mathrm{N}si})\mathrm{SM_N}\,,\ [\mathrm{kg/day}],$$

(32) $$G^{2}_{\mathrm{EA}n} = (Q_{\mathrm{N}} - Q_{\mathrm{N}si})\mathrm{SO_N}\,,\ [\mathrm{kg/day}].$$

i) Section 9 – the necessary quantities of nutrients needed in the agricultural ecosystem endowed with indirect irrigation system:

(33) $$G^{1}_{\mathrm{EA}n} = G_{si1} + G_{\mathrm{N}si1}\,,\ [\mathrm{kg/day}],$$

(34) $$G^{2}_{\mathrm{EA}n} = G_{si2} + G_{\mathrm{N}si2}\,,\ [\mathrm{kg/day}].$$

As the standardized permitted limits only allow relatively low values of the fertilizing elements necessary to an agricultural ecosystem endowed with an irrigation system, the rest of the necessary fertilizing elements is taken from the water technological line of the WWTP. The extra sludge quantity is used in the agricultural ecosystems $\mathrm{EA_1}$, $\mathrm{EA_2}$,..., EA_n.

Taking this into account, in both types of irrigation we can establish the type of the necessary treatment according to the mineral substances (N, P, K, Ca, S, etc.) and to the organic substances of interest, the type of the necessary treatment further determining the necessary design of the water and sludge treatment technological lines.

The type of treatment (E) is established by the following general relation [7]:

(35) $$E,\ [\%] = \frac{\mathrm{SM_{inf}} - \mathrm{SM_{ef}}}{\mathrm{SM_{inf}}} \ \text{ or } \ E,\ [\%] = \frac{\mathrm{SO_{inf}} - \mathrm{SO_{ef}}}{\mathrm{SO_{inf}}}.$$

The values for SM_{inf} , SO_{inf} are established by laboratory tests, and the values SM_{ef} and SO_{ef} are the necessary values for the agricultural ecosystem endowed with an irrigation system with treated waste waters.

4. Conclusions

If the waters of the emissary (river, lake) in section 4 have superior characteristics, in section 2 more polluted waters can be discharged, but which, mixed with the waters of the emissary must meet the standard values in section 5.

If the waters of the emissary in section 4 are polluted waters, then in section 2 waters of superior quality must be discharged in order that the mixt meet the standard values in section 5.

If we followed the efficiency of different characteristic equipments and groups of equipments in different arrangements and final concentrations, [mg/L], taking into account the elements of the waste water of interest to be used for irrigations, then we could design a technological line to meet the specific targeted waste water quality of the effluent (Table 1).

Table 1

Average Performances that can be Obtained by Controlling the Neccessary Elements for Agriculture

Nr	Installations and procedures	MS		CBO_5		CCO	
		η , [%]	*C* mg/L	η , [%]	*C* mg/L	η , [%]	*C* mg/L
1	Grit removal units (grids, screen)	5...20	–	5...10	–	–	–
2	Primary clarification	40...60	–	20...35	–	20...35	–
3	Physico-chemical treatment	80...95	20	40...65	100	40...65	150
4	Extended aeration	90	30	95...98	20	80	90
5	Average biological load active sludge tanks	90	30	90...95	30	80	90
6	Primary clarification+ +average biological load active sludge tanks	90	30	90...95	30	80	90
7	Primary clarification+ +small biological load active sludge tanks(with nitrification)	90	30	95	20	80	90
8	Primary clarification + +high biological load filters	85	40	80	60	75	120
9	Primary clarification+ +biological small load filtration	90	25	90	25	80	90

Table 1
Continuation

Nr	Installations and procedures	MS		CBO_5		CCO	
		η , [%]	*C* mg/L	η , [%]	*C* mg/L	η , [%]	*C* mg/L
10	Physico-chemical treatment+granular filters for carbonic polutants	95	15	90	30	80	90
11	Pysico-chemical treatment+granular filtres for carbonic and nitrate polutants	95	10	95	10	90	50
12	Primary clarification+average biological load active sludge tanks+sand filters	95	10	95	10	90	50
13	Primary clarification+ +average biological load active sludge tanks+granular filters for nitrate polutants	95	10	95	10	90	50
14	Primary clarification+biological load active sludge tanks+simultaneous elimination of phosphorus+ filtration	95	<5	95	<5	90	50
15	Primary clarification+ +small biological load active sludge tanks+floculation+clarification+sand filters and CAG+clorination	–	< 1	–	< 1	–	10
16	Idem + membrane[1)]	–	<1	–	<1	–	<10

[1)] total content of solid matters: 100..200 mg/L.

We can finally notice that performance comes out as a result of increasing the biological processes at the expense of the physico-mechanical ones.

Received, July 14, 2010

"Gheorghe Asachi" Technical University of Iaşi,
Department of Hidrotechnical Structures
and Sanitary Engineering
email: v_cretu_2002@yahoo.com
and
**Department of Transportation Infrastructure*
and Foundations
e-mail: scprotoby@yahoo.com

R E F E R E N C E S

1. Brown R.J., *Sewage and Organic Irrigation.* (cited from the date basis NTIS-Gov.Rep Announca), 1988.
2. Dima M., *Epurarea apelor uzate urbane*. Edit. Junimea, Iaşi, 231-232, 1998.
3. Ionescu S., *Irigarea culturilor.* Edit. Ceres, Bucureşti, 1982.
4. Negulescu C.Al., *Unele rezultate privind utilizarea apelor uzate la irigarea planta-țiilor silvice.* ICPGA, Ses. şt., **XXVIII**, Bucureşti, 1986.
5. Negulescu M., *Protecția calității apelor.* Edit. Tehnică, Bucureşti, 1993.
6. Tobolcea V., *Managementul tratării apelor uzate*. Edit. Tehnopress, Iaşi, 2004.
7. Tobolcea V., *Contribuții privind epurarea apelor uzate pentru folosirea în agricul-tură*. Edit. Tehnopress, Iaşi, 2004.

UNELE ASPECTE PRIVIND VALORIFICAREA APELOR UZATE TRATATE

(Rezumat)

Epurarea apelor uzate pentru folosințe agricole în sistemele de irigații reprezintă ansamblul de măsuri şi procedee prin care impuritățile de natură chimică sau bacteriologică conținute în apele uzate sunt reduse la anumite limite încât aceste ape să nu dăuneze solurilor şi culturilor. Prin componentele lor trebuie să contribuie la sporirea producției şi să nu pericliteze ecosistemul.

Schemele tehnologice ale stațiilor de epurare sunt condiționate de gradul de epurare, ca efluentul să îndeplinească rolul de reglare a necesarului de substanțe nutritive în ecosistemul agricol ce constituie folosința.

Se propun scheme ale gospodăriei calitative pentru o stație de epurare ce deserveşte un sistem de irigații cu irigare directă şi cu irigare indirectă.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

THE INFLUENCE OF ACCIDENTAL FLOODS ON THE HYDROTECHNICAL WORKS STABILITY AND THEIR IMPACT ON THE ENVIRONMENT

BY

M. DIMA and DIANA-ANDREEA DONCIU

Abstract. The causes of accidental floods and their impact on the environment are studied. Torrential rains represent an important factor in accidental floods. The impact on the environment is for a short period, but the effects might be disastrous and long standing.

Key words: accidental floods; torrential rain.

1. Introduction

The hydrotechnical works executed on a water course can be built with the purpose of shore protection (dikes) or water accumulation for the individual use (dams). Based on the natural and anthropogenic factors specific to an area, in exploitation can appear phenomena which put in danger their stability and the environmental state through the impact they can induce.

In this paper, the effect of accidental floods caused by torrential rains are analysed. These are more disastrous than the natural floods regarding the way in which the environment is affected. Their production creates an ecological perturbation. Thus, some case studies in Romania are performed, on which mitigation and environmental protection measures are developed.

2. Torrential Rains

A torrential rain is defined like an atmospheric phenomenon characterized by a great water volume which falls in a short period of time. Its duration can vary from a few minutes to several hours, and its intensity diminishes when the distance starting from the rain center grows. The mean intensity of a torrential rain can be expressed as the ratio between the height of the fallen rain and its duration

$$h_m = \frac{h}{t}, \tag{1}$$

where: h_m is the mean intensity of the rain, [mm/h], [mm/min], which remains on the surface; h – the height of torrential rain [mm]; t – the duration of torrential rain, [h], [min].

The way in which the basin reacts when it is subjected to a load is named *hydrological response* and it is described in Fig. 1.

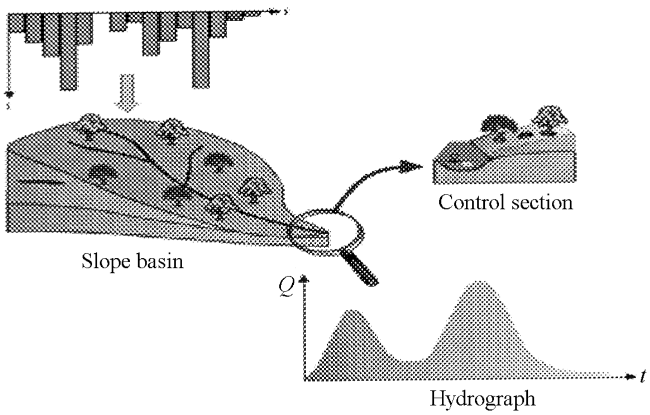


Fig. 1 – The hydrological response principle on a slope basin.

A torrential rain fallen on the slope basin surface can have as consequences, at a control station situated on the course of a river which discharges into an accumulation lake, a null answer without flow modifications and flash floods, or a positive answer with flow modifications and flash floods.

According to the Norton principle, the rain transformation into a hydrographer (Fig. 2) is defined through gradually aplication of two functions: the *production function or infiltration function* and the *transfer function*. The first function allows the determination of the net rain starting from the brute rain. The transfer function helps also to determine the flash floods hydrographer which results from the net rain. At the transition of the rain graphs into a flash floods hydrographer, all the weather, physical and hydrological characteristics of the slope basins interced. The hydrological response of a slope basin is influenced by a lots of factors like

a) climate conditions of the environment;

b) precipitations (spatial and temporal repartition, intensity and duration);

c) the morphology of the slope basin;

d) structure of the hydrographical system;

e) physical properties of the slope basins.

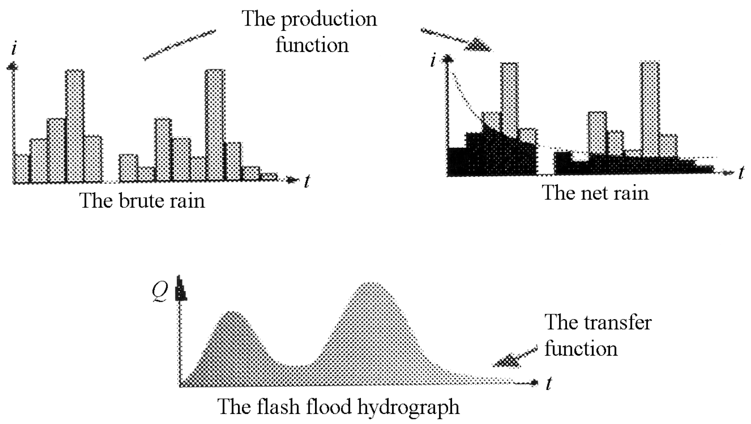


Fig. 2 – The brute rain transformation into a flash flood hydrograph.

Therefore, IATE/HYDRAM (the Institute of Soil ans Water Management) has developed an informatic application which allows to study the hydrological response on a basin that is subjected to a precipitation load.

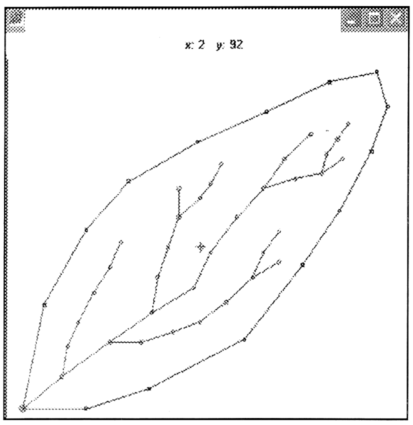


Fig. 3 – The basin's geometry.

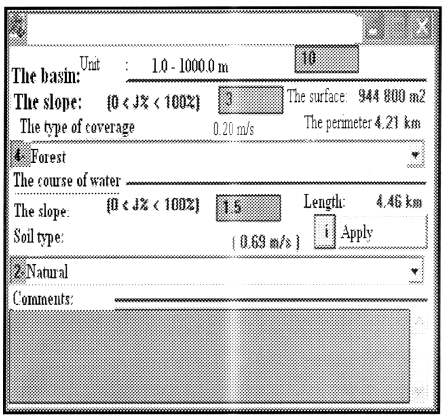


Fig. 4 – The basin's characteristics.

Behind the use of application on a certain basin with a hydrographic system situated upstream of an accumulation lake, the results are the followings: the basin and hydrographic system's geometry (Fig. 3), the basin's characteristics (Fig. 4 – surface, perimeter, slope, soil), the brute and net rain (Fig. 5) and the resultant hydrographer (Fig. 6).

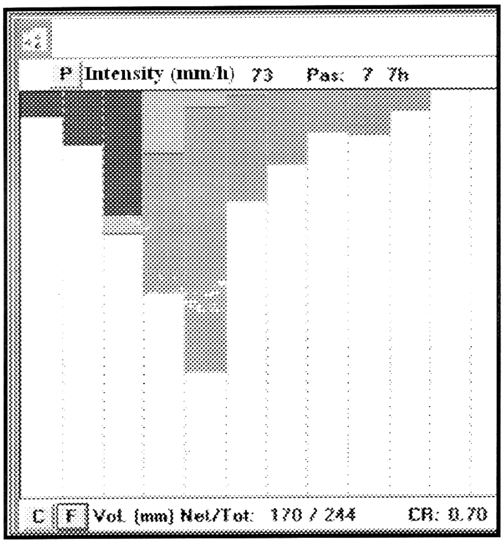


Fig. 5 – The brute and net rain.

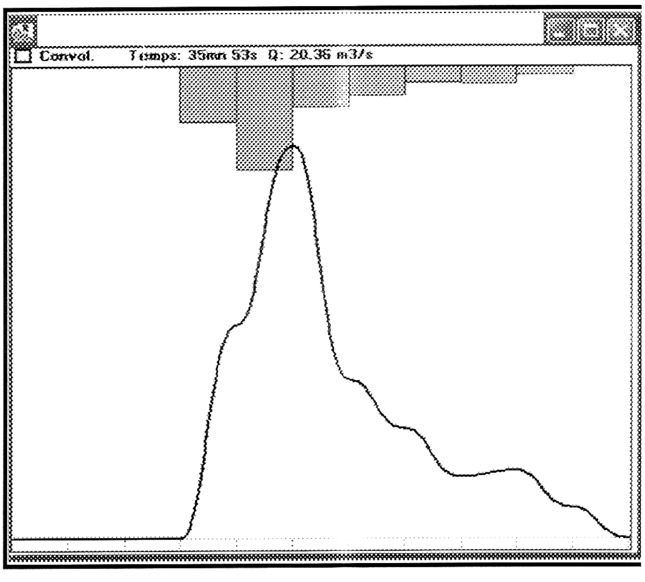


Fig. 6 – The resultant hydrograph.

3. Case Sudies: the Belci Dam and Fash Foods in Romania

The dams that are built with local materials and the concrete dams are not designed to resist to spilling over dam; if the discharge occurs accidentally, the dams are partially or totally broken, and the accumulation is rapidly drained. The accumulation lakes exert a great influence on the versants and the areas around dams.

In the case of Belci dam the breakage happened as a result of an exceptional flash flood which induced spill over dam. The rainfalls between the 28…29th of July 1991 from Western Carpathians and Sub-Carpathians in Moldova produced a flood wave on Tazlău river (Bacău county) about 7 m height. In just half an hour, at Lucăceşti hydrometric station, on 30 km upstream, 95.6 L/m^2 of precipitations were registered, and at Livezi station, on 16 km upstream, were registered 148.8 L/m^2. The downstream hydro was stopped due to a technical malfunction, and the power supply of dam mechanism was switched off.

The lake water level had risen quickly, so the water reached the upper limit and began to spill over the earth dam. At about 4:50 a.m. a downstream increase of the flow of about 1,800 m^3/s was produced, which denotes the dam collapse. At 7:15 a.m., the lake was almost empty, and at 7:50 a.m. the Tazlău river was flowing through a channel formed by the sediments from the lake and it was passing downstream through a breach formed on left shore of the dam's dike. The maximum flow of the flash flood on the Tazlău river between the 28…29th of July was of about 3,100 m^3/s.

The earth dam failure mechanism was the superficial erosion of the downstream upper side, simultaneous with its saturation and then the downstream embankment slide followed by pronounced erosion. The accident's causes were: in the design phase, the dam was classified in the first class of importance, for which the design flows of 0.1% insurance and 0.01% verification, were much inferior to the determined values based on the hydrological observations from 25 years of exploitation, of 1,515 m^3/s and, respectively, 2,450 m^3/s. Although known, the change of maximum flows did not led to an increase of the evacuation capacity. In these conditions, spill over dam and then the failure were produced due to the exceptional flash flood from the night of the accident, estimated at 2,800…3,000 m^3/s, and due to the impossibility of operating the hydro-mechanical equipment because of power supply failure.

The effects of this flash flood were represented by 25 losses of human lives and 250 downstream houses were totally affected.

Flash floods on Ialomița, Prahova and Sărata rivers – September 2005: between the 19…22th of September 2005 high precipitation took place in superior basins of the Prahova and Ialomița rivers. These lead to a great flash flood forming on the Ialomița, Prahova, and Sărata rivers. The levels and maximum flows recorded at hydrometric stations in the formation and propagation period of the flash flood are indicated in Table 1.

Table 1

The Maximum Levels and Flows, September 2005

Hydrometric station	Date	Maximum level cm	Maximum flow m^3/s
Adâncata	21.09.2005	510	912
Coşereni	22.09.2005	741	1,332
Ciochina	25.09.2005	559	830
Slobozia	27.09.2005	432	470
Ţăndărei	29.09.2005	543	468

The levels and flows were maintained over danger baselines for a long period namely

a) H.S. Adâncata: 54 hours;
b) H.S. Coşereni: 72 hours;
c) H.S. Ciochina: 127 hours.

After the overflow of the dangerous levels, spills over dam occur

a) The dike on the left shore of the Prahova river – Adâncata village: the dangerous level was exceeded with 110 cm, resulting spill over dike.

b) The Moldoveni dike – Patru Frați – the left shore of the Ialomița river: spill over dike occurs in two areas about 50 m causing versants erosions, and the water reached in Moldoveni village.

c) Because of the great flow the water was discharged on the highway between Urziceni and Bucharest on DN 2, Bărbuleşti village being flooded. The water spilled over the dike on the right shore of the Sărata river producing two breaches through erosion. After the water has retreated, another two breaches were created for water drainage from Bărbuleşti village to Sărata river.

d) The Coşereni dike – Bărbătescu: the water was spilled over dike in Axintele village; a breach about 40 m was caused by erosion, and the water reached in Bărbătescu village. This dike presents an erosion of the versant of about 100 m length, the dike's stability being weakened. For water evacuation from Bărbătescu village an artificial breach was created downstream of the dike.

e) The Slobozia dike – Bucu – the left shore of the Ialomița river : in downstream, the water was spilled over dike causing a breach of about 15 m. A pasture surface and agriculture lands were flooded without endangering the inside of the village.

f) The Mărculeşti dike – Țăndărei – the right shore of the Ialomița river: a breach of 30 m was produced through dike failure in Sudiți village. In this area the versant of the dike was eroded, weakening its stability on 300 m length. It is mentioned that the maximum flows recorded in hydrometric stations exceeded about 30 times the mean annual values.

The flash flood produced between 21…30th of September 2005 is comparable with the flash flood in 1975. In the Adâncata – Urziceni – Manasia area, the floods were produced due to spill over dike through overrunning with 110 cm of dangerous level. At the dike from Ion Roată village a breach of 50 m was formed, the dike being poorly designed. Therefore, for bringing the dike at the safety parameters required, suggestions and substantiation notes were made.

4. The Environmental Impact and Safety Measures

The environmental impact is for a short term, but the effects are present for a long term. The water from downstream area of the dam reaches heights that can overrun peoples' houses, and due to very high velocities can produce devastating effects on the environment over a large area.

During floods, water can infiltrate in chemical toxic storage systems producing an accidental and massive pollution. The water contains contaminated suspense materials in high concentrations and large quantities of heavy metal ions attached on sediments which are deposited in the flooded area at the end of the flash flood, having long term effects on the quality of water. The quality of underground water (used as water supply) is degraded along with the choking of fountains from peoples' farms. Due to the erosion and soil washing, the turbidity on the water course can increase. A lot of houses, farms, agricultural lands, cultivations, traffic routes, bridges and hydrotechnical works are devastated (Fig. 7).

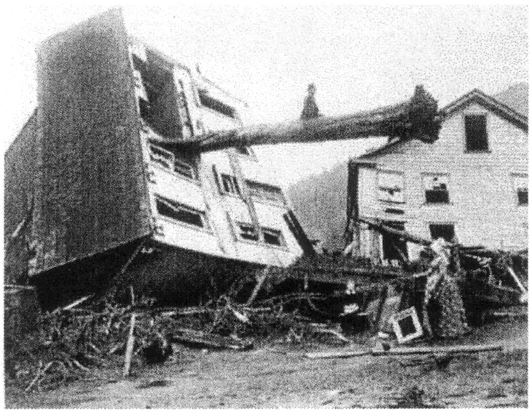


Fig. 7 – The Johnstown dam breakage due to the water effects (1889).

The sediments during flash floods have a washing and carriage effect on organic substances, including pathogen bacteria, viruses, modifying the ecological balance and affecting the life conditions of plants and animals. The accidental floods influence the flow of underground water through rising levels over the soil leading to an excess of humidity with negative effects on cultivations, foundation soils and soil quality.

The landscape is degraded. Temporary, favourable environments for diseases transmission can be created due to water stagnation for a long term, fact that favours the development of infections' vectors (Fig. 8).

Fig. 8 – Water stagnation in Indonesia.

Because the precise determination of damages is difficult, with CADANAV project (2001), Beck and Musy use a simplified approach for vulnerability evaluation (Table 2).

Table 2

Damages Determination and Evaluation

Damages' levels	Material losses	Losses of human lives	Secondary effects
Minimum	Reduced material losses and reduced costs for restoration. Evaluation in monetary units.	Losses of human lives and accidents are rare, as a result of land occupation or its accidental use. Evaluation in losses of human lives.	Reduced secondary effects.
Medium	Material losses at individual levels. Evaluation in monetary units.	Losses of human lives are probable but the recorded cases are isolated. Evaluation in losses of human lives.	Localized secondary effects. Evaluation in monetary units.
Maximum	Significant material losses in territory with high costs of restoration. Evaluation in monetary units.	Great losses of human lives affecting large groups of persons. Evaluation in losses of human lives.	Generalized secondary effects (economics, social and politic). Evaluation in monetary units.

5. Proposals for Diminishing the Effects of Accidental Floods

Despite all the protection measures that were taken against floods during flash floods, there is always a risk of flooding. Two types of protection measures against floods are defined: structural and non-structural measures.

Depending on the way the structural measures act, they are divided in

a) measures that reduce the maximum flow of the flash flood;

b) measures that reduce the maximum levels in beds;

c) measures that reduce the flash floods' duration;

d) measures that protect the population and the objectives from river bed.

The reduction of maximum flows of flash floods, in practice, is realized through

a) the development of the versants from the basin, including forestations and retention works of the rainwater and works for flowing delay in urban areas;

b) permanent accumulations;

c) temporary accumulations and rehabilitation works of the rivers;

d) works for water derivation.

The reduction of maximum levels in rivers bed is made through

a) the cleaning of rivers' beds;

b) the development of rivers' beds.

The non-structural measures are

a) territory planning and management; management of the rivers' bed; elaboration of the risk charts;

b) hydrological warnings and forecasts of the flash floods;

c) revaluation of the hydrotechnical works exploitation for protection against floods with the help of forecast information on flash floods;

d) planning the best method to use the agricultural land in order to retain the water in soil;

e) creating a legal background in which can function the institutions responsible for the elaboration of strategies and decisions at state level;

f) economical instruments: insurance of material goods by insurance companies; elaboration of negotiation criteria between the involved factors in the use of flooded areas.

6. Conclusions

Taking into account the above observations, it result that the hydrotechnical works, especially the dams with their accumulation lakes, are exposed, due to natural and anthropogenic factors, to some risks whose effects are difficult to quantify.

Thus, the authors consider that, besides a good monitoring with adequate devices and instruments, technically measures are submitted for rapid intervention after torrential rains.

Received, July 14, 2010

"Gheorghe Asachi" Technical University of Iaşi,
Department of Hidrotechnical Structures
and Sanitary Engineering
email: diana_timofti@yahoo.com

R E F E R E N C E S

1. Stănescu V.Al., Drobot R., *Măsuri nestructurale de gestiune a inundaţiilor*. Edit. HGA, Bucureşti, 2002.
2. Roşu C., Creţu Gh., *Inundaţii accidentale*. Edit. HGA , Bucureşti, 1998.
3. Giurma I., Crăciun I., *Hidrologie şi hidrogeologie*. Vol. **1**, Inst. Politehnic, Iaşi, 1987.
4. Giurma I., *Viituri şi măsuri de apărare*. Edit. „Gh. Asachi", Iaşi, 2003.
5. Şelărescu M., Podani M., *Apărarea împotriva inundaţiilor.* Edit. Tehnică, Bucureşti, 1993.
6. http://echo.epfl.ch/e-drologie/chapitres/chapitre11/main.html

INFLUENŢA INUNDAŢIILOR ACCIDENTALE ASUPRA STABILITĂŢII CONSTRUCŢIILOR HIDROTEHNICE ŞI IMPACTUL LOR ASUPRA MEDIULUI ÎNCONJURĂTOR

(Rezumat)

Se studiază cauzele inundaţiilor accidentale şi impactul lor asupra mediului. Ploile torenţiale reprezintă un factor important în inundaţiile accidentale. Impactul asupra mediului înconjurător este de scurtă durată, dar efectele pot fi dezastroase şi pe termen lung.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

THE INFLUENCE OF TROPOSPHERIC REFRACTION IN GLOBAL POSITIONING SYSTEM

BY

D. ILIOI, ERSILIA ONIGA and GABRIEL SĂNDULACHE

Abstract. This paper analyses the tropospheric effects on Global Positioning System (GPS) signals and how tropospheric refraction varies depending on the atmospheric parameters, season and elevation angle. There will be presented the main mathematical formulas for the tropospheric refraction and will be determined how the observations elevation angle influences the measurements.

Key words: GPS; satellite; geodesy; troposphere; ionoposhere; refraction.

1. Introduction

The troposphere represents the lowest, gaseous part of the atmosphere situated between the surface of the Earth to about 40…50 km. The propagation delay of the Global Positioning System (GPS) signals through the troposphere depends on the water vapour content and on temperature. Hence, tropospheric refraction varies with geographic location and season.

The propagation of radio waves through the troposphere is subject to the laws of physics. The signal path bents from the straight geometrical connection between the observer and the satellite and as a result of tropospheric refraction, the optical distance measured is longer than the direct geometrical range.

2. The Tropospheric Refraction Models

The troposphere can be defined as the gaseous part of the lower atmosphere where the weather takes place. Within the troposphere the temperature decreases with height by 6.5°C and varies horizontaly with only a few degrees/km. Given the fact that charged particles are virtually absent and the uncharged atoms and molecules are well mixed, the troposphere can practically be considered a neutral gas. Furthermore, because nearly 90% of the atmospheric mass is below 16 km altitude and nearly 99% below 30 km [2], the index of refraction, which is slightly greater than 1 to begin with, decreases with increasing height and becomes nearly 1 at the upper limit of the troposphere, corresponding to the continuously decreasing density of the medium.

The index of refraction does not depends on the frequency of the signal; it depends on air pressure, temperature and water vapour pressure of the atmosphere. Because these three parameters vary so much and are so dynamic within the troposphere, it is very difficult to predict and/or model the index of refraction.

A direct measurement of the refractivity along the signal propagation path is then not feasible. Therefore various models for a description of the height-dependent behavior of the refractivity have been developed. Best results were obtained by H o p f i e l d [6], who has published the basic research in the field. Input parameters are mostly the meteorological surface data near the observation site.

The impact of the state of the troposphere on the waves propagation (δd_t) can be characterized by the following algorithm:

$$\delta d_t = \delta d_d + \delta d_w = \frac{K_d}{\sin\sqrt{E^2 + 6.25}} + \frac{K_w}{\sin\sqrt{E^2 + 2.25}}, \tag{1}$$

where: K_d and K_w describe the total effect of the tropospheric refraction in the direction to the zenith, corresponding to the dry term and to the wet term, respectively, and E represents the elevation angle of the satellite the way it is seen by the observer, as illustrated in Fig.1.

The dry and the wet terms, δd_d and δd_w , are determined separately because their parameters are formulated as distinct functions of height

$$\begin{cases} K_d = 155.2 \times 10^{-7} \dfrac{P}{T} H_d, \\ K_w = 155.2 \times 10^{-7} \dfrac{4,810e}{T^2} H_w, \end{cases} \tag{2}$$

with P – the air pressure, in Hectopascal, [HPa], e – the partial pressure of the water vapour, [HPa], and T – representing the temperature, [K]; H_d and H_w are the effective altitudes of the dry and the wet terms, respectively.

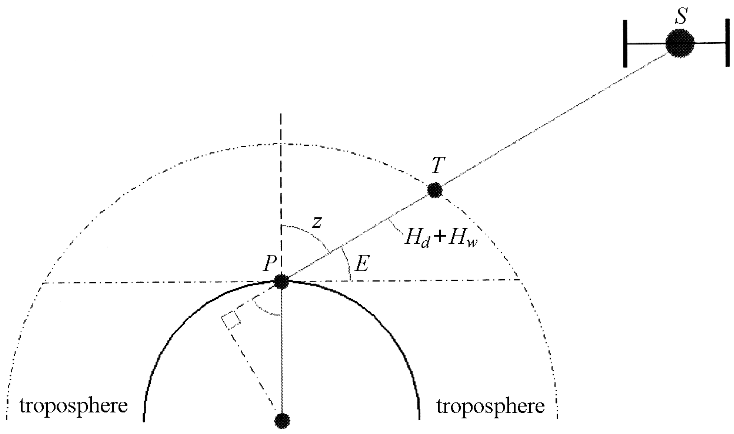


Fig. 1 – The tropospheric model.

Generally, for H_w a mean value is accepted (H_w = 11,000 m), but the parameter H_d was determined by Helen H o p f i e l d [6] empirically from globally distributed balloon data

(3) $$H_d = 40,136 + 148.72\left(T - 273.16\right).$$

For elevations $E > 30°$, Harold B l a c k [5] proposes the simple correction formulas

(4) $$\delta d_t = \delta d_d + \delta d_w = 2.31P \operatorname{cosec} E + K_w \operatorname{cosec} E,$$

where: P is the air pressure in atmospheres (1 atm = 1,013.25 Hpa), and K_w – a regional empirical constant with values ranging from 0.05 to 0.28, as showed in Table 1.

Table 1

Variation with Season and Region of K_w

Region and Season	K_w
Summer in tropical areas or mean latitudes	0.28
Spring or autumn in mean latitudes	0.20
Winter in maritime latitudes	0.12
Winter in continental mean latitudes	0.06
Polar regions	0.05

3. The Determination of Tropospheric Refraction Corrections

Based on the model presented above, there were determined the values for the corrections that characterize the phenomenon of tropospheric refraction in GPS measurements for the region of Iaşi county, Romania, during the seasons of summer and winter.

For the studied case was considered a temperature of 20°C near the observation site for the summer and –10°C during the winter, with an atmospheric pressure of 1,013.25 HPa, as presented in Table 2. With eqs. (2) and (3) there were also determined the actual dry altitudes, along with the total tropospheric refraction effect to the zenith, with respect to the dry and wet components, respectively.

Table 2
The Parameters of the Tropospheric Refraction Correction for Iaşi County

Parameters		Summer	Winter
Temperature, T		20°C	–10°C
Atmospheric pressure, P		1,013.25 HPa	1,013.25 Hpa
Partial water vapour pressure, e		36.25 HPa	5.52 Hpa
Dry altitude, H_d		43,110.4 m	38,648.8 m
Wet altitude, H_w		11,000 m	11,000 m
The tropospheric refraction effect to the zenith	K_d	2.3138 m	2.3109 m
	K_w	0.3467 m	0.0655 m

In Table 3 were indicated the tropospheric refraction corrections for Iaşi county, calculated with eq. (1), based on Hopfield model. The values were determined for different elevation angles of the observations.

Table 3
The Tropospheric Refraction Corrections for Iaşi County [Hopfield]

E		90°	60°	45°	30°	15°	10°	5°
δd_d, [m]	Summer	2.31	2.67	3.27	4.61	8.82	12.93	23.75
	Winter	2.31	2.67	3.26	4.60	8.81	12.91	23.72
δd_w, [m]	Summer	0.35	0.40	0.49	0.69	1.33	1.97	3.81
	Winter	0.07	0.08	0.09	0.13	0.25	0.37	0.72
δd_t, [m]	Summer	2.66	3.07	3.76	5.31	10.15	14.91	27.56
	Winter	2.38	2.74	3.36	4.74	9.06	13.29	24.44

From the analysis of these values one can observe that the effect of tropospheric refraction increases with increasing of zenith angle, z, or, in other words, with decreasing the elevation angle, E. For elevations $E < 10°$ the influence easily exceeds 10 m.

On the other hand, the portion of the wet term, which depends on the distribution of water vapour in the atmosphere and is therefore harder to model, reaches only around 10% of the total influence.

Moreover, the values in Table 3 show that the differences from summer to winter conditions between the total errors due to the tropospheric refraction in determining the pseudorange at GPS signal propagation are also within 8…10%. Same thing, when station distances are smaller < 50 km and when the height differences are small (in non mountainous regions, as Iaşi county), the atmospheric conditions are sufficiently correlated with one another which means that the water vapour content of the air is almost identical horizontally.

It is hence not advisable to introduce the observed meteorological data separately for each station into the adjustment of a small network.

4. Conclusions

The resulting range error for GPS signals, produced by the tropospheric refraction, can vary from less than 1 m to more than 25 m.

The effect of tropospheric refraction increases severely for GPS observations at low elevation angles.

If the stations are close together, the tropospheric residual error disappears almost completely by differentiating the relative observation mode.

Received, December 25, 2009

"Gheorghe Asachi" Technical University of Iaşi,
Department of Cadastre
email: dilioi@yahoo.com

R E F E R E N C E S

1. Davies K., *Ionospheric Radio*. IEEE Electromagnetic Waves series **31**, Peter Peregrinus, London, 1990.
2. Lutgens F., Tarbuck E., *The Atmosphere: an Introduction to Meteorology*. Prentice Hall, Upper Saddle River, NJ, 1998.
3. Langley R., *Propagation of the GPS Signals*. Teunissen, Kleusberg, 1998, 111-149.
4. Seeber G., *Satellite Geodesy*. Walter de Gruyter, Berlin-New York, 2003, 589.
5. Black H.D., *An Easily Implemented Algorithm for the Tropospheric Range Correction*. J. of Geophys. Res., **83**, *B4*, Washington, 1825-1828 (1978).
6. Hopfield H.S., *Two-Quartic Tropospheric Refractivity Profile for Correcting Satellite Data.* J. of Geophys. Res., **74**, Washington, 4487-4499 (1969).
7. Schüler T., *On Ground-Based GPS Tropospheric Delay Estimation*. Ph. D. Diss., Institute of Geodesy and Navigation, Univ. FAF, München, Germany, 2001.

INFLUENȚA REFRACȚIEI TROPOSFERICE ASUPRA MĂSURĂTORILOR GPS

(Rezumat)

Se analizează efectul troposferei asupra semnalului GPS, modul de variație a refracției troposferice în funcție de regiunea geografică, de sezon, precum şi în funcție de unghiul de oblicitate.

Sunt prezentate expresiile pentru corecțiile ce trebuie aplicate observațiilor GPS, astfel încât sa fie eliminate erorile datorate fenomenului de refracție troposferică la măsurarea pseudodistanțelor.

În ultima parte sunt determinate, pe un caz concret, corecțiile ce trebuie aplicate măsurătorilor GPS, efectuate pe raza județului Iaşi.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

CONSIDERATIONS REGARDING THE GRAPHIC PARCELING FOR CADASTRAL WORKS

BY

HORAŢIU HOGAŞ, MARCEL ROMAN and D. ILIOI

Abstract. This paper proposes a graphical solution to solve the serial-parallel detachments for cadastral works, namely the triangular parallel detaching series. The graphical solution is put forward along with the mathematical formulas that support it theoretically.

Key words: cadastre; graphic parceling; detachments; parcel maps.

1. Introduction

Cadastre and Land Registration Law no. 7/1996 together with the property laws, have provided the legal framework necessary to solve the issues related to the land property, evidence and inventory, land registration in public documents – the Land Registry Lodging Book, thus facilitating real estate transactions, mortgage loans, etc. In certain cases, real estate transactions required that land be parceled out. Often, the only available graphical information for prompt, yet less precise, analysing and solving these issues were provided by an analogical support represented by either a topographical or cadastral plan or a plot annexed to the property documents, all of them drawn up at high and very high scales. The present paper suggests a solution for parceling out graphically a land plot in parcels of equal areas. For this reason it is assumed that the land plot has a triangular shape. It was chosen the triangular shape due to the fact that on the one hand, it is the simplest way with regard to mathematical proceedings, and, on the other hand, in the most cases the solutions for the other polygons are reduced to triangles.

2. The Triangular Graphic Parceling

First, it is considered a land plot of triangular shape and known area. The problem requires detaching the whole surface in a series of *n* plots of equal area and further more that the detaching straight lines to be parallel with the triangle base (Fig. 1).

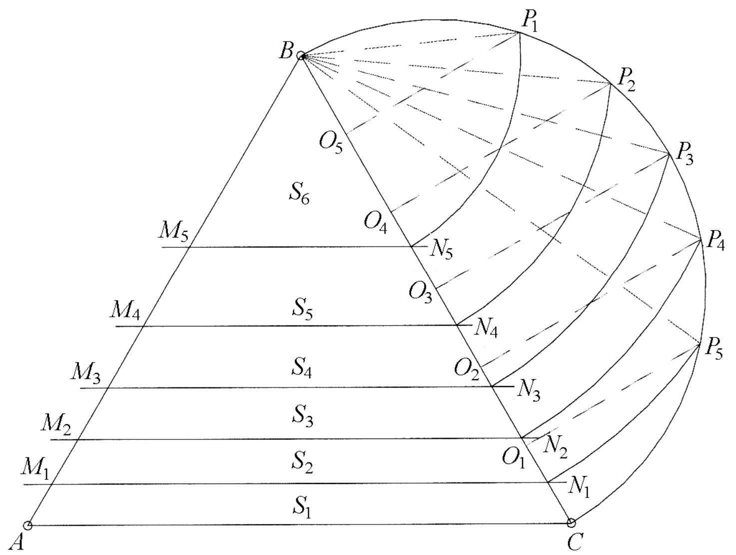


Fig. 1 – The triangular parallel detaching series, graphical solution.

In order to solve this problem, the following auxiliary graphical structures are plotted:

a) It is drawn a semicircle having as diameter the $\overline{BC}$ side of the triangle.

b) $\overline{BC}$ side of the triangle is divided in so many equal parts as the number of parcels, respectively *n* (in the example shown in Fig.1, one has considered $n = 6$). Thus, there were obtained the points O_i, ($i = \overline{1,5}$).

c) From the points O_i, ($i = \overline{1,5}$), were raised perpendiculars on the $\overline{BC}$ side of the triangle until they intersected the drawn semicircle in the points P_i, ($i = \overline{1,5}$).

d) Placing the compass tip in B, arcs of radius $\overline{BP_i}$ were drawn, and as a result N_i points, with ($i=\overline{1,5}$), were determined.

e) Starting from the points N_i, ($i=\overline{1,5}$), were drawn parallels to $\overline{AC}$ side of the triangle and thereby the sought detaching straight lines were obtained.

Solving the triangular parallel dislocation series is based on the following lemma:

"In ΔABC, if O divides $\overline{BC}$ side with a ratio, noted r, *i.e.* $\overline{CO}/\overline{BC}=r$, $r\leq 1$, then $S_{MNCA}/S_{\Delta ABC}=r$", as seen in Fig. 2.

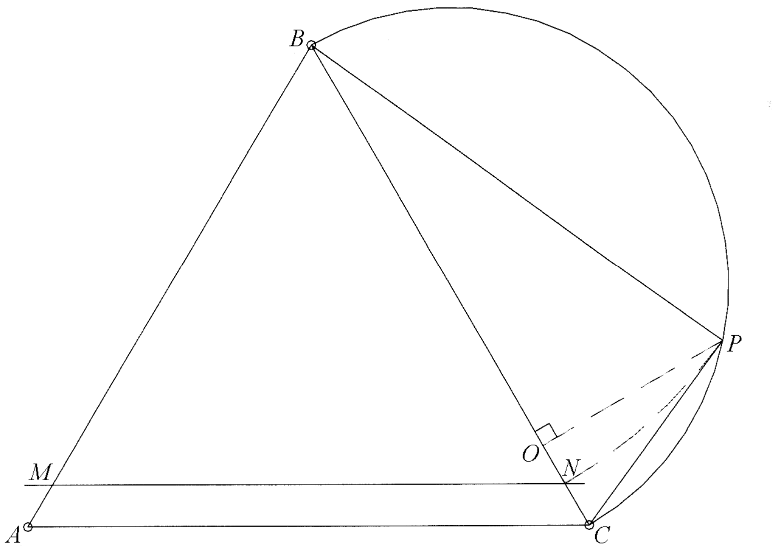


Fig. 2 – The graphic parallel detaching of a given land area.

In order to demonstrate the lemma enounciation, one has proceeded in the following manner:

a) Due to $\Delta BMN \approx \Delta ABC$, it can be written:

$$\frac{S_{\Delta BMN}}{S_{\Delta ABC}}=\left(\frac{\overline{BN}}{\overline{BC}}\right)^2. \tag{1}$$

b) In ΔBPC, right-angled in P (due to the fact that the BPC angle subtends the diameter $\overline{BC}$), using the cathetus theorem it results

$$\overline{BP}^2=\overline{BO}\cdot\overline{BC}. \tag{2}$$

c) Yet $\overline{CO}/\overline{BC} = r$, which gives

(3) $$\frac{\overline{BO}}{\overline{BC}} = 1 - r \text{ and } \overline{BO} = (1-r)\overline{BC}.$$

Consequently it can be written

(4) $$\overline{BP}^2 = (1-r)\cdot\overline{BC}\cdot\overline{BC} \;\; i.e.\;\; \frac{\overline{BP}^2}{\overline{BC}^2} = 1 - r,$$

or

(5) $$\frac{\overline{BN}^2}{\overline{BC}^2} = 1 - r.$$

But according to eq. (1)

(6) $$\frac{\overline{BN}^2}{\overline{BC}^2} = \frac{S_{\Delta BMN}}{S_{\Delta ABC}},$$

which leads to

(7) $$\frac{S_{\Delta BMN}}{S_{\Delta ABC}} = 1 - r.$$

Since

(8) $$\frac{S_{\Delta BMN} + S_{MNCA}}{S_{\Delta ABC}} = 1 \text{ or } \frac{S_{\Delta BMN}}{S_{\Delta ABC}} + \frac{S_{MNCA}}{S_{\Delta ABC}} = 1 \;\; i.e.\;\; \frac{S_{MNCA}}{S_{\Delta ABC}} = 1,$$

then

(9) $$\frac{S_{MNCA}}{S_{\Delta ABC}} = r.$$

Returning to the triangular parallel detaching series, if

(10) $$\frac{\overline{CO_1}}{\overline{BC}} = r, \quad r \in (0,1)$$

and based on the built graphical plots considered, where,

$$\overline{CO_1} = \overline{O_1O_2} = ... = \overline{O_nB}, \tag{11}$$

it results

$$\frac{\overline{CO_2}}{\overline{\overline{BC}}} = 2r, \quad \frac{\overline{CO_3}}{\overline{\overline{BC}}} = 3r, ..., \frac{\overline{CO_n}}{\overline{\overline{BC}}} = nr. \tag{12}$$

But according to the above mentioned lemma,

$$\frac{S_1}{S} = r, \quad \frac{S_1 + S_2}{S} = 2r, ..., \frac{S_1 + S_2 + ... + S_n}{S} = nr, \tag{13}$$

where S_i , $\left(i = \overline{1, n}\right)$, represents the area of trapeziums $M_iN_iN_{i\text{-}1}M_{i\text{-}1}$, $\left(i = \overline{1, n}\right)$, and S is the area of ΔABC. Thus it is achieved the stated goal that

$$S_1 = S_2 = ... = S_n = s, \tag{14}$$

hence all the detached areas are equal.

3. Conclusions

1. The existence of numerous graphical documents on analogical support only, often requires the employment of graphical solutions for parceling out. The present paper suggests a solution to this kind of graphical problems together with the mathematical formulas that support it theoretically.

2. If the areas to which graphical detachments are carried out are polygons with a number of sides higher than three, the solving can be performed similarly by reducing the problem to the development of a triangular parallel detaching series.

Received, February 15, 2010

"Gheorghe Asachi" Technical University of Iaşi,
Department of Cadastre
email: hhogas@yahoo.com

R E F E R E N C E S

1. Tămăioagă Gh., Tămăioagă D., *Cadastrul general şi cadastrele de specialitate*, Edit. Matrix Rom, Bucureşti, 2005.

2. * * * *Ordinul 634/2006 pentru aprobarea Regulamentului privind conţinutul şi modul de întocmire a documentaţiilor cadastrale în vederea înscrierii în cartea funciară*. Monitorul Oficial al României, Partea I, nr. *1048*, 29 decembrie 2006.

CONSIDERAŢII PRIVIND PARCELAREA GRAFICĂ ÎN LUCRĂRILE DE CADASTRU

(Rezumat)

Se prezintă o soluţie de rezolvare pe cale grafică a detaşărilor paralele în serie, în triunghi, din cadrul lucrărilor de cadastru. Dacă suprafeţele din care se efectuează detaşările grafice sunt poligoane cu numărul de laturi mai mare ca trei, rezolvarea este asemănătoare, reducând problema, după caz, la una de detaşare în serie, în triunghi.

În lucrare sunt de asemenea prezentate şi formulele matematice care reprezintă suportul teoretic al soluţiei grafice propuse.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

INCREASING THE INTAKE CAPACITY OF THE TIMIŞEŞTI NEW DRAIN BY REDUCING THE LOSSES UNDER THE DRAIN FOUNDATION RAFT

BY

C. NICU, *ESMERALDA CHIORESCU, **M. DIMA and ADRIAN NICU

Abstract. The proposed solution involves the application of modern technologies consisting in producing waterproof screens, embedded in the base, waterproof layer of the aquifer technology that involves only the investment expenses, not operational energy expenditure; in these conditions, regardless of slab drain placement related to the waterproof layer, it can be considered, in terms of hydraulics, as a perfect drain.

Key words: drain; water supply; hydraulics.

1. Introduction

The aim of this paper is to present a calculus method for improving the capacity of drains used in water supply. Are presented modern technologies for producing waterproof screens, waterproof layer for the aquifer that does’nt use operational energy expenditure.

2. Research Method

It was used the MQV3.m program which consists in transcription using MATHLAB and modernization of the program from BASIC language MQV3.BAS used in [4]. These programs solve the fundamental equation of gradually varied flows, with varied flow in prismatic channels, considering water depth, $h = h(s)$, as an independent variable, and the flow, $Q = Q(s)$, as a dependent variable. For our application, the specific flow, $q = q(s)$, is determined as secondary of $Q = Q(s)$ flow and represent the exact flow captured by D.N. Timişeşti under actual operating conditions as imperfect drainage, $q_{\text{Imp}} = = q_{\text{Imp}}(s)$.

MQV3.m program input data include the geometric characteristics of D.N. Timişeşti – the water surface width, $B = B(h)$, the current life sectional area, $A = A(h)$, and hydraulic characteristics – flow equivalent modulus $K_{\text{ech}} = = K_{\text{ech}}(s)$ – specific features determined in this paper [5].

Table 1

Hydraulic Parameters of the Timişeşti New Drain and the Calculus of the Specific Flow in the Perfect Drain Hypothesis

No.	Point	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	s, [m]	124.40	376.30	630.30	884.40	1,145.30	1,415.0	1,680.6	2,055.70
2	Z_{RAFT}, [m]	268.787	269.439	270.080	270.768	271.281	272.011	272.800	273.764
3	$Z_{\text{WP\_LAY}}$, [m]	267.075	267.040	267.506	268.453	269.456	270.847	272.438	272.882
4	h, [m]	0.952	0.951	0.943	0.929	0.907	0.877	0.839	0.774
5	q_{Imp}, [L/s/m]	0.040	0.040	0.080	0.060	0.080	0.244	0.270	0.302
6	T, [m]	1.712	2.399	2.574	2.315	1.825	1.164	0.362	0.882
7	$p= qPf\,/\,q_{\text{Imp}}$	1.176	1.234	1.248	1.227	1.185	1.126	1.047	1.099
8	qPf, [L/s/m]	0.047	0.049	0.100	0.074	0.095	0.275	0.283	0.332
9	q_{Loss}, [L/s/m]	0.007	0.009	0.020	0.014	0.015	0.031	0.013	0.030
No.	Point	*9*	*10*	*11*	*12*	*13*	*14*	*15*	–
10	s, [m]	2,424.60	2,675.40	2,926.90	3,178.70	3,468.20	3,719.90	3,900.90	–
11	Z_{RAFT}, [m]	274.970	275.558	276.070	276.562	277.138	277.560	278.040	–
12	$Z_{\text{WP\_LAY}}$, [m]	272.781	273.188	273.596	274.005	274.552	275.083	275.457	–
13	h, [m]	0.695	0.633	0.564	0.489	0.394	0.304	0.236	–
14	q_{Imp}, [L/s/m]	0.430	0.308	0.092	0.064	0.307	0.307	0.307	–
15	T, [m]	2.189	2.370	2.474	2.557	2.586	2.487	2.583	–
16	$p= qPf\,/\,q_{\text{Imp}}$	1.217	1.232	1.240	1.247	1.249	1.241	1.249	–
17	qPf, [L/s/m]	0.523	0.379	0.114	0.080	0.384	0.381	0.384	–
18	q_{Loss}, [L/s/m]	0.093	0.071	0.022	0.016	0.077	0.074	0.077	

The representative data from hydro-geological and exploitation studies referring to the Timişeşti drains underground intake have been summarized in Table 1, rows 1,...,5 and 10,...,14 where: s is the spatial coordinate of the drain axis, with origin ($s = 0$) on the drain inlet with the collector shaft (C_0 – for the New Drain); Z_{RAFT} – drain foundation raft level (of drain lying); $Z_{\text{WP\_LAY}}$ – level of aquifer base layer (considered waterproof); T – aquifer opening (the vertical distance between base layer and foundation raft); h – water depth on drain (determined through measurements); q_{Imp} – specific flow captured by the drain, considered as imperfect drain, corresponding to the depth h; it was determined through numerical simulation with the MQV3.m program [4]); qPf –

specific flow drain captured by the perfect drain, corresponding to the depth $h + T$, (which will be determined using Loss_q_Drain.m program [6]).

Pier_q_Dren.m program was replaced by english translation in Loss_q_Drain.m program. The used MATHLAB Loss_q_Drain.m program [6], presents as input data: hydro-conductivity, k, the water depth in drain, h_0 , the water surface width in drain , $B = B(h_0)$, the opening of aquifer, T, and specific flow captured, considered as hydraulic imperfect , q_{Imp}. The output data of the program are: specifically captured flow (under the same hydrostatic pressure conditions in the aquifer, H, as in imperfect drain), qPf, considered as perfect hydraulic drain, water depth, $h + T$; specific flow losses, q_{Loss} and the ratio of the flows of perfect and imperfect drain, $p = qPf/q_{\text{Imp}}$.

Values for opening the aquifer, T, have been evaluated with the relationship

$$T = Z_{\text{RAFT}} - Z_{\text{WP\_LAY}}, \tag{1}$$

and are summarized in Table 1, rows 6 and 15.

Interpreting values for T-opening, it appears that the new drain has sections presented, in terms of hydraulics, imperfect ($T > 0$), so the solution proposed to increase the capacity of abstraction is applicable on sections with $T > 0$ (Table 1, rows 6 and 15).

Coordinates points s_i , with $i = \overline{1,15}$ (Table 1, rows 1 and 10), are located in the middle of the section bordered by C_{i-1} and C_i inspection chambers, as were deduced

$$\Delta s_i = 2\left(s_i - x_{i-1}\right) \text{ and } x_i = x_{i-1} + \Delta s_{i-1}, \text{ with } x_0 = 0 \text{ and } i = \overline{1,15}, \tag{2}$$

where x_0 , x_1 ,…, x_{15} are the coordinates of C_0, C_1,…,C_{15} inspection chambers, and Δs_i represent the lengths of influence sections for each inspection chamber.

Weighted average depth of water in the drain, h_{Med} , and the specific average flow captured by D.N., weighted in relation to the length of influence section, have been evaluated using the following relationships:

$$h_{\text{Med}} = \frac{1}{L_{\text{Dren}}} \sum_{i=1}^{15} h_i \Delta s_i = 0.7155 \text{ m}, \tag{3}$$

$$q_{\text{Imp}_{\text{Med}}} = \frac{1}{L_{\text{Dren}}} \sum_{i=1}^{15} \Delta s_i \left(q_{\text{Imp}}\right)_i = 0.1994 \text{ L/s/m}, \tag{4}$$

where L_{Dren} = 4,078 m is the total length of D.N., h_i and $(q_{\text{Imp}})_i$ are values for h depth (Table 1, rows 4 and 13), and, respectively, for the specific flow, q_{Imp} (Table 1, rows 5 and 14).

As for the new drain already exist technical solutions for increasing transmission capacity [5], we will further make a quantitative analysis in terms of increasing the abstraction capacity of the drainage by eliminating flow losses under the drain. For the aquifer exploited by D.N. Timişeşti was adopted the hypothesis of homogeneous and isotropic porous medium with average hydro conductivity (at saturation) $k_{\text{med}} = 0.0020$ m/s.

Running Loss_q_Drain.m program [6] for: $k = k_{\text{med}} = 0.0020$ m/s, $h_0 = h_{\text{Med}} = 0.7155$ m, $B = 1.3$ m, $q_{\text{Imp}} = q_{\text{Imp}_{\text{Med}}} = 0.1994$ L/s/m and

$$T \in \{0, 0.43, 1.43, 3.0, 10.0\}, \tag{5}$$

have resulted the following values for specific flow qPf and the ratio p:

$$qPf \in \{0.1994, 0.2104, 0.2333, 0.2532, 0.3131\}, \tag{6}$$

respectively,

$$p \in \{1, 1.055, 1.17, 1.27, 1.57\}. \tag{7}$$

The set of points: $\left(T(i), p(i)\right)$, with $i \in \{1, 2, ..., 5\}$ was approximated by applying the method of least squares, by the following quadratic polynomial:

$$p = -0.0049582T^2 + 0.10556T + 1.0095755. \tag{8}$$

For T opening values (Table 1, rows 6 and 15), using the approximation polynomial (8), have resulted values for p ratio (s. Table 1, lines 7 and 16); then for specific flow q_{Imp} (Table 1, rows 5 and 14), represented by the following relations:

$$qPf = pq_{\text{Imp}} q_{\text{Loss}} = qPf - q_{\text{Imp}}. \tag{9}$$

Values for specific flow qPf were determined in Table 1, lines 8 and 17, and for specific flow losses, q_{Loss} in Table 1, rows 9 and 18.

Flows in downstream section of the D.N. (for connecting to the well) for imperfect drain Q_{Imp}^{av} and for the perfect drain Q_{Pf}^{av}, and the total loss of flow, Q_{Loss}, are evaluated by the following relations:

$$Q_{\text{Imp}}^{av} = \int_0^{L_{\text{Dren}}} q_{\text{Imp}}(s)\,\mathrm{d}s,\ Q_{Pf}^{av} = \int_0^{L_{\text{Dren}}} qPf(s)\,\mathrm{d}s,\ Q_{\text{Loss}} = \int_0^{L_{\text{Dren}}} q_{\text{Loss}}(s)\,\mathrm{d}s. \tag{10}$$

Approximating integrals (9) by sums it results:

$$Q_{\mathrm{Imp}}^{\mathrm{av}} = \sum_{i=1}^{15} \Delta s_i \left(q_{\mathrm{Imp}}\right)_i = 795.9 \text{ L/s}, \tag{11}$$

$$Q_{Pf}^{\mathrm{av}} = \sum_{i=1}^{15} \Delta s_i \left(qPf\right)_i = 941.6 \text{ L/s}, \tag{12}$$

$$Q_{\mathrm{Loss}} = \sum_{i=1}^{15} \Delta s_i \left(q_{\mathrm{Loss}}\right)_i = 145.7 \text{ L/s}. \tag{13}$$

It can be ascertain that the flows Q_{Imp}^{av}, Q_{Pf}^{av} and Q_{Loss}, check the following relationship:

$$Q_{Pf}^{av} - Q_{\mathrm{Imp}}^{av} = 941.6 - 795.9 = 145.7 \text{ L/s} = Q_{\mathrm{Loss}}. \tag{14}$$

Considering the flow values from relations (11),…,(13), it was determined the increase of the captured flow in percentage points

$$\Delta Q_{\%} = \frac{Q_{Pf}^{av} - Q_{\mathrm{Imp}}^{av}}{Q_{\mathrm{Imp}}^{av}} \cdot 100 = \frac{Q_{\mathrm{Loss}}}{Q_{\mathrm{Imp}}^{av}} \cdot 100 = \frac{145.7}{795.9} \cdot 100 = 18.3\%. \tag{15}$$

3. Conclusions

The deduced value under certain simplifying assumptions indicates the size for increasing the flow captured by the proposed technical solution and demonstrate its suitability.

Received, October 25, 2010

SC Cernaconstruct SRL, Iaşi,
email: nicu_constantin@yahoo.com
* "*Ion Ionescu de la Brad*" *University of Agricultural Sciences and Veterinary Medicine, Iaşi*
and
** *"Gheorghe Asachi" Technical University of Iaşi, Department of Hydrotechnical Constructions*
email: mdima@yahoo.com

R E F E R E N C E S

1. Bârsan E., *Water Supply* (in Romanian). Edit. CERMI, Iaşi, 2001, 157.
2. Mateescu Cr., *Hydraulics* (in Romanian). Edit. Did. Pedag., Bucharest, 1963, 157.

3. Popescu Şt., Giurma R., *About a New Application of the Fundamental Formula for the Gradually Varied Motion in River Bed*. Bul. Inst. Politehnic, Iaşi, **XLVI (L)**, *1-4*, s. Hydrot., 5-9 (2004).
4. Popescu Şt., Giurma R., *Contributions to Account of Discharge Module for a Catchment Drain with Acces Bridge. Applications*. Bul. Inst. Politehnic, Iaşi, **XLVI (L)**, *1-4*, s. Hydrot., 12–20 (2004).
5. Popescu Şt., Giurma R., Chiorescu E.. *Estimate of Leakage under a Partially Penetrating Drain in an Unconfined Aquifer. Application for the New Drain at the Timişeşti Underground Water Catchments*, *Iaşi*. Bul. Inst. Politehnic, Iaşi, **L(LIV)**, *1-4*, s. Hydrot. (2004).
6. * * * ISPIF, 1972.
7. * * * ISLGC, 1987.

MĂRIREA CAPACITĂȚII DE CAPTARE A DRENULUI NOU TIMIŞEŞTI PRIN DIMINUAREA PIERDERILOR PE SUB RADIERUL DRENULUI

(Rezumat)

Soluția propusă presupune aplicarea unei tehnologii moderne , constând în realizarea de ecrane impermeabile, încastrate în stratul de bază, impermeabil, al acviferului, tehnologie care presupune doar cheltuieli de investiții, dar nu şi cheltuieli aferente energiei operaționale; astfel, în aceste condiții, indiferent de cota de amplasare a radierului drenului în raport cu stratul impermeabil, acesta poate fi considerat, din punct de vedere hidraulic, ca dren perfect.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

SOLUTIONS FOR LAND RECLAMATION OF PRUT RIVER FLOODPLAIN BETWEEN ALBIȚA AND FĂLCIU

BY

CORNELIU CISMARU, VICTOR GABOR and MIRCEA-DIMITRIE ATANASIE

Abstract. The aim of this study is to analyse the actual conditions for the operation and maintenance of the land improvement works, the contributing factors to soil salinity, and the alternatives to improve the current condition. The prevention of increasing soil salinity in actual conditions requires the rehabilitation of the surface drainage system, especially by reducing drain spacing accompanied by soil scarifying activity.

Key words: land reclamation; soil salinity; drainage system; scarifying.

1. Introduction

The land reclamation developments in Prut River flooding area between Albița and Fălciu consist of a series of dikes on the side of the river, an 18,655 ha drainage system, and an irrigation system with open main canals and water distribution networks for sprinkler irrigation on 16,795 ha. In addition, there are 560 ha of land with subsurface horizontal drainage on saline and alkaline soils whose are situated on a landstrip adjacent to the terrace area. The dikes, the surface drainage system, the works for control of torrential water courses originating on the terrace area and the works for soil protection on the sloped lands of the terrace were finished in the 1966…1970 period. The irrigation infrastructure was carried out in the 1977…1980 period. Beginning with 1984,

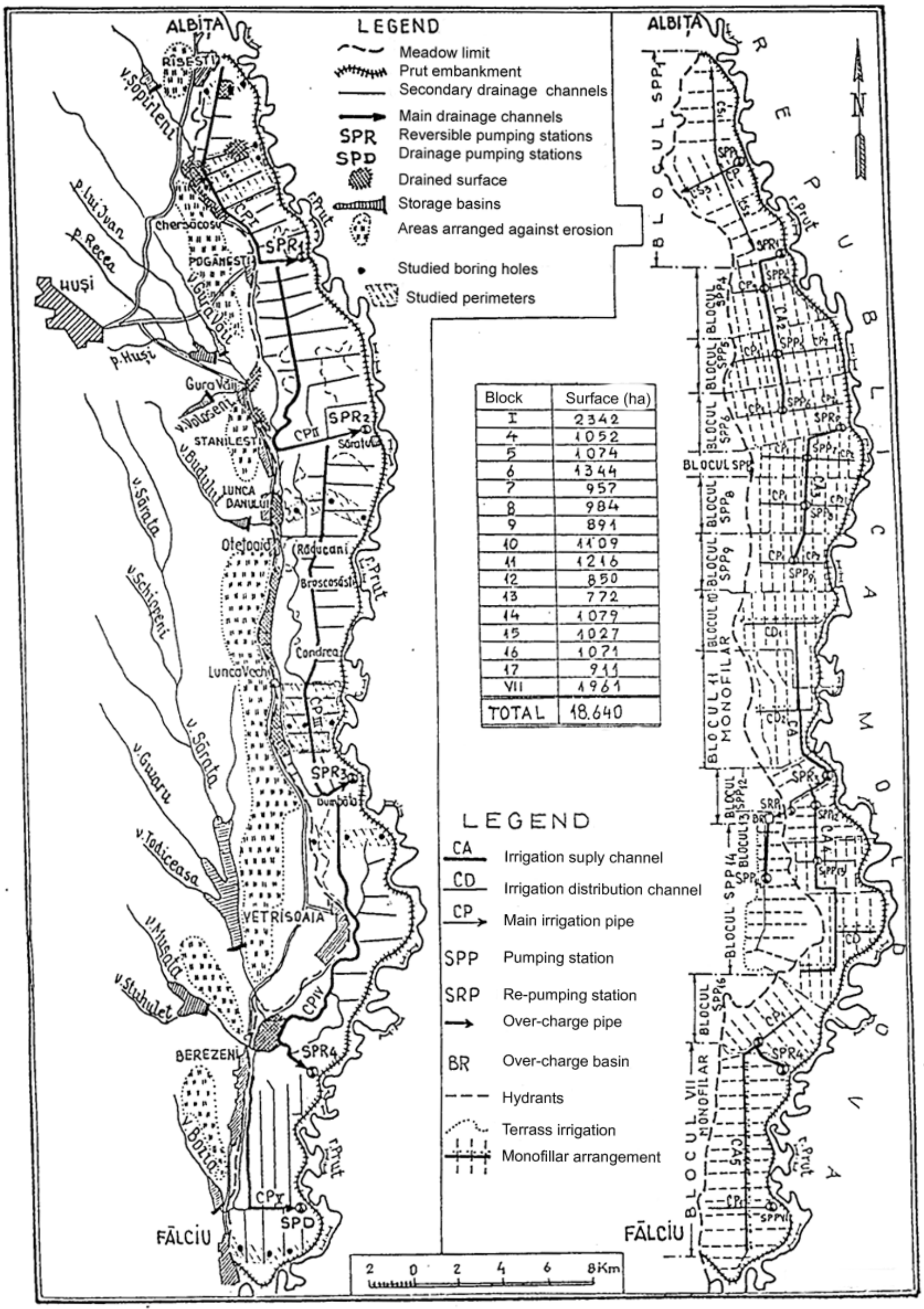


Fig. 1 – Drainage system of Albița-Fălciu arrangement.

modernization works for both the irrigation system (on 1,726 ha) and the drainage system was performed. Furthermore, 1995 was the year when modernization works of all main pumping plants situated near Prut River started. The main aim of these complex measures is to minimize the salinization and water logging and to diminish the damage to agricultural crops.

Investigations into the operation performance of reclamation works confirmed that the salinization of soils in correlation with groundwater conditions (regarding the depth and the salinity of the groundwater) has intensified following the area being impounded and drawn out from natural flood of Prut River. Other factors contributing to this phenomenon are the low permeability of the soil layers, the deficiency of internal drainage, the inefficient irrigation practices and canal seepage. These features are observed on the landstrip situated near high terrace and within the central landstrip of the floodplain, where internal natural drainage of soils is very slow. It is evident that during a 16 year period from 1974 to 1989, the use of irrigation water with a salinity between 0.4…0.5 g/L generated a low to moderate phenomenon of secondary soil salinization which attenuated in time. This dynamic has changed since 1990 when the social-economical conditions lead to a lesser utilization of the irrigation systems and the under-maintenance of the irrigation and drainage works (Fig. 1). Finally, the salt leaching process due to excess irrigation and the influence of surface drainage collectors were significantly diminished.

The aim of this study is to analyse the actual conditions for the operation and maintenance of the land improvement works, the contributing factors to soil salinity, and the alternatives to improve the current condition.

2. Research Method

The soil water balance in our investigation area is determined by rainfall rate, irrigation, evapotranspiration, and the upflux from the shallow aquifer. The dissolved salts in the groundwater upward flow are the main contributor to soil salinity balance.

Their contribution varies in time mainly due to various groundwater conditions such as depths and salt concentration. The local groundwater within the study area has an ascensional character due to the supply of groundwater from higher lands. Prut River has a supply action of floodplain groundwater during high levels and a drainage action during opposite conditions.

The salt balance components of the root soil zone were analysed for the 1995...2007 period. Monthly precipitation data is obtained from Vaslui meteorological stations. The water level regime of Prut River was analysed based on the recordings of the Prut River Water Administration at Drânceni and Fălciu hydrostations. These stations are located immediately upstream and downstream from study area, respectively. The dynamics of apparent depth of water table (which was measured by observation wells) and groundwater salinity concentration were provided by the hydrological Service of Water Administration, Prut, referring to observation wells situated on four alignments: Răseşti, Lunca Banului, Vetrişoaia, and Fălciu.

The simulation of soil salinization process was carried out using UPFLOW-v.2. model of Catholic University Leuven-Belgium [3], where the main output is upflux from groundwater. Several input elements were considered, such as the stratigraphy and hydro-physical properties of soil profile (the depth of soil root zone is of 0.5 m), monthly real depth of water table (this is an apparent depth, modified by the coefficient developed by O. T o m i ț ă [4]), the salt concentration of groundwater, the evapotranspiration rate (calculated with Penman-Monteith formula), and the soil water content for a well irrigated soil.

The significance of the input factors shows a net difference in transversal direction upon the Prut River direction depending on the soil profile and its physical properties, the water pressure of groundwater, and the real depth of water table. In the fooldplain land landstrip situated near high terrace, there are alluvial soils with very low permeability and slow drainage porosity (2.5…6.2%), from the land surface down to 4…5 m depth. The real depth of groundwater table varied from about 2 m over wet periods up to about 5 m over dry periods, while the salt concentration of groundwater in observation wells varied between 2 and 3 g/L.

In the floodplain's central zone, stratification of soil is about the same as in near foot terrace zone. The drainage porosity has medium values of 0…1 m depth, but downward it fast diminishes and stabilizes at about 3% (from 1.4 m depth to water table). Real depth of water table ranged from 2.5 m to 4 m and the salt concentration of groundwater in observation wells varied between 1 and 2.5 g/L.

In the landstrip zone near Prut River there is a great influence of rover water level variations on the groundwater table depths. Real depths of groundwater are in the range of 3…5 m. Salt concentration of groundwater is in range of 1…2 g/L in observation wells, but overpasses 2.5 g/L in dry years. The soil stratification from surface to groundwater is composed mainly by loam, sandy clay, clay, sand, and clay loam layers, all of which generally have a good permeability, with the exception of the clay layer which is about 1 m in depth.

3. Salt Amount Rising from Groundwater in Soil Root Zone

Simulations of salt build-up were carried out using the previously demonstrated model for each of the three zones of floodplain between Albița and Fălciu. A well observation was chosen as the representative data point for conditions influencing the salt move-up.

On average, annual salt inflow to the active soil layer supplied from groundwater are 0.619 t/ha in near foot terrace zone, 1.354 t/ha in central part of floodplain and 0.144 t/ha in the zone near Prut River [1]. These differences are due to various amounts of upward flow and salt concentration of groundwater. The largest salt amount builds into the soil root zone during the dry years, with water deficit during cool season, especially when we observe a gradual increase of groundwater salinity.

4. Soil Salt Evolution and Leaching Efficiency Due to Increased Natural Rainfalls

During the study period we observed reduced salt leaching by natural rains that occurred only during cool periods of the year when the soil water regime is in excess and only in the proximity of the drainage canals. In other circumstances, the salinization process is intensified. In the conditions of successive years with limited precipitations in the cool period of the year, it is possible to reach elevated values of soil salt concentration that can generate low yielding crops.

To ensure a leaching process of soil salts it is necessary to rehabilitate the subsurface drainage system by promoting reduced drain spacing and to extend the area provided with horizontal subsurface drainage on the central and the near high terrace land strips of the floodplain [2].

The soil water balance simulation was carried out for the condition of a horizontal drainage system with drains 12.5 m apart and 1.2 m depth and with a filtering layer situated above the drains with a 50 cm height. The simulations tacked into account two alternatives: scarified and non-scarified soils. It was considered that the subsurface drainage system helps evacuate 30% of exceeding water in non-scarified soils and 70% in the scarified soils conditions [4]. Salt leaching efficiency was measured during experiments for condition of predominant soil texture in study area, silty-clay respectively, and for 0.5 m depth of soil (Table 1).

Table 1
Salt Leaching Efficiency

Depth of applied water, [mm]	250	125	62.5	30	15
Leaching efficiency (remaining salinity/initial salinity)	0.55	0.7	0.85	0.92	0.97
Salinity reduction, [%]	45	30	15	8	3

The simulations of slat leacing process under the action of soil water excess, especially in the cool period of the year, were carried out with monthly values within the 1996...2007 year period (Table 2 and 3).

It is evident that the best results of leaching soil salts were obtained for the scarified soil alternative during the years with water excess in the cool season. However, if this water excess is low, as was the case during the last years, the soil salinity will increase or remain at the same level. In the case of non-scarified soils, the dtainage efficiency is lower.

Table 2

Soil Saline Balance under Natural Salt Leaching in Following Situation: Subsurface Horizontal Drainage and Scarified Soil (*for the Land Strip of Floodplain Situated Near High Terrace Zone*)

Year	Water excess in the cool year period, [mm]	Percent of leached salt, [%]	Salt input from groundwater		Initial soil salinity mg/100 g of soil	Final soil salinity mg/100 g of soil
			mg/100 g of soil	t/ha year		
1995			5.95	0.387	734	577.4248
1996	92.26	22.1424	5.72	0.372	577.4248	473.0414
1997	79.45	19.068	6.25	0.407	473.0414	364.5354
1998	101.08	24.2592	11.2	0.731	364.5354	300.8977
1999	85.54	20.5296	19.2	1.25	300.8977	293.0123
2000	34.65	9.001538	22.3	1.45	293.0123	293.4428
2001	27.51	7.463692	8.4	0.54	293.4428	296.7897
2002	8.61	1.722	10.1	0.66	296.7897	249.6995
2003	80.29	19.2696	8.2	0.53	249.6995	234.3686
2004	36.61	9.423692	0.74	0.05	234.3686	195.9709
2005	69.58	16.6992	2.27	0.15	195.9709	166.931
2006	66.57	15.9768	2.5	0.17	166.931	163.2657
2007	17.08	3.693333	8.13	0.53	163.2657	171.3957

Table 3

Soil Saline Balance under Natural Salt Leaching for Subsurface Horizontal Drainage and Non-Scarified Soil (*Same Area*)

Year	Water excess in the cool year period, [mm]	Percent of leached soils, [%]	Salt input from groundwater		Initial soil salinity mg/100 g of soil	Final soil salinity mg/100 g of soil
			mg/100 g of soil	t/ha year		
1995			5.95	0.387	734	666.148
1996	39.54	10.05477	5.72	0.372	666.148	612.7653
1997	34.05	8.872308	6.25	0.407	612.7653	552.4143
1998	43.32	10.86892	11.2	0.731	552.4143	511.497
1999	36.66	9.434462	19.2	1.25	511.497	515.6078
2000	14.85	2.95	22.3	1.45	515.6078	525.7498
2001	11.79	2.358	8.4	0.54	525.7498	530.2698
2002	3.69	0.738	10.1	0.66	530.2698	492.9114
2003	34.41	8.949846	8.2	0.53	492.9114	485.1904
2004	15.69	3.23	0.74	0.05	485.1904	447.3033
2005	29.82	7.961231	2.27	0.15	447.3033	415.2052
2006	28.53	7.683385	2.5	0.17	415.2052	411.6266
2007	7.32	1.464	8.13	0.53	411.6266	419.7566

For these reasons, the reduction of soil salinity is more probable during the years with significant water excess during the cool period; during other years soil salinity is stationary or it may rise during dry years. These features reveal the importance of taking actions of scarifying the soil with a repetition every 2…3 years, for a successive period of dry years. However, for a period of years with water excess in cool season, the operation of scarifying soil is sufficient if repeated at intervals of 3…5 years. With these measures, soil salinity can be favourably influenced and maintained at reduced levels for a longer period. During irrigation season it is necessary to use a water regime that can maintain the soil solution concentration at a level demanded by agricultural crops in order to obtain the planned yields. The soil salinity management could be done by leaching soils with irrigation water from the Prut River. Nevertheless, this alternative demands the use of an actual sprinkler irrigation system, which in turn requires higher costs for water pumping and distribution on the fields.

5. Conclusions

The soil salinization process of the Prut River floodplain from Albiţa at Fălciu is more severe in landstrips near the high terrace and in the central zone. This is justified mainly by lithological and hydrological conditions.

The prevention of increasing soil salinity in actual conditions requires the rehabilitation of the surface drainage system, especially by reducing drain spacing and extending the area with subsurface horizontal drainage (the latter is in correlation with soil salinity evolution and the degree of irrigation usage).

Wherever these undertakings are successful, they could achieve a proper management of the soil salinity. Soil desalinization efficiency using water excess in the cool season depends on the drainage system efficiency as well as the salt leaching efficiency, both being very strongly influenced by the soil scarifying activity.

Received, October 25, 2010

"Gheorghe Asachi" Technical University of Iaşi,
Department of Hydrotechnical Improvements
and Environmental Engineering
email: vicgabor@yahoo.com

R E F E R E N C E S

1. Atanasie M.D., *Studii şi cercetări privind comportarea în exploatare şi fundamentarea soluţiilor de reabilitare şi moderniyare a lucrărilor de îmbunătăţiri funciare din unitatea hidroameliorativă Albiţa-Fălciu*. Teză de doctorat, Univ. Tehnică „Gh. Asachi", Iaşi, 2008.
2. Cismaru C., Prepeliţă D., Gabor V., Atanasie M.D., *Cercetări privind soluţiile tehnice de reabilitare şi modernizare a lucrărilor de irigaţii din lunca râului Prut* (*sectorul Albiţa-Fălciu*). Lucr. Simp. de comun. şt. al Fac. de Agr., Iaşi, s. Agron., **47**, 21-22 oct. 2004.

3. Raes D., De Proost P., *Model to Assess Water Movement from a Shallow Water Table to the Root Zone*. Agric. Water Manag., **62**, *2* (2003).
4. Tomiţă O., *Cercetări privind influenţa lucrărilor ameliorative din incinta îndiguită Albiţa-Fălciu, asupra solurilor şi apelor freatice*. Teză de doctorat, Univ. de st. agr. şi med. veter. „Ion Ionescu de la Brad”, Iaşi, 1999.

POSIBILITĂŢI DE EFICIENTIZARE A LUCRĂRILOR DE ÎMBUNĂTĂŢIRI FUNCIARE DIN ZONA DE LUNCĂ A RÂULUI PRUT ÎNTRE ALBIŢA ŞI FĂLCIU

(Rezumat)

Se analizează condiţiile existente din Lunca râului Prut, în amenajarea complexă Albiţa-Fălciu, pe linia exploatării şi întreţinerii lucrărilor hidroameliorative precum şi posibilităţile de îmbunătăţire a stării regimului hidrosalin al solurilor. Prevenirea creşterii salinităţii necesită lucrări suplimentare de îndesire a sistemelor de drenaj existente, associate cu utilizarea lucrărilor de scarificare periodică.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

INSURANCE OF CONCRETE QUALITY IN COLD WEATHER USING ADDITIVES

BY

GABRIELA BOICU, *OLIMPIA BLĂGOI and
***DORIN COTIUŞCĂ-ZAUCĂ**

Abstract. The paper summarizes the factors and mechanisms modifying the setting and hardening of the concrete, the contribution of the set-accelerators and/or anti-freezing admixtures to improve the concreting at low temperatures. The study focused on the effects of additive' type and dosage, of cement dosage, at standard testing temperature and at –5°C air temperature, on the concrete strengths. For this purpose, a C25/30 concrete was prepared with two series of additives' combinations (superplasticizer with set-accelerator; superplasticizer with anti-freezing additive), for each thermal cycle. Three sets of batches were prepared with various additive dosages. The compressive strengths at 7 and 28 days were tested.

Key words: rost action; concrete; set-accelerators; anti-freezing additives.

1. Introduction

The insurance of concretes quality begins at the batch plant, being the team effort regarding mix design, precise testing, and detailed planning. Then, the quality during mixing, transportation, placing and curing of concrete, especially in adverse weather conditions, must be maintained.

The concreting in cold weather is a common and necessary practice, and every work must be considered carefully to adopt its unique requirements:

temperature of the delivered concrete; protection during transport, placement, and finishing; curing temperatures. The number one rule is to avoid freezing of the concrete at an early age, typically within first 24 hours.

To concrete in cold weather brings some benefits such as slow hardening, final resistances higher than those at the reference temperature (the reference temperature is considered 20°C in Europe, but 23°C in North America), hydration products with a finer structure and more uniformly distributed in the cement paste.

In the same time, there are some drawbacks such as a severe evaporation and drying of the concrete surface, extended setting, low rate of the early-strength gain, expensive safety requirements.

The concrete production can be operated during the entire year by introducing additives in the concrete mix.

2. Correlation between Characteristics of Concrete and Frost Resistance

2.1. Microstructure of Cement-Paste Matrix. Macrostructure of Concrete

The performance of concrete is strongly influenced by the technological process and environmental conditions under which the structure of cement stone takes shape. This matrix arises from the coagulation, coagulation-crystallization, and condensation–crystallization processes that, in turn, depend on the nature and intensity of the forces which manifest in these polyphase and polydisperse systems.

The coagulation structures (due to electrostatic, van der Waals, capillary, and gravity forces) are specific to unhardened or hardening cement paste ongoing strengthening. They are characterized by coagulation bonds that provide thixotropical properties, plasticity and low strength to the cement paste. The coagulation structures form the "matrix" of the future product.

The kinetics of Portland cement hydration is influenced by its mineralogical composition under the specific conditions of the cement–water system. The chemical additives can strongly change this kinetics by modifying the properties of solutions in contact with cement. Therefore, the effect of additives depends also on the hydration phase of cement when they are introduced.

The coagulation–crystallization structures originate of the solution super-saturation subsequent to the coagulation structures occurrence. They develop in two stages: formation of crystallization germs and formation of crystal lattice.

The condensed–crystallized structures result from the polycondensation reactions accompanied by the formation of spatial lattices with strong bonds of the new hydration phase. The hardened cement structure is heterogeneous regarding the appearance and composition.

During the structure development, various discontinuities occur inside the concrescences and at their boundaries, as follows [1]: gel pores, capillary pores, air pores, pores under aggregates grains, water voids, micro-cracks and fissures, and intra-aggregate pores.

The structural discontinuities influence the behavior of concrete as a function of their volume and distribution pattern.

The calcium silicate hydrate (CSH), resulted from cement hydration, is a colloidal amorphous gel, which contains pores of 1.5…3 nm in size, called *gel pores*. The hydration products cannot precipitate in pores having diameters smaller than about 2 nm. Due to the small size of the gel pores and due to the great affinity of the water molecules to the gel surfaces, the movement of water in the gel pores does not contribute much to the cement paste permeability.

The bulk volume of CSH gel after the hydration of a cement grain requires 60% more volume than the original volume of the unhydrated cement grain and the water, and this expansion moves into capillary pores that have about of 3…1,000 nm in size. As hydration proceeds, the amount and distribution of the capillary and gel pores change considerably.

The volume of capillary pores is reduced because these become filled with hydration products, and the volume of gel-pores increases as more gel is formed. In addition, there is a net reduction in total porosity [2]. Consequently, the permeability, resistance of frost, and durability of concrete depend on the capillary pores.

The air voids (or spherical pores), having sizes of 5…100 μm, are formed by entrenched atmospheric air during mixing and, sometimes, might intercept the capillary pore network.

Pores under aggregate grains, of smaller size than 5 mm, result by the evaporation of bleed water locked under gravel grains, and are interconnected through the capillary pores.

The water voids (or pits and cavities) are larger than 5 mm and result after an insufficient compaction.

The micro-fissures and cracks are due to the chemical processes of hydration, because of the variations in temperature and humidity. Typically, the crazing cracks are distributed throughout the microstructure.

The development of micro-cracks at low temperature values, in protected concrete, is achieved in better conditions than at high temperatures.

The intra-aggregate pores and cracks exist *a priori*.

2.2. Role of Water in Structure Formation

The water has a decisive role in structure generation. The pattern of water linking to cement hydrates and its physical state control all physical - chemical processes occurring in concrete and also the concrete behavior to frost depends on the type and intensity of bonding forces.

Firstly, it must show that the fluid within the pores of cement paste is not water, but highly concentrated solutions.

The non-bound water is held by surface tension, capillary forces in pores and cracks and the adsorbed water is held on surfaces due to molecular forces of the solid phase.

The zeolitic water is similarly to adsorbed water, yet it is bounded on crystals. Zeolites set and lose water continuously without changes in structure. Some additives have such properties.

The water of crystallization enters into the crystal structure, but is not chemically bonded to the anhydrous salt, but the water of constitution is present as hydroxyl group.

The microstructure of obtained matrix suffers changes, especially, in the volume and distribution of the pores, because of the aggregate presence. In order to obtain a concrete performance specific to the *F* exposure class, the correlation between the amount of air involved and the maximum size of aggregates is established by norms.

3. Behaviour of Unhardened Concrete at Frost

The existing water in the capillary pores freezes when the air temperature falls below 0°C and thus the volume increases. Consequently, concrete is subjected both to the pressure of formed ice and the hydrostatic pressure of unfrozen water in discontinuities. The concrete resistance to freeze depends mainly on the degree of saturation and pore structure of the matrix. If near a cavity where is formed ice there is a free space where unfrozen water may be expelled, then the cement-paste matrix is not deteriorated.

This is the reason of the air-entraining additives used in the concrete preparation. Similarly, an aggregate particle must have low porosity or the capillary system to be interrupted by a large number of macro-pores.

Recent studies [3] have shown, on the one hand, that the dynamics of the water–ice transition can be expressed by the Avrami' Law and, on the other hand, that it must to consider the complexity of the involved factors: temperature, heat conduction and convection, ice content, the progressive increasing of alkali content in the unfrozen water, the large differences in permittivity between liquid water, ice, air, and mineral porous medium, the dependence of the water dielectric constant of temperature, and to take account of the pores network in matrix.

The Avrami' Law assumes that the water in pores is a metastable phase and so explains that the formation of ice is achieved from the nucleation of the ice germs and from the growth of the already stable ice crystals. These processes take place on the account of remained liquid water.

The pressures of ice and water on their contact interface must be equals and, consequently, this interface tends to become planar (Gibbs-Thomson and Young-Laplace equations).

The pressure evolution in time presents three steps: first, an increase triggered by the occurrence of the ice stable nuclei, then a relaxation induced by the flow of the unfrozen water, and, finally, a new pressure increase until the crystallization end [3].

4. Concreting in Cold Weather

The concreting in cold season requires some changes throughout the technological process. Therefore, the concreting stages must be designed only based on the physical-chemical strengthening phenomena. The cold represents a damage based on the following considerations: the ordinary concrete gains strength slower at temperatures up to –4°C, very slowly under –4°C and is not gaining strength below –10°C, when the cement-paste matrix does not form.

The placement and/or any treatment that disturb the matrix have to be operated when the cement paste has reversible thixotropical properties [4]. For instance, the concretes rich in tricalcium aluminate (C3A) and gypsum have to be placed immediately after preparation, due to in the first minutes forms calcium trisulfatic hydroaluminate whose destruction is irreversible. However, these concretes are very suitable for cold weather.

Understanding the concrete strengthening at low temperatures by highlighting the intermediate stages and active species is one of the most difficult issues of the chemical reactions kinetics. The slower intermediate stages, hence having lower reaction rates, will control the rate of the global mechanism. The chemical reactions rate depends on temperature and reactants concentrations. The temperature increasing augments the velocity of reactant particles, and so the kinetic energy. The number of effective collisions between particles that reach the activation energy increases per unit of time and will enhance the process.

In heterogeneous systems, the reaction kinetics is also influenced by the contact surface area, because the collision probability of two particles is very high in a solution, in powdery mixture the reaction is located in contact points, but for crystals, the contact points are very small.

The low temperatures influence the cement hydration also by higher demand for heat of hydration. The minimum energy (energy barrier) required by hydration–hydrolysis processes can originate from the hydration heat of ions, external heat contribution or catalysts use. The activation energy depending on temperature and reaction rate is expressed by Arrhenius equation.

At low temperatures, the $Ca(OH)_2$ and $CaSO_4$ solubility increases leading to the supersaturation of $Ca(OH)_2$, and thus influencing the crystallization rate.

At low positive temperatures, the final mechanical properties of hardened concretes are improved due to the morphology of the hydration products, and the reduction of discontinuities in micro- and macrostructure. The calcium aluminates hydration in the presence of gypsum favours the formation of calcium trisulfatic hydroaluminate whose stability increases strongly at low temperatures.

The time span of concrete keeping up to freezing depends on the conditions of solid skeleton forming, the freezing point and the cooling rate. The ice formation is influenced by the concrete porosity, knowing that the freezing point of capillary water depends on the tube diameter. In fresh concrete, the pores have a radius of about 100 nm, which means that the water freezes at –2 …–3°C. As the cement hydration occurs, the water is adsorbed on the surface of hydration products, and the pore diameter decreases, so that the water will freeze at lower and lower temperatures ever.

Winter, is opportunely to prepare the mixture with cements releasing large heat of hydration but, the current technique is to mix set-accelerator and anti-freezing additives in concrete.

In this sense, we used, in our studies, the cement CEM I 42.5 R with set-accelerator and anti-freezing additives.

5. Assurance of Concrete Quality in Cold Weather by Chemical Additives

In order to improve the concrete behavior under special circumstances, chemical and mineral admixtures are used.

According to their effect on the concrete technology, the chemical additives are classified into: normal category (air-entraining, water reducers, set accelerators, set retarders, plastifiants) and special category (corrosion inhibitors, shrinkage reducers, alkali-silica reactivity inhibitors, colouring, workability improvers).

In the present work we comply with the requirements of 012-1/2007 EU norm, which recommends using the combination of a set - accelerator with an anti-freezing additive.

In order to understand and manage the complex action of additives, it is necessary to know the factors that govern the physical-chemical processes in concrete bulk, in the presence of additives.

5.1. Additives Controlling the Setting and Hardening of Concretes

The setting and hardening controller additives are mostly water soluble compounds that change the solubility of cement anhydrous compounds, saturation degree of solutions, coagulation and crystallization rates of hydration products. The same substance can be an accelerator or a retarder as a function of the dose used and the cement composition.

The chemical reactions in heterogeneous systems take place with/without the transfer of binder into solution, involving surface chemical reactions and processes of particles' diffusion.

The nucleation and crystallization processes control the cement strengthening and, in their turn, depend on the ionic activity of the electrolytes' solutions, the ionic strength and pH of solutions, temperature, and the nature of the electrolytes existing in the cement–water system.

According to the predominant action these additives can be classified in four categories [4] as below:

a) Dissolvent additives that increase the solution ionic strength and they form ions exerting a coagulant action. This category includes

a_1) salts derived from strong bases and weak acids that hydrolyse, forming basic solutions, enhancing the calcium aluminates dissolution and formation of coagulation structures;

a_2) salts derived through hydrolysis, from strong acids and weak bases form acidic solutions, influencing the hydration of calcium silicates; resulting ions with high valence and strong coagulant character, accelerating the setting;

a_3) salts originating from strong acids and bases that act as hardening accelerators, due to the increasing of ionic strength of the solution.

b) Additives that modify the solubility of $Ca(OH)_2$ and $CaSO_4$. This category contains

b_1) substances that remove calcium hydroxide from solution and accelerate the setting and hardening (*e.g*. alkalis, NaCl, KCl, and $CaCl_2$);

b_2) substances decreasing the calcium sulfate solubility will increase the solution saturation with $CaSO_4$ (*e.g*. sodium, magnesium, or aluminum sulfates; inorganic salts derived from strong acids containing more electropositive ions than Ca^{2+} (*e.g*. $BaCl_2$, $SrCl_2$).

c) Additives which react with cement hydration products forming complex salts mostly are inorganic calcium salts from strong acids (*e.g*. $CaSO_4$, $CaCl_2$) that react directly with the calcium aluminates in the initial stage of hydration and form complex salts. Such salts are hardening accelerators.

5.2. Anti-Freezing Additives

The anti-frost additives act on two purposes, either to lower the freezing point of the water from concrete, or to promote the cement hydration at negative temperatures. These two ways of intervention of anti-frost additives could be explained as follows.

The freezing point is lowered, generally, in the presence of a solute, than in a pure solvent (Raoult' Law). The solute particles cannot enter the solid phase, hence fewer molecules participate at the equilibrium. Again, the re-establishment of equilibrium is achieved at a lower temperature at which the rate of freezing becomes equal to the rate of liquefying. The freezing point depression of a solution containing a dissolved additive represents a colligative property [4].

The dissolution of a salt in water is accompanied by the hydrates occurrence, so that the water freezing requests an additional energy to destroy these hydrates. As the solution concentration increases, the frost temperature decreases. This is the case of the eutectic mixtures, characterized by the eutectic point.

The latest generation of additives [4], [5] includes a wide range of products based on polymers, derivatives of polycarboxylic acids, poly-carboxylate ether, phosphonates, naphthalene sulfonate, lignosulphonates, etc., whose functions can be chosen only by dosage adjusting.

6. Laboratory Studies on Concretes with Additives for Cold Weather Conditions

We studied the effects of the additive type, the cement and additives' dosages, at the air temperature of –5°C, on the characteristics of concretes. For this purpose, two sets of combinations of additives were used.

The first combination includes a super-plasticizer and a set-accelerator with the dosages and properties as below:

a) 1% superplasticizer of last generation, based on modified phos-phonate, having the freezing point of –3°C, and a low content of chlorine ion;

b) 1.5% set-accelerator, free-chlorides, with the freezing point of –15°C.

The second combination contains a superplasticizer and an anti-freezer with the dosages and properties as follows:

a) 0.8% superplasticizer high-range water-reducer, based on polyether-polycarboxylate;

b) 1% anti-freezer based on calcium nitrate that can prevent the concrete cracking at –20°C.

Corresponding to C25/30 concrete grade, an ordinary Portland cement CEM I 42.5 R in 400 kg/m^3 dosage, water for 0.47 W/C ratio, and aggregates with a nominal maximum size of 16 mm, coming from the "Frasin" gravel pit, have been mixed.

For every above-mentioned combination, three sets of batches were prepared in accordance with three different dosages namely, series 1: blank mix (BM) containing 400 kg cement/m^3 and additives in doses as above mentioned, series 2: BM +7%, and series 3: BM –7%.

All materials were maintained for 72 hours, in the climatic chamber, before to prepare the concretes.

The specimens were kept in the curing chamber for 7 days and 28 days, respectively, thereafter the tests were performed.

5. Results and Conclusions

Analysing the results obtained from the first combination of additives, it was noticed that the 7-days strength of the concrete specimens stored in cold is with 31.81…21.68% lower than those stored under normal thermal conditions (Fig. 1).

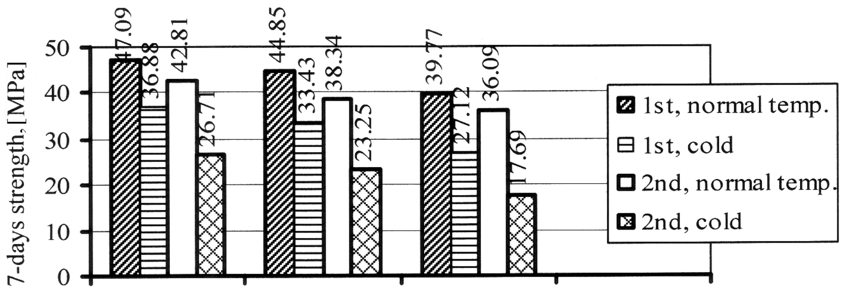


Fig. 1. – The 7-days strength evolution for all hypotheses; BM: blank mix.

As regards the 28-days strength, the spread of values is more pronounced, of 35.14…21.82% (Fig. 2).

The resistances increased with the dosage of additives.

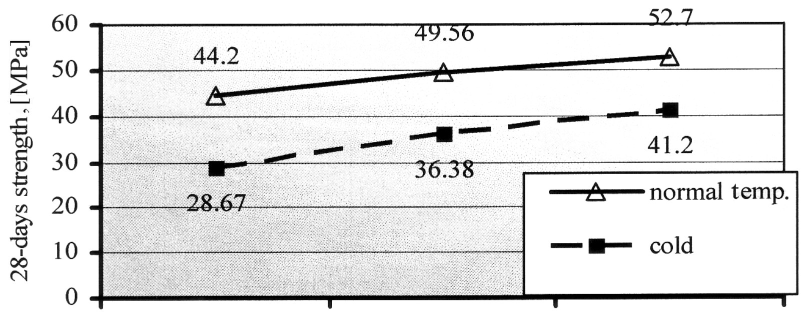


Fig. 2. – The 28-days strength of the first type concretes at normal temperature and col; BM: blank mix.

The second combination of additives is characterized by very low 7-days strength, which values are with 50.98…37.61% smaller than those of the blank samples (Fig. 1).

However, the 28-days strength shows important increases, the losses of resistance being only of 17.31…9.84% (Fig. 3).

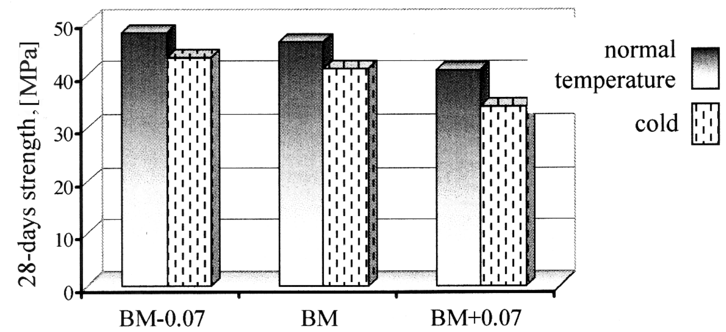


Fig. 3. – The 28-days strength of the second type concretes at normal temperature and cold; BM: blank mix.

The efficiency of the second combination of additives on the 28-days strength is of 45.1…49.26% compared with the first combination of additives.

For those constructions that require an early demolding, the 1-st combination of additives would be recommended, but with caution at the progressive loading of the construction (Fig. 1).

The second combination of additives is the most recommended if the constructions will be loaded at the 28-days age (Fig. 3).

Received, April 2, 2010

State Inspectorate for Constructions, Suceava,
e-mail: gabita_wol@yahoo.com
and
**"Gheorghe Asachi" Technical University of Iaşi,*
Department of Structural Hydrotechnics
and Sanitary Engineering
email: oblagoi@yahoo.com
cotiusca@yahoo.com

REFERENCES

1. Aligizaki K, *Pore Structure of Cement-Based Materials: Testing, Interpretation and Requirements*. Taylor & Francis Publ. House, Abingdon, 2005.
2. Blăgoi O., Patraş B., Georgescu M., Cotiuşcă D., *Acceleration of the Concrete Hydraulic Constructions Degradation by Freeze-thaw Cycles* (2007), CD Proc. of the Internat. Scient. Sess. "Education and Scientific Research at European Standards" of "Henri Coandă" Air Force Academy, May 2007, Brashov, Romania.

3. Fen-Chong T., Fabbri A., Azouni A., *Transient Freezing–thawing Phenomena in Water-filled Cohesive Porous Materials*. Cold Regions Sci. and Technol., **46**, *10*, 12-26 (2006).
4. Moldovan V., *Additives in Concretes* (in Romanian), Edit. Tehnică, Bucureşti, 1979.
5. Phatak T.C., Agarwal S.K., Masood I., *The Effect of a Superplasticizer on the Properties of Concrete and Mortar*. Mater. a. Struct., **25**, *150*, 355-357 (1992).

ASIGURAREA CALITĂȚII BETOANELOR PE TIMP RECE FOLOSIND ADITIVI

(Rezumat)

Se prezintă factorii şi mecanismele care modifică priza şi întărirea betonului, contribuția acceleratorilor de priză şi/sau a aditivilor anti-îngheț la îmbunătățirea betonării la temperaturi scăzute. Studiul s-a focalizat pe efectele tipului şi dozajului de aditiv precum şi ale dozajelor de ciment, la temperatura standard şi la temperatura de –5ºC, asupra rezistențelor betonului. Pentru cele două cicluri termice a fost preparat beton C25/30, cu două serii de combinații de aditivi diferiți şi, pentru fiecare serie, s-au pregătit trei seturi de epruvete cu diferite dozaje de aditivi. S-au determinat rezistențele la 7 şi 28 de zile.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVI (LX), Fasc. 3, 2010
Secţia
HIDROTEHNICĂ

DEGRADATION OF WATER QUALITY BY ACCIDENTAL POLLUTION

BY

MIHAELA DUMITRAN

Abstract. In recent years, water-system approach to extreme weather phenomena and accidental pollution has become an increasingly use more. This paper aims to review some aspects of accidental pollution of water with cyanide in the river Someş affected area in Hungary. I will present notions the pollution, water catchment Someş with reference to water resources,cyanide pollution of the river Someş in detail the impact of the environment, measured at source pollution, and conclusions. Pollution represents the contamination of the environment with different substances–pollutants from human activities operating in the atmosphere, water or soil. The authorities have taken measures to reduce and avoid any adverse effects of accidents from water users and the environment for the Someş-Tisa. Introducing the Water Framework Directive 2000/60/EC which establishes good water status by 2015. For Romania, one of the most important things is to implement the Water Framework Directive in improving the quality of surface water, a prerequisite for ensuring a better water service for population and environmental conservation, for is live safe in a common European space.

Key words: accidental pollution; water quality; drainage; hydrology; cyanides.

1. Introduction

It is required good quality water because water is a key component of environment. For this reason, water quality protection currently receives major dimensions. Environmental pollution with mercury, toxic chemicals, lead, cyanide and other substances increased significantly in recent years as it shows the inventory of toxic emissions from the Environmental Protection Agency [5] Water pollution is altering the physical, chemical and biological characteristics of water, produced directly or indirectly by human activities which cause water to become unfit for normal use for the purposes for which such use was possible, ahead of the alteration. Activity to protect water quality is encouraged by the Water Framework Directive using the adjective "good water" for all the water. In this paper, the author examine, the accidental cyanide pollution in the Baia Mare on the Someş-Tisa river in 2000, one of the many problems of water pollution. Under the Water Framework Directive are presented findings to improve the quality of river level (a decrease in values for quality indicators BOD_5, COD-Cr, heavy metals), the situation is far from satisfactory and that we need sustainable management water.

2. Presentation Space Someş-Tisa River Basin

Space Someş-Tisa river basin is located in the N and NW of the country, bounded to the north, the river Tisa, which has sources in the western Carpathian forest territory of Ukraine, forms the border between Romania and Ukraine over a length of 61 km between localities „Valea Vişeului" and Piatra and flows into the Danube in Hungary. Total area of space Someş-Tisa river basin is 22,380 km^2, representing a share of 9.4% of the country. Volumes of water drained in an average year are about 1,600 million/m^3 in the Tisa river basin and 2,600 million m^3 in river catchment. The hydrographic network is constituted by two separate basins, Tisa and Someş-Gutâi separate volcanic mountain range and the mountains Rodnei Ţibleş. As regards Someş river, the river network density is 0.35 km/km^2 and convolution coefficient 2.12. In connection with the evaluation indicators of the category of priority substances/dangerous priority, water quality in basin Someş has inadequate indicators on Lead, Copper and Nickel in most sections where they were monitored these substances.

Hydrographic network of the basin is formed in Romania, the Tisa tributaries draining the left of the Maramureş depression (Fig. 1): Vişeu, Iza, Săpânța, Baia, „Valea lui Francisc" and Tisa rivers that enter across the border: Batarci with Târna Mare, Egher with Hodos, and Turul. Of these, significant in water intake are: Vişeu, Iza (rivers with strongly asymmetric sub-basins), Batarci and Turul.

3. Cyanide Pollution of the River Someş, Baia Mare

In recent years (1998…2006) was a large number of cyanide spills in the environment that presents a major threat and is continuing to restore water quality . An example would be the production of hydrogen cyanide gas, which is toxic catologat fight in the Convention on the prohibition of the development, production, storage and use of chemical weapons and on their destruction opened for signature in Paris in 1993 [5].

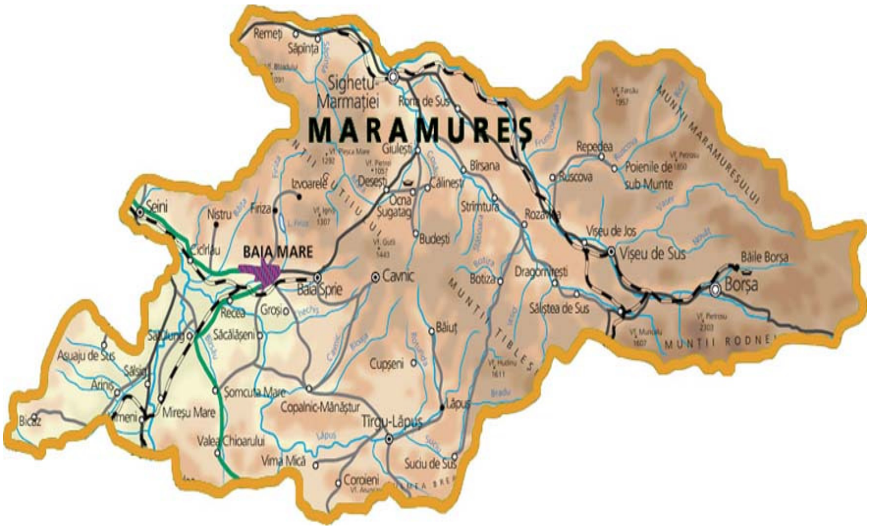
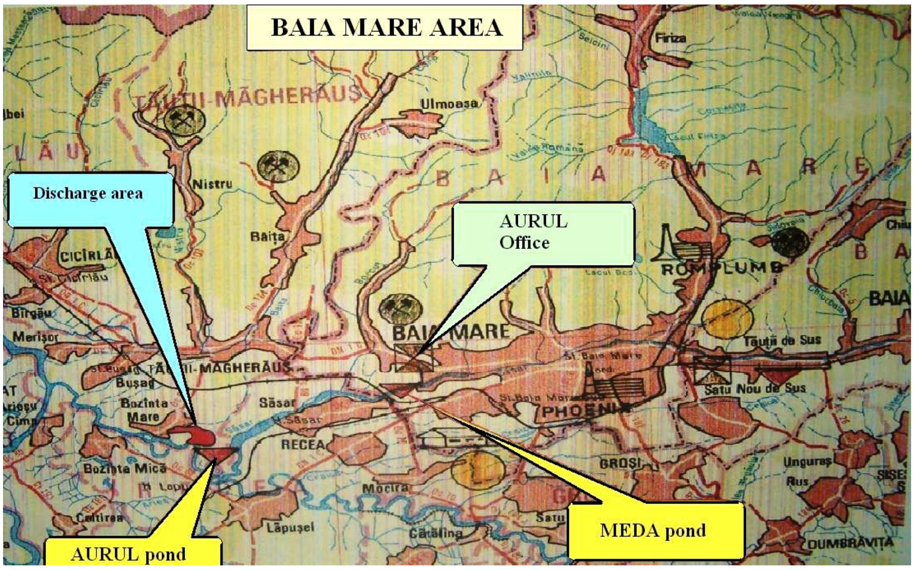
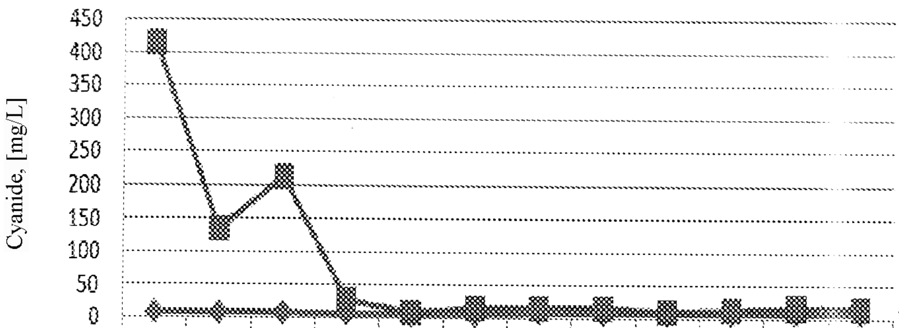


Fig. 1 – District Maramureş.

Pollution is defined in various ways. Thus, the Geneva Conference in 1961 as a present "direct or indirect modification of the composition or condition of any source of water due to human activity so that the waters are unfit for use at their normally risk to human health and the integrity of aquatic ecosystems”. The first law on water quality assurance have been issued in England in 1338 and then in France in 1404 in contrast to Germany legislation is only less than six volumes. Romania have been used previously a water quality classification system with four classes, but recently adopted 5 class system for physical-chemical limits for surface water. These can be compared with those recommended by the European Directive.

Introducing the event: produced in the night of January 30, 2000, when due to abundant rainfall in the preceding days, the existing liquid material into the lake Bozânta – Aurul has leaked (Fig. 2) which has released a quantity of water with cyanide (Table 1) in the river and around 100,000 m^3 from the river Lăpuş. (Figs. 3 and 4). They completed the work of closing the guilds controlled evacuation whith about 50 L/s for the drop in pond water at a safe level [18].Following the Convention between the Romanian Government, the Government of the Czech Republic, Government of RRS Yugoslavia, the USSR and the Hungary concerning the protection of the river Tisa and its tributaries from pollution, signed in Szeged, May 28, 1986, HCM nr.136/12.07.1986, if pollution of the river Tisa and its tributaries in the country either contracting party as a result of damage, natural disasters, any other special situations or in case of occurrence of such a danger, that contracting party shall take measures necessary to remove or limit the consequences of her and will inform the contracting parties within which can spread the consequences of accidental water pollution.





	SC Aurul	SC Aurul	SC Aurul	Lăpuş	Lăpuş	Bonzanta	Bonzanta	Bonzanta	Bonzanta	Bonzanta	Bonzanta	Bonzanta
Cyanide, [mg/L]	405.5	126.4	204.8	19.16	0.913	7.774	6.68	7.09	1.984	4.58	7.477	6.485
pH	9.39	9.05	8.97	8.3	7.65	7.38	9.57	8.84	8.96	8.96	9.4	9.03

Fig. 3 – Results of tests carried out following pollution products from S.C. Gold S.A. of 30/01/2000.

Developments in case of discharge of cyanide in Baia Mare, Romania.
Evolution of the wave of cyanide
January 30 – cyanide leakage occurs in the area of Baia Mare, Romania.
February 1 – cyanide plume reached Romanian-Hungarian border.
February 5 – cyanide is found in tests conducted at Tiszalôk.
February 9 – wave reached Szolnok.
February 11 – wave passes Yugoslav-Hungarian border
February 13 – wave reached Belgrade (Perlez), Yugoslavia.
February 15 – wave reached the Romanian border, the Ram.
February 17 – cyanide tests appear in the Iron Gates, Romania.
February 25…28 – wave reaches Danube Delta [11].

4. Results and Discussion

4.1. Results Analysis in Baia Mare

Table 1
Results of Tests Carried out Following Pollution Products from S.C. Aurul S.A. of 30/01/2000

No crt	The collection	Data	Time collection	pH	Cyanide mg/L
1	Pond S.C. AURUL	31.01.2000	10:00	9.39	405.5
2	Pond S.C. AURUL	01.02.2000	08:00	9.05	126.4
3	Pond S.C. AURUL	01.02.2000	16:50	8.97	204.8
4	River Lăpuş downstream the pond	31.01.2000	12:00	8.30	19.16
5	River Lăpuş downstream the pond	02.02.2000	20:20	7.65	0.913
6	Pond Bozanta	05.02.2000	11:20	7.38	7.774
7	Pond Bozanta	06.02.2000	10:45	9.57	6.68
8	Pond Bozanta	06.02.2000	23:10	8.84	7.09
9	Pond Bozanta	07.02.2000	20:10	8.96	1.984
10	Pond Bozanta	09.02.2000	18:00	8.96	4.58
11	Pond Bozanta	12.02.2000	09:00	9.40	7.477
12	Pond Bozanta	12.02.2000	17:00	9.03	6.485

Table 2

Results of Tests Carried out Following Pollution from SC Aurul SA Dated 30.01.2000 Made by Laboratory SGA Maramureş

No crt.	The collection	Date	Time collection	*Q* m^3/s	pH	Cyanide mg/L
1	River Someş-s.Cicărlău	31.01.2000	11:00	111	8.14	13.26
2	River Someş-s.Cicărlău	31.01.2000	17:00	120	7.92	5.45
3	River Someş-s.Cicărlău	31.01.2000	20:30	127	7.92	5.15
4	River Someş-s.Cicărlău	31.01.2000	22:20	131	7.96	2.09
5	River Someş-s.Cicărlău	01.02.2000	24:10	134	7.98	1.90
6	River Someş-s.Cicărlău	01.02.2000	02:10	136	7.94	1.87
7	River Someş-s.Cicărlău	01.02.2000	04:10	138	7.84	0.095
8	River Someş-s.Cicărlău	01.02.2000	06:00	142	7.60	0.082
9	River Someş-s.Cicărlău	01.02.2000	09:30	–	7.67	0.670
10	River Someş-s.Cicărlău	01.02.2000	12:00	–	7.65	2.350
11	River Someş-s.Cicărlău	01.02.2000	14:50	–	7.47	0.772
12	River Someş-s.Cicărlău	01.02.2000	17:50	170	7.65	0.587
13	River Someş-s.Cicărlău	01.02.2000	20:30	–	7.68	2.467
14	River Someş-s.Cicărlău	01.02.2000	22:30	–	7.78	0.598
15	River Someş-s.Cicărlău	02.02.2000	24:30	–	7.77	0.390
16	River Someş-s.Cicărlău	02.02.2000	02:30	–	7.84	0.365
17	River Someş-s.Cicărlău	02.02.2000	04:30	–	7.89	0.159
18	River Someş-s.Cicărlău	02.02.2000	06:30	199	7.91	0.090
19	River Someş-s.Cicărlău	02.02.2000	10:10	–	7.79	0.120
20	River Someş-s.Cicărlău	02.02.2000	14:40	–	7.90	0.104
21	River Someş-s.Cicărlău	02.02.2000	17:20	196	7.83	0.074
22	River Someş-s.Cicărlău	02.02.2000	21:00	–	7.90	0.339

Table 2
Continuation

No crt.	The collection	Date	Time collection	Q m^3/s	pH	Cyanide mg/L
23	River Someş-s.Cicărlău	03.02.2000	24:00	–	7.50	0.057
24	River Someş-s.Cicărlău	03.02.2000	04:00	185	7.71	0.052
25	River Someş-s.Cicărlău	03.02.2000	10:10	–	7.88	0.031
26	River Someş-s.Cicărlău	03.02.2000	22:30	–	7.74	0.074
27	River Someş-s.Cicărlău	04.02.2000	06:30	176	7.77	0.048
28	River Someş-s.Cicărlău	04.02.2000	12:45	–	7.87	0.079
29	River Someş-s.Cicărlău	04.02.2000	18:00	–	7.81	0.039
30	River Someş-s.Cicărlău	04.02.2000	24:00	–	7.62	0.015
31	River Someş-s.Cicărlău	05.02.2000	06:00	192	7.06	0.015
32	River Someş-s.Cicărlău	05.02.2000	18:00	178	7.84	0.043
33	River Someş-s.Cicărlău	06.02.2000	06:00	156	7.80	0.049
34	River Someş-s.Cicărlău	06.02.2000	17:30	145	7.74	0.043
35	River Someş-s.Cicărlău	07.02.2000	06:00	134	7.82	0.036
36	River Someş-s.Cicărlău	07.02.2000	18:30	142	7.80	0.039
37	River Someş-s.Cicărlău	08.02.2000	06:00	167	7.90	0.032
38	River Someş-s.Cicărlău	08.02.2000	18:10	174	7.65	0.035
39	River Someş-s.Cicărlău	09.02.2000	06:00	188	7.75	0.028
40	River Someş-s.Cicărlău	09.02.2000	18,30	232	7.51	0.016
41	River Someş-s.Cicărlău	10.02.2000	06:00	336	7.77	0.014
42	River Someş-s.Cicărlău	11.02.2000	07:00	296	7.71	0.016
43	River Someş-s.Cicărlău	12.02.2000	07:00	264	7.80	0.024
44	River Someş-s.Cicărlău	13.02.2000	07:00	253	7.88	0.012

Table 2

Continuation

No crt.	The collection	Date	Time collection	*Q* m^3/s	pH	Cyanide mg/L
45	River Someş-s.Cicărlău	14.02.2000	07:00	228	7.88	0.016
46	River Someş-s.Cicărlău	15.02.2000	07:00	212	7.81	0.006
47	River Someş-s.Cicărlău	16.02.2000	07:00	192	7.79	0.007
48	River Someş-s.Cicărlău	17.02.2000	07:00	170	7.31	0.009
49	River Someş-s.Cicărlău	18.02.2000	10:00	–	8.10	0.003
50	River Someş-s.Cicărlău	19.02.2000	07:20	–	8.05	0.008
51	River Someş-s.Cicărlău	20.02.2000	07:30	–	7.15	0.002

Table 3

Analysis Results of the Bălți S.C. Aurul S.A.

No. crt	No. pet	Date	Time	pH	Cyanide mg/L
1	15	02.02.2000	14:40	7.5	17.80
2	44	02.02.2000	15:00	8.34	240.80
3	18	02.02.2000	15:30	7.51	29.48
4	50	02.02.2000	14:45	7.80	18.10
5	10	02.02.2000	11:10	7.30	8.766
6	35	02.02.2000	10:00	7.06	9.61
7	51	02.02.2000	11:20	6.54	12.028

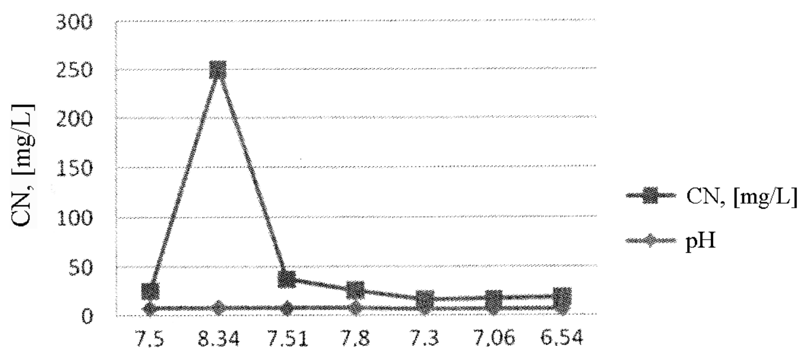


Fig. 4 –Analysis results of the Bălți S.C. Aurul S.A.

Tisa basin was one of the cleanest rivers in Europe shelters at least 20 protected fishs [16]. Pollution has reached about 800 km to Hungary, Serbia, the Danube in the Black Sea. The liquid, containing a large quantity of cyanide, produced adverse environmental impact, namely: water cyanide contamination of rivers Lăpuş, Someş, Tisa and Danube (Fig. 4). The accident in Baia Mare remains one of the most relevant examples in this respect as demonstrated and UNEP report in March 2000.

Table 4

Points of Chemical Hazard in Areas Affected bz Leakage of Cyanide

Chemical	Recommendations WHO 1993, [μg/L]	UE standards for drinking water, [μg/L]	Test date	Locality	Concentration μg/L
Arsenic	10	10	1992	Baia Mare	400
Cadmium	3	5	1992	Baia Mare/River Săsar	20
Copper	2	2	1992	Busag/River Lăpuş	2,200
			During escape	Cicarlău	10,500
			During escape	Romanian-Hungarian border	18,000
			Missions UN	Lake "Gold"	412,300
Cyanide	The recomandations WHO on the acceptable level of cyanide: Hungarian standard: 100 mg/L Romanian standard: 10 mg/L Standard on the Rhine: 25 mg/L		During escape	Around leakage	19,400
			During escape	Satu Mare/river Someş	7,800
			During escape	Csenger	32,600
			During escape	Hungarian-Yugoslavia border	1,500
			Missions UN	Lake "Aurul"	66,000...81,000
			Missions UN	Well private Bozanta Mare	785
			Missions UN	Danube Delta	58
Lead	10	10	1992	Cicărlău/River Someş	320
			Missions UN	River Maros	22

N o t e: Leakage of cyanide from the Baia Mare, Romania, 2000 – United Nations Mission held on February 23 and March 6 [11].

The data show that concentrations level of arsenic and lead in Săsar, Lăpuş, Someş and Tisa pass between 100...1,000 times the acceptable concentrations (Tables 2 and 3). Levels of cadmium at Lăpuş, Săsar were also very high (Table 4). In Hungary concentrations of lead, copper, manganese and iron were very high at several points along the Tisa river. In areas downstream of pollution were discovered heavy metal concentrations in sediment. In Hungary there are no long-term effects on the health of consumers after mining accident (Table 4). Water treatment plant in Szolnok was arrested during the wave of cyanide while passing treated water during the accident showed cyanide concentrations lower than the Hungarian standard [10].

4.2. Measures at the Source of Pollution

The most important measures against water pollution are

a) identification of discharge of dangerous toxic substances;

b) closing the contour of the dam guilds of the tailings pond “gold” to stop the discharge of cyanide restricting the water pollution at source [11];

c) construction of special pools of waste collection and waste to prevent their direct discharge into surface waters;

d) construction of water protection areas;

e) monitoring with an increased frequency of physico-chemical, watching the movement and evolution of the concentration wave of pollution;

f) monitoring water quality in affected areas of existing wells and drilling, by the representatives of Public Health;

g) possible development of a system of taking clarified water flow, version available in special situations, the tailing pond “gold” in another pond at the “Bozanta” [13].

4.3. References on Water Framework Directive 2000/60/EC

Water Framework Directive was transposed into national law by Law no.*310*/2004 amending and supplementing Water Law. No. *107*/1996. Press office of the Someş-Tisa Water Directorate explained that the Water Framework Directive (WFD) is a European law that European Union member states must implement and respect it. This can be achieved only through measures to minimize water pollution.Timetable for implementation of the WFD requires that draft action program to be completed by December 2008, then under debate, during 2009 and included in the first Management Plan, which will be published in late 2009. WFD (2000/60/EC) is an ambitious and innovative approach to water management in the European Union, legislative elements key of the directive referring to: the protection of all waters, regardless of their type rivers, lakes, sea coastal groundwater, identification and achievement of objectives to help the achievement of the rating of “good water” for all waters by 2015, transboundary cooperation between countries and between all parties involved, ensuring active participation in the conduct of water resources management all the responsible institutions, including Non Governmental Organization and local communities, creation of financial exploitation of water policies and ensure effective implementation of the “polluter pay” principle.

5. Conclusions

1. Effects of cyanide spillage in the Someş-Tisa rivers had disastrous environmental consequences, destroying aquatic fauna of these rivers.

2. Someş-Tisa river pollution cause degrade the physical-chemical and biological accidentally happened.

3. Revitalization was incomplete and in some cases, quality of surface water and groundwater are below European standards (not mine closure solves mine water that pollutes local rivers).

4. Study on risk management-related industrial activities and mining of Baia Mare.

5. Lakes containing toxic waste or other noxious liquid must have drainage systems to prevent overloading and rupture of dams.

6. Equipping with systems to prevent the population in emergency situations of plants using cyanide.

7. Necessary dialogue between the government and the mining industry members to achieve best practice in mining.

Received, April 2, 2010

”Gheorghe Asachi” Technical University of Iaşi, Department of Geodesy and Environmental Engineering
email: MihaelaDumitran@yahoo.com

R E F E R E N C E S

1. Giurma I., *Special Hydrology* (in Romanain). Edit. Politehnium, Iaşi, 2004.
2. Ştefanache D., Giurma CR., *Hydrology and Hydrogeology – Applications* (in Romanain). Edit. Politehnium, Iaşi, 2001.
3. Giurma I., Crăciun I,. Giurma-Handley C.R., *Hydrology.* Edit. Politehnium, Iaşi, 2006.
4. Vasiliu D., *Environmental Monitoring* (in Romanain). Edit. Politehnium, Bucharest, 2007.
5. Băloiu V. *et al.*, *Water Management* (in Romanain). Edit. Tehnică, Bucureşti, 1971.
6. * * * Direction of Water Someş-Tisa and the Romanian Waters NA.
7. Clepan D., *Environmental Pollution* (in Romanain). Edit. Altip, Alba-Iulia, 2000.
8. * * * United Nations Development Programme (UNEP) and Office for the Coordination Humanitarian Affairs (OCHA)
9. http://apa8.blogspot.com/2009/09/substante-chimice-toxice-mercur-plumb.html

10. http://www.ape.sibiu.ro/04.Management ape/01.calitate/calitate.htm
11. http://www.uab.ro/reviste_recunoscute/revcad/revcad_2007/27.ludusan_nicolae.pdf
12. http://www.ziaruldeiasi.ro/national-extern/scandalul-cianurilor-din-tisa-traver-seaza-ni16ln
13. http://uebcampus.wordpress.com/2008/02/27/romania-nu-gusta-cianura/
14. * * * *Water Framework Directive*. 2000/60/EC, 2000.
15. http://www.icia.ro/proiect.aspx?pID=66
16. http://www.greenagenda.org/eco-aqua/supraf.htm
17. http://www.mmediu.ro/departament_mediu/starea_mediului/rom/cap2/r_int.htm
18. * * * STAS *4706*/1988.
19. www.mmediu.ro-Implementation of the new Water Framework Directive on pilot basins.

DEGRADAREA CALITĂȚII APEI PRIN POLUARE ACCIDENTALĂ

(Rezumat)

În ultimii ani abordarea sistemică a fenomenelor hidro-meteorologice extreme şi a poluării accidentale a căpătat o utilizare din ce în ce mai mare. Lucrarea îşi propune să treacă în revistă unele aspecte legate de poluarea accidentală a apelor cu cianuri din râul Someş cu afectare şi în zona Ungariei. Se prezintă noțiuni de poluare în bazinul hidrografic Someş cu referire la resursele de apa, poluarea cu cianuri a râului Someş cu detaliere a impactului produs asupra mediului, măsuri la sursa de poluare şi concluziile ce se degajă. Poluarea constă în impurificarea mediului cu diferite substanțe (poluanți) în urma activităților oamenilor care acționează în atmosferă, apă, sol.