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HYDROTECHNICS

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CONTRIBUTIONS TO THE ESTABLISHING OF DIRECTIONS IN PLANE AND ERROR VALUE OF THE HORIZONTAL DEFORMATION VECTOR OF THE STUDIED CONSTRUCTIONS, CORRESPONDING TO THE MAXIMAL PROBABILITY

BY

GH. NISTOR, **I. NISTOR and *GH. ANDRICIOAEI

Abstract. In the complex operation of the deformations and horizontal displacements measuring of the studied constructions, called for short horizontal deformations vector, the principal geodesic method is represented by the microtriangulation method. Based on the cyclical angular and linear of precision measurements, performed from the fixed points of the network, in the frame of this method, the horizontal deformations vector in the fixed control points on the studied construction is determined.

The small and very small values of the changes suffered by the constructions in execution and operating as well as the exigencies concerning the precision of the determinations, impose a searching of a great complexity study.

In this work, a method of establishing of the directions in plane and value of the error of the vector of horizontal deformation of the studied construction corresponding to the maximal probability is presented.

Key words: deformation; vector; microtriangulation; error probability.

1. Introduction

The rising of the constructions qualitative level and choosing of the optimal solutions are performed by completing the strength and stability calculation with laboratory search on models and measurements and observations upon constructions in nature, accomplished by some instruments and methods of high technicality.

The survey of the behaviour *in situ* of the constructions refers to the position and form changes, of the assembly or some parts of it, as well as to appearance of some evolutive phenomena which would be affecting the sofeguard of the construction.

The geodesic methods report the position of certain points fixed on construction, called *control points* or *aiming marks*, to the fixed points/marks situated outside the construction, on stable ground and outside the influence zone of the construction, achieving the general system of reference. These methods have a wide use in the operating end phase.

From the geodesic methods group, the microtriangulation is used in the survey of the behaviour *in situ* of the massive constructions (barrages, viaducts, locks, bridges) and of the grounds round it as well. The design and materialization of the microtriangulation network points is achieved on the base of an anticipation study which assures the closest results to reality of the parameters which characterize the construction. The determination of the horizontal deformations vector is realized on the base of cyclic measurements of the microtriangulation network, executed with the help of the theodolits or total stations of precision. The measurements in each cycle are executed with the same precision as in the initial case.

The compensation calculus is performed rigorously on the base of the mean square method, to obtain the most probable values of the horizontal deformation vectors in the all control points from the studied construction. Using the most adequate mathematical model, one can realize also a complete evaluation of the measurements precision and of deformation vectors.

2. Establishing of the Directions in Plane and the Value of the Horizontal Deformation Vector of the Studied Construction, Corresponding to the Maximum Probability

From the beginning it must be underlined that, as distinct from the case of determination of the position in plane of new points of the geodesic network, where the establishing of the optimal conditions of determination are obtained by analysing the minimum of the pedal curve generated by the ellipse of errors in every determined point, in the case of the determination of the horizontal deformation vector of a studied construction this is not possible. In this case, the error of the horizontal deformation vector depends, in the first place, on the position/direction of the vector with respect to the rectangular system of axes, in which the determinations are achieved. The system of rectangular axes X, Y is chosen so that it coincide with the principal axes of the studied construction or with the directions along which the solicitations are largest. The microtriangulation network used in the survey of the behaviour of an arched dam is presented in Fig. 1. The structure of the network includes the following categories of points: control points or aiming marks ($P_1, P_2,\ldots,P_N$), fixed on the aval pavement of the barrage, station points (*I*, *II*, *III*, *IV*), from which the cyclical measurements are executed, points of reference (K_1, K_2, K_3) from

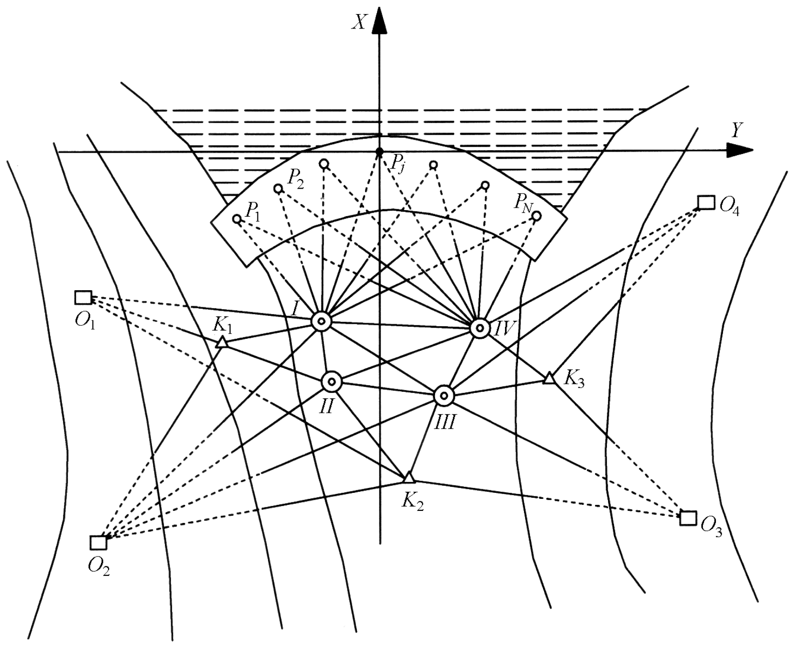

Fig. 1 – Network of microtriangulation.

which one determine possible changes in the position of the station points and points of orientation (O_1, O_2, O_3, O_4) situated in the grounds with a high degree of stability are determined. Because of the difficult conditions in which one realizes the survey of the behaviour in time of the massive constructions, submitted to different solicitations from the fixed points of the micro-triangulation network is realized, the most indicated method of treating of the measurements resulted from different cycles of observations is the rigorous method of the indirect measurements – Gh. N i s t o r algorithm [1]. In the frame of this algorithm one performs the determination of the horizontal deformation vector, simultaneously for a number of *N* control points, fixed on the construction, from a number of *P* fixed points of the network in function of *r* direct measurements on the ground, for example horizontal angles. This algorithm presents a character of wide generality being valid for different methods of determinations.

By Gh. Nistor algorithm, are calculated, in the first place, the components of the horizontal deformation vector with the matrix relation [1]

(1) $$X_{n1} = -Z_{nr} L_{r1}$$

or in developed form

(2) $$\begin{bmatrix} \Delta X_1 \\ \Delta Y_1 \\ \dots \\ \Delta X_N \\ \Delta Y_N \end{bmatrix} = -\begin{bmatrix} z_{11} & z_{12} & \dots & z_{1r} \\ z_{21} & z_{22} & \dots & z_{2r} \\ \dots & \dots & \dots & \dots \\ \\ z_{n1} & z_{n2} & \dots & z_{nr} \end{bmatrix} \cdot \begin{bmatrix} l_1 \\ l_2 \\ \dots \\ \\ l_r \end{bmatrix}.$$

The constant matrix which appears in relations (1) and (2) is obtained from the elements of the initial cycle as a product,

(3) $$Z_{nr} = \tilde{Q}_{nn} A_{nr}^T P_{rr},$$

and the matrix of the free terms has as elements the differences between the horizontal angles measured in the initial/zero cycle and the actual one

(4) $$l_i = \beta_{0i} - \beta_{1i} = \Delta\beta_i, \quad (i = \overline{1, r}).$$

Based on the components ΔX_j, ΔY_j, $(j = \overline{1, N})$, the horizontal deferomation vectors

(5) $$\mathcal{L}_{N,1} = \mathcal{L}_{n/2,1} = \begin{bmatrix} L_1 \\ L_2 \\ \dots \\ L_N \end{bmatrix} = \begin{bmatrix} \sqrt{\Delta X_1^2 + \Delta Y_1^2} \\ \sqrt{\Delta X_2^2 + \Delta Y_2^2} \\ \dots\dots\dots\dots \\ \sqrt{\Delta X_N^2 + \Delta Y_N^2} \end{bmatrix},$$

and its orientations in plane, corresponding to each control point,

(6) $$\theta_{N,1} = \theta_{n/2,1} = \begin{bmatrix} \theta_{L_1} \\ \theta_{L_2} \\ \dots \\ \theta_{L_N} \end{bmatrix} = \begin{bmatrix} \arctan\left(\Delta Y_1 / \Delta X_1\right) \\ \arctan\left(\Delta Y_2 / \Delta X_2\right) \\ \dots\dots\dots\dots \\ \arctan\left(\Delta Y_N / \Delta X_N\right) \end{bmatrix},$$

are calculated.

The precision evaluation of the components of the horizontal deformation vector in every control point of the construction is achieved using the variance–covariance matrix [3]

(7) $$s_x^2 = s_0^2 \tilde{Q}_x,$$

where s_0 is the quadratic mean error of the weight unity and represents the mean error of the differences of the horizontal angles, measured in two cycles of observations given by relation

(8) $$s_0 = \pm\sqrt{\frac{V^T PV}{r-n}}.$$

The product in denominator is calculated by

(9) $$V_{1r}^T P_{rr} V_{r1} = L_{1r}^T P_{rr} L_{r1} + X_{1n}^T A_{nr}^T P_{rr} L_{r1}.$$

The value of the weight unity characterizes the conditions of measuring, that is the postcompensation precision of the measurements.

$\tilde{Q}_x$ is the matrix of the cofactors (matrix of the weight coefficients of the unknowns/components) and has the form

(10) $$\tilde{Q}_x = \begin{bmatrix} Q_{X_1X_1} & Q_{X_1Y_1} & \cdots & Q_{X_1X_N} & Q_{X_1Y_N} \\ Q_{X_1Y_1} & Q_{Y_1Y_1} & \cdots & Q_{X_NY_1} & Q_{Y_1Y_N} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ Q_{X_1X_N} & Q_{X_NY_1} & \cdots & Q_{X_NX_N} & Q_{X_NY_N} \\ Q_{X_1Y_N} & Q_{Y_1Y_N} & \cdots & Q_{X_NY_N} & Q_{Y_NY_N} \end{bmatrix}.$$

The square mean errors of the components of the horizontal deformation vector in the control point j, $(j = \overline{1,N})$, are expressed by

(11) $$s_{\Delta X_j} = \pm s_0 \sqrt{Q_{X_jX_j}}, \quad s_{\Delta Y_j} = \pm s_0 \sqrt{Q_{Y_jY_j}},$$

and the mean error of the vector will be

(12) $$s_{L_j} = \sqrt{s_{\Delta X_j}^2 + s_{\Delta Y_j}^2}.$$

Because it is found that the square mean errors do not characterize so well the precision, it is established [2] that the domain, in which the deformation vector from each control point will be situated, is represented by pedal curve, generated by the ellipse of errors having the area expressed (Gh. Nistor, Gh. Andricioaei, 1994) [4] by

$$A_p = \frac{\pi}{2}\left(A^2 + B^2\right), \tag{13}$$

where A and B are semiaxes of the ellipse of errors. To drawn the pedal curve from every control point j, $(j = \overline{1, N})$, based on matrix (7), it is necessary to calculate the following elements [1], [3] (Fig. 2):

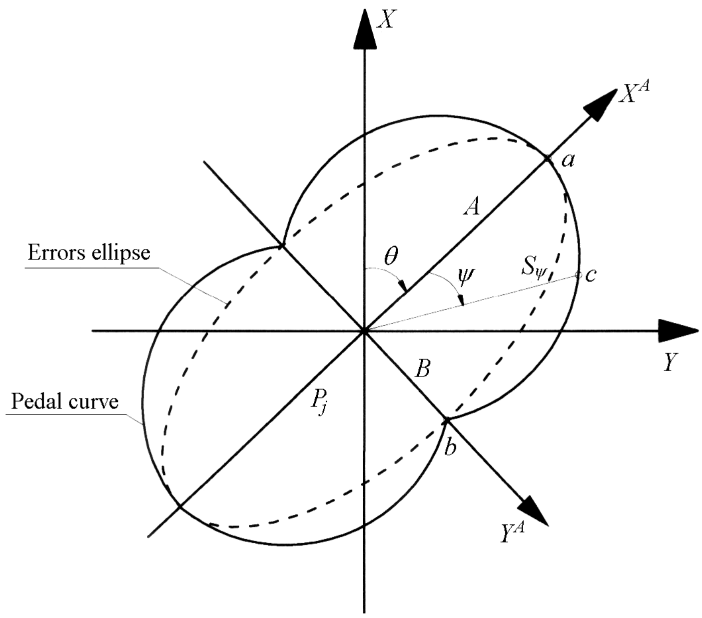

Fig. 2 – Errors ellipse and pedale curve ($A/B \cong 2$).

a) The orientations of the semiaxes of the ellipse of errors, corresponding to the rectangular system X^A, Y^A, by using the trigonometric equation

$$2\theta_j = \arctan\frac{2Q_{X_jY_j}}{Q_{X_jX_j} - Q_{Y_jY_j}} \Rightarrow \theta_j, \theta_j \pm 100^{g}. \tag{14}$$

b) The semiaxes of the ellipse of errors

$$(15)\ A_j = \pm s_0 \sqrt{\frac{1}{2}\left(Q_{X_jX_j} + Q_{Y_jY_j} + q_j\right)},\ (16)\ B_j = \pm s_0 \sqrt{\frac{1}{2}\left(Q_{X_jX_j} + Q_{Y_jY_j} - q_j\right)},$$

where

$$q_j = \sqrt{\frac{1}{2}\left(Q_{X_jX_j} - Q_{Y_jY_j}\right)^2 + 4Q^2_{X_jY_j}},\ \ q_j > 0. \tag{17}$$

c) The drawing, at a superunit scale of the pedal curve generated by the ellipse of errors, with the help of equation

$$S^2_\psi = A^2_j \cos^2\psi + B^2_j \sin^2\psi, \tag{18}$$

where ψ represents the angle between axis X^A and any direction, considered in direct sense and contained in [0, 2π] interval. Eq. (18) offers the expression of the vector radius of the pedal, representing the error of the vector along the considered direction,

$$S_\psi = \sqrt{A^2_j \cos^2\psi + B^2_j \sin^2\psi}. \tag{19}$$

Analysing the relation (13) we conclude that for a given ellipse, the pedal area can takes different values as function of the semiaxes A and B ratio. For example, for the small semiaxis B area of the pedal is a function of the form

$$A_p = \frac{\pi}{2} B^2 \left[\left(\frac{A}{B}\right)^2 + 1\right]. \tag{20}$$

The fact that for an ellipse of errors concerning the determination of the horizontal deformation vector, of given area, will result pedals of different areas, corresponding to the ratio of semiaxes, it means that also the probability of situation of the deformation vector on the surface of each pedal will be different, and certainly more than in the case of situation in the domain of ellipse of errors, P_e = 39.35%.

In [4] is established a relation which permits to compute the probability that the deformation vector belong to the domain represented by the pedal curve generated by the ellipse of errors (Gh. Nistor, Gh. Andricioaei, 1996)

$$p_P = 1 - \frac{1}{2\pi}\int_0^{2\pi} \exp\left[-\frac{1}{2}\cdot\frac{A^4\cos^2\psi + B^4\sin^2\psi}{\left(A^2\cos^2\psi + B^2\sin^2\psi\right)^2}\right]\mathrm{d}\psi. \tag{21}$$

For the calculation of the probability one can use a computer program or the Simpson's approximation formula [5]. Relation (21) being difficult to access, one recommends to use the minimum and maximum values between which will be situated P_p, that is the probability that the deformation vector will be situated within the domain represented by the pedal curve of the errors ellipse. This will be expressed by inequalities [4], [5]:

$$1 - \exp\left(-\frac{1}{2}\right) \le P_p \le 1 - \exp\left[-\frac{\left(A^2 + B^2\right)^2}{8A^2B^2}\right]. \tag{22}$$

An analysis of the inequalities (22) shows that the probability for the deformation vector to be situated within the domain of the pedal curve will be necessarily included between a minimum value and maximum one. But the minimum value expressed by the first term of (22) represents in fact the probability for the deformation vector to be situated in the domain of the errors ellipse, obtained by the known relation

$$\begin{aligned} P_e &= \frac{1}{2\pi AB}\int_0^{2\pi}\mathrm{d}\psi\int_0^1 \exp\left(-\frac{1}{2}S^2\right) ABS\,\mathrm{d}S = \\ &= -\exp\left(-\frac{1}{2}S^2\right)\Bigg|_0^1 = 1 - \exp\left(\frac{1}{2}\right) \cong 0.3935 \end{aligned} \tag{23}$$

or in percents, $P_e = 39.35\%$.

The maximum value of the probability represented by the third term of (22) depends on the values of the semiaxes, more exactly on their ratio. To make obvious the influence of the ratio of semiaxes over the maximum of probability, the inequalities (22) can be written in the form

$$0.3935 \le P_p \le 1 - \exp\left[-\frac{1}{8}\left(\frac{A}{B} + \frac{B}{A}\right)^2\right]. \tag{24}$$

The search of relation (21) allows us to study the extremum values of the probability, corresponding to the different directions round the control point. Minimum values of the probability are obtained along the directions [4]

$$\psi_{\min} = 0^{\mathrm{g}}, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, 2\pi, \tag{25}$$

and correspond to the probability that the horizontal deformation vector from the construction to be situated in the domain of the ellipse of errors, $P_e = 0.3935$. The other points of extremum, which correspond to the directions along which the probability under discussion is maximum, will be (Fig. 3)

$$\psi_{\max};\ \pi - \psi_{\max};\ \pi + \psi_{\max};\ 2\pi - \psi_{\max}, \tag{26}$$

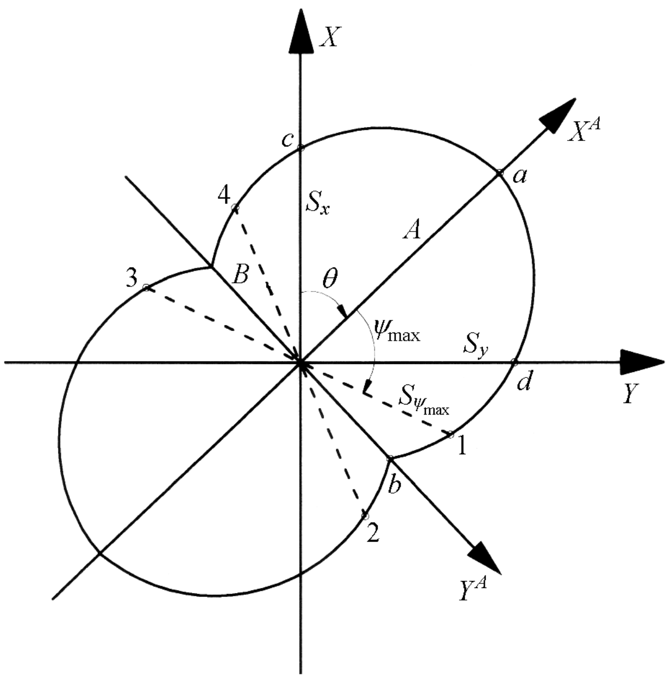

Fig. 3 – Directions in a plane and of the magnitude of the error of the horizontal deformation vector according to the maximal probability.

where the angle $\psi_{\max}$, between axis X^A and the direction under consideration, is computed with [4],…,[6]

(27)
$$\psi_{\max} = \arccos\sqrt{\frac{B^2}{A^2 + B^2}}.$$

Along the four directions, defined by the angular values (26), the maximum of the probability under consideration is computed with the relation

(28)
$$P_{p\max} = 1 - \exp\left[-\frac{1}{8}\left(\frac{A}{B} + \frac{B}{A}\right)^2\right],$$

which represents the third term of inequality (24). Along the direction with maximum probability one can compute the square mean error of the horizontal deformation vector of the studied construction with the expression of the vector radius of the pedal curve

(29)
$$S_{\psi_{\max}} = \sqrt{A^2 \cos^2 \psi_{\max} + B^2 \sin^2 \psi_{\max}}\,.$$

Considering the practical example when the ratio of the semiaxes is A/B = 2.14, the probability that the horizontal deformation vector to lie in the pedal domain will be maximum and equal to P = 0.5422 along the directions represented by angles $\psi_1 = 72^{g}20^{c}$, $\psi_2 = 127^{g}80^{c}$, $\psi_3 = 272^{g}20^{c}$ and $\psi_4 = 327^{g}80^{c}$. Along these directions, the square mean errors of the deformation vector will be equal to $S_{\psi_{\max}} = 22.4$ mm, very close to the minimum error represented by the small semiaxes, B = 17.5 mm. This result is remarkable only when the horizontal deformation vector of the studied construction, corresponds to the one of these directions.

3. Conclusions

When the determination of the horizontal deformation vector from the control points from the studied construction with respect to the measurements achieved from the fixed points of the microtriangulation network is studied, is obligatory to analyse the possibilities to obtain the smallest errors along the directions in plane of the deformation vectors. This is possible only in the case when are known with anticipation the directions in plane along which will be produced the deformations and horizontal displacements. For example, in the study of a gravity dam case, the deformations will appear along the direction of the hydrostatic pressure. In these situations will be studied the geometry of the microtriangulation network which leads to the configurations of the pedals from the control points which, by choosing the precision of the cyclic angular measurements, will permite to obtain the deformation vectors with small errors and maximum probability. This wish will be realized in the frame of two operations:

a) Determination through projection of the configuration and orientation in plane of each pedal, so that the small semiaxis to coincide with the direction of the deformation vector by studying the disposition of the station points. In this manner will be influenced the values of the elements of the cofactor matrix (the weight square and rectangular coefficients) of the vector components on axis X, Y with respect to which the determinations are achieved.

b) The increment of the precision of the cyclical geodesic measurements which will lead to the increment of the precision of the cyclical angular and linear differences, and implicitly to the increment of the precision of the deformation vector.

In the situation when it is not possible to know in advance the direction in plane of the deformation vector, will follow up that the pedals to draw near the configuration of a circle ($A/B \cong 1$); in this case, the square mean errors will be the same along all directions round the control points.

At the level of whole construction one recommend to achieve a statistical study of the results, for example by using the interval and domain of confidence method with the aim of the establishing, with a given probability, the state of efforts and deformations of the construction under study.

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CONTRIBUȚII LA STABILIREA DIRECȚIILOR PE PLAN ŞI A MĂRIMII VECTORULUI DE DEFORMAȚIE ORIZONTALĂ AL CONSTRUCȚIILOR STUDIATE, CORESPUNZĂTOARE PROBABILITĂȚII MAXIME

(Rezumat)

Principala metodă geodezică de măsurare a deformațiilor şi deplasărilor orizontale ale construcțiilor studiate, denumită pe scurt vectorul deformațiilor orizontale, o reprezintă metoda microtriangulației. În cadrul acestei metode, prin măsurători ciclice unghiulare şi liniare de precizie, executate din punctele fixe ale rețelei de urmărire, se determină vectorii deformațiilor orizontale în punctele de control fixate pe construcția studiată. Valorile mici şi foarte mici ale modificărilor suferite de construcțiile în exploatare, ca şi exigențele în privința preciziei determinărilor, presupun un studiu atent şi de mare complexitate al preciziei măsurătorilor, cât şi al condițiilor optime de determinare, stabilite prin geometria rețalei.

Se determină valorile unghiulare ale direcțiilor pr plan şi mărimea erorii vectorului de deformație orizontală din fiecare punct de control al construcției studiate, corespunzătoare probabilității maxime.

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A CASE STUDY CONCERNING THE DEFORMATIONS OF A RAILWAY BRIDGE'S EMBANKEMENT

BY

ANDREI-BOGDAN SÎMPETRU and MIHAELA PROCA-SÎMPETRU

Abstract. On the railway section Bucharest–Constantza at 191+252 km, out of Medgidia station, it was designed a new bridge that supports three tracks (the Ist and the IInd track of this section, the IIIrd track – Medgidia – Negru Vodă line).

In the first stage at the bridge's infrastructure construction works it was noticed the sliding of the Ist track's railway embankment on the Medgidia side, the traffic being temporarily stopped; there were required series of topographic measurements in several stages for tracking horizontal and vertical deformations and establishing the necessary measures. Thus, it was emphasized that the abutment from Medgidia settled approximately 5 cm in two hours and it was sliding into the river bed.

After the tests were completed it was decided the embankment's reinforcement, re-circulation and topographic monitoring for the abutments and for the temporary bridges throughout the length of time for bridge's construction works.

Key words: bridge; railway; deformation; measurements.

1. Introduction

Romania's strategic options in transport infrastructure regard the development of physical specialized and efficient infrastructure networks, compatible with the European and the international infrastructures [1].

The specific objectives are represented by rehabilitation, modernization and development of transport infrastructure to improve passenger comfort, increasing their safety and efficiency of freight, to align national transportation system to European system. Also it has to maximize positive effects and to minimize the overall and local impact on the environment that transport activities generate and are generally focused on

a) stopping the degradation of the infrastructure and maintaining the transportation system;

b) bringing the operating parameters and enhancement of existing capacity by repairing and modernizing the infrastructure;

c) removal or preventing the traffic's restrictions, bottlenecks and agglomerations;

d) increasing the capacity on certain sections of the Pan-European Transport Corridors IV, VII, IX and further work to achieve the TINA network (Transportation Infrastructure Needs Assessment), to ensure interconnection and interoperability between routes and transport modes;

e) interconnection with corridor TRACECA (Transport Corridor Europe-Caucasus-Asia);

f) promotion of the ecological transport technologies [1].

2. Case Study

In the area of Carasu Valley, in the south of Dobrogea plateau, on the railway section Bucureşti – Constanța at 191+252 km, in Medgidia railway station, Y head, over the Cabu River *was designed* a new railway bridge to sustain three railway tracks (Fig. 1) (main tracks I and II belonging to corridor IV, section Bucureşti – Constanța, and track III Medgidia – Negru Vodă) with independent *superstructures* on each track with of 11.00 m span, simple leaned on alignment and bearing, having the superstructure achieved by metallic beams included in reinforced concrete slab, with the line on gravel sand bed, with the construction heights of 1.24 m (h_c) and the leaning heights of 1.27 m (h_r). *The substructure* of the new railway bridge is composed of two reinforced concrete abutments, continuous under the superstructures, with a total length of 15.90 m and the elevation height of 4.67 m. The joints of the infrastructures with the embankments, both upstream and downstream, were made with supporting walls, founded directly, for the protection of the future channel's banks for waters' discharge (Cabu River and used waters from the industrial platform in Medgidia) [2].

For the infiltration waters flow there was foreseen a collector drain, founded on simple concrete foundation, with a transversal slope which joins the drain, behind the supporting walls of the slope protection.

The construction of the railway bridge at 191+252 km was coordinated with the protection's construction at the same km, the technological processes for the two works being interdependent.

The technological flow in first stage, in which this case study it is placed, was: closing of the traffic on Ist track, pulling of the electricity contact of the track and its taking into pieces; leveling the broken stone prism and the embankment; laying out the platform for the first 8 columns and executing them, according to the project; introducing heavy type metallic sheet-pile through ramming for the execution of the foundation plates, in the first stage on the area affected by the temporary bridges, on approx. 3,00 m on both sides of the track I beam and also into the wall parallel with track II; introducing 6 metallic pipes throughout ramming; leveling between the sheet-piles walls; laying out the ends of the metallic pipes for the temporary bridges' leaning and the wind bracings too; mounting the prefab blocks of reinforced concrete for the bridges' leaning on the embankment and introducing the temporary bridge on track; reconnecting the rail circuits; insuring the electric isolation on the temporary bridges with direct setting; earthing grounding of the superstructure of temporary bridges' superstructure; mounting the rail in completion and connecting it to the existing superstructure; repositioning of the electrification pillars and remounting the power supply; reopening the traffic on track under speed limit of 30 km/h, in speed by stages of 5 km/h on the first 24 h; keeping under supervision the temporary bridges on the entire length of duration of their operation in track, by remedying eventual faults and by bringing them under the admitted limit of tolerance; keeping the under speed limit of 30 km/h on track II and at normal speed on track III [2].

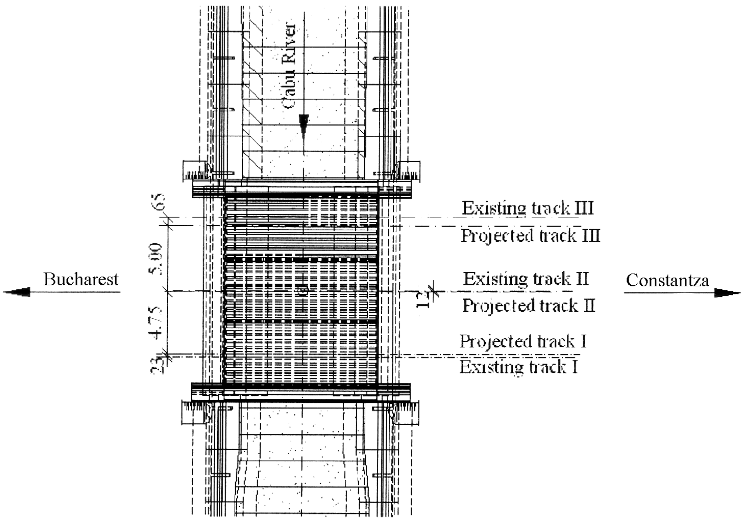

Fig. 1 – The designed railway bridge, at km 191 + 252, over Cabu River.

During the construction works at 191+252 km bridge's substructure in the first stage, after the temporary bridge was mounted and the traffic was reopened, it was observed the sliding of the embankement around Ist track abutment area from Medgidia; therefore the traffic was reclosed and there were requested series of topographical measurements (planimetric and altimetric), on several stages (before, during and after passing a locomotive) in order to determine the abutment's deformations and take the necessary actions [3].

In Tables 1 and 3 there are shown the measurements' results performed during the test *on the first day, after track's I traffic reclosing*, the observed marks being placed according to the sketch in Fig. 2.

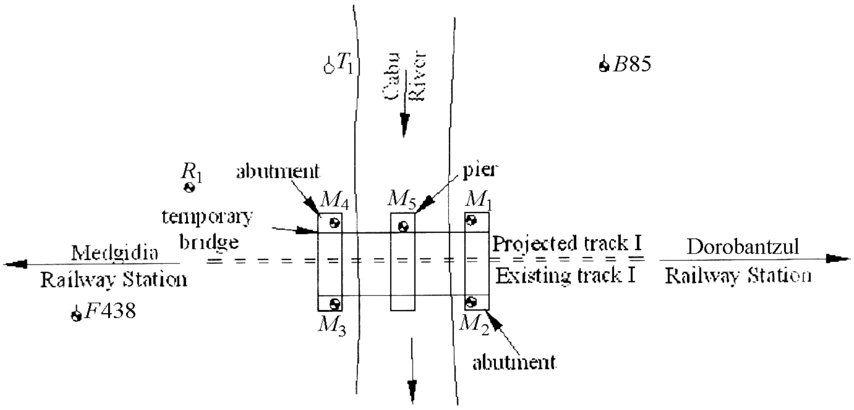

Fig. 2 – Sketch of the marks positions on the bridge at km 191+252.

Table 1

Level Measurements Made after the Closing of Track I

Set no.	Notes	Mark	Elevation m	Time H:m:s
1	Without a locomotive	M_2	12.94512	10:18:26
		M_1	12.92603	10:21:18
		M_5	13.95707	10:23:14
		M_4	12.93001	10:24:44
		M_3	12.91418	10:26:38
2	At the third wheel of the locomotive	M_4	12.91579	10:47:54
3	At the middle of the locomotive	M_4	12.91291	10:59:35
4	At the fifth wheel of the locomotive	M_4	12.90532	11:19:48
5	At the fifth wheel of the locomotive	M_4	12.90337	11:29:50
6	At the 6th wheel of the locomotive	M_4	12.89952	11:40:50
7	Without the locomotive	M_4	12.90212	11:48:25
		M_3	12.89177	11:51:11
		M_5	13.95697	11:53:06
	Reset			
8	After the locomotive has passed one time over the bridge	M_3	12.88622	12:28:29
		M_4	12.89658	12:31:53
9	After the locomotive has passed 3 times over the bridge	M_4	12.88179	12:46:31
		M_3	12.86854	12:48:06
		M_1	12.92545	12:53:52
		M_2	12.94442	12:55:28

It is specified that:

a) the altimetric measurements (Table 1) were made from R_1 mark and related to the bench mark F438 (Z = 13.969 m);

b) the planimetric measurements (Table 3) were made in a local system, from T_1 mark (X = 5,000.000 m, Y = 1,000.000 m) to the concrete bench mark B85 (having, in this system, the coordinates: X = 4,940.303 m, Y = 1,019.901 m), T_1-B85 being considered the basis of these measurements;

c) the benchmarks F438, B85 and the marks R_1 and T_1 were placed safe from the working area, in firm places [3].

According to the data resulted from level measurements (Table 1), the final settlings in mark's positions revealed that only the abutment from Medgidia was unstable (Table 2).

Table 2

The Settlings of the Abutments and of the Temporary Pier in Mark's Position

Mark	Settlings, [mm]	Elapsed time, [H:m]
M_1	0.58	2:32
M_2	0.70	2:37
M_3	45.64	2:21
M_4	48.22	2:22
M_5	0.10	1:30

Viewing also the charts of the settlings in marks M_4 (Fig. 3) and M_3 (Fig. 4) it can be concluded that the utmost differences between series are at the beginning and at the end of the test (series 1 – 2 and 8 - 9).

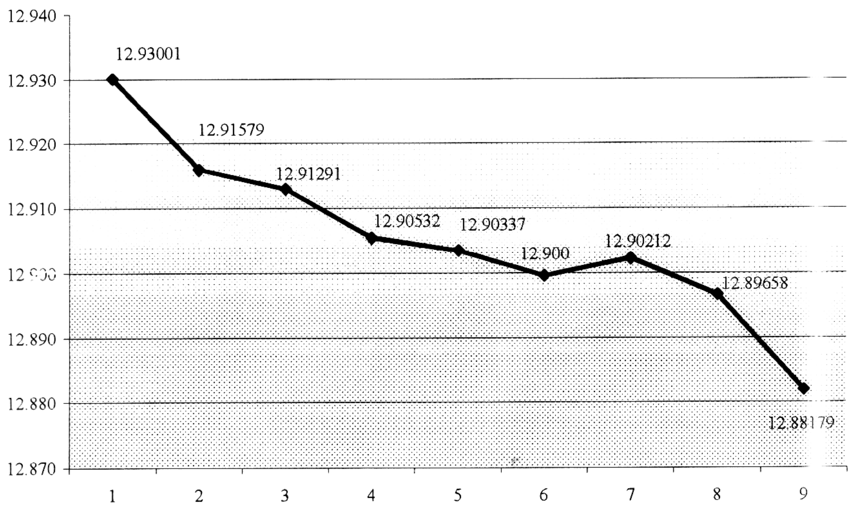

Fig. 3 – Chart of the settlings in mark M_4 .

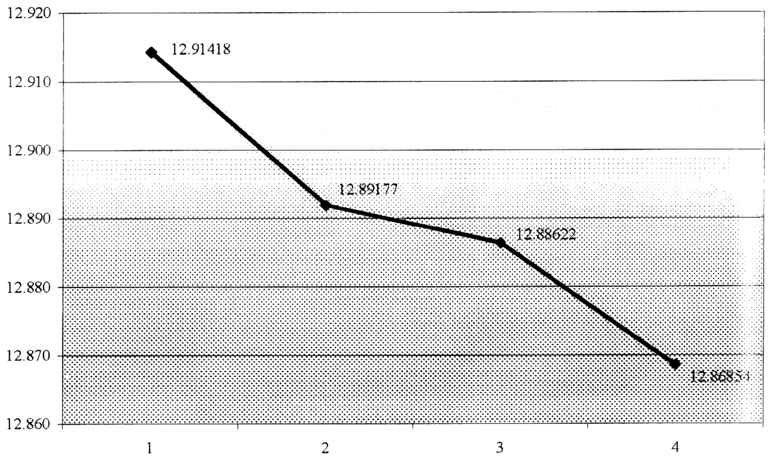

Fig. 4 – Chart of the settlings in mark M_3 .

Table 3

Total Station Measurements Made after the Closing of Track I

Set no.	Notes	Mark	Coordinates, [m] X	Coordinates, [m] Y	Time H:m
I	Without a locomotive	M_2	4,964.265	984.707	10:08
		M_1	4,965.026	987.677	10:10
		M_5	4,979.180	983.710	10:11
		M_4	4,993.944	981.236	10:12
		M_3	4,993.013	977.658	10:13
II	At the third wheel of the locomotive	M_4	4,993.946	981.237	10:41
		M_3	4,993.014	977.659	10:42
III	At the middle of the locomotive	M_4	4,993.947	981.237	10:52
		M_3	4,993.014	977.659	10:53
IV	At the fifth wheel of the locomotive	M_4	4,993.947	981.236	11:09
		M_3	4,993.014	977.659	11:12
V	At the fifth wheel of the locomotive	M_4	4,993.948	981.236	11:21
		M_3	4,993.014	977.659	11:23
VI	At the 6th wheel of the locomotive	M_4	4,993.947	981.237	11:32
		M_3	4,993.015	977.660	11:33
VII	Without the locomotive	M_4	4,993.945	981.238	11:39
		M_3	4,993.012	977.661	11:42
		M_5	4,979.180	983.710	11:46
	Reset				
VIII	After the locomotive has passed one time over the bridge	M_4	4,993.939	981.240	12:18
		M_3	4,993.005	977.663	12:20
XI	After the locomotive has passed 3 times over the bridge	M_4	4,993.936	981.242	12:42
		M_3	4,993.000	977.665	12:44

The data resulted from the planimetric measurements (Table 3) and the sketches of the horizontal deformations in marks M_4 and M_3 (Figs. 5 and 6), revealed that the abutment from Medgidia was sliding towards the temporary pier, therefore into the riverbed [3].

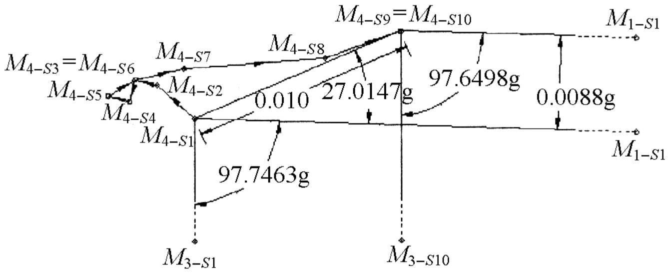

Fig. 5 – Sketch of the horizontal deformations in mark M_4, relative to marks M_1 and M_3.

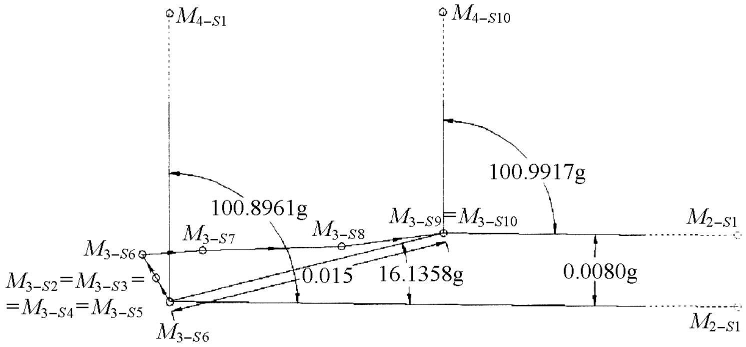

Fig. 6 – Sketch of the horizontal deformations in mark M_3, relative to marks M_2 and M_4.

Considering these measurements it was decided the reinforcing of the embankment in the abutment's area.

The topographical measurements in order to determine the abutment 's deformations from Medgidia continued as it follows:

a) before and after the new temporary bridge was mounted;

b) before, during and after passing a locomotive, having two empty wagons attached;

c) before and after the tamping machine has passed;

d) before and after a fully loaded freight train has passed;

e) after more trains have passed, during the night;

f) every day, under restricted speed limit for passing trains, by a frequency of 2 or 3 times per day until the deformations were included in requested tolerances for this kind of works [3].

After the traffic on I[st] track was reopened under speed limit of 30 km/h, in speed by stages of 5 km/h on the first 24 h, the temporary bridges were kept under supervision on the entire time length of their operation in track, by remedying eventual faults and by bringing them under the admitted limit of tolerance [2].

3. Conclusions

Topographical measurements are necessary at each stage of the construction works.

The measurements in each new set must be made under the same conditions as the first reference set: the same instruments, at eventually the same height, the same points of station and same marks, in order to preserve the unity of the determinations.

The deformations results must be represented very clear, in order to forewarn and preview unwanted security accidents.

The topographical measurements for determining the horizontal and vertical deformations must continue even after the construction is completed.

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STUDIU DE CAZ PRIVIND DEFOMAŢIILE TERASAMENTULUI UNUI POD DE CALE FERATĂ

(Rezumat)

Pe tronsonul de cale ferată Bucureşti–Constanța, la km 191+252, la ieşirea din stația de cale ferată Medgidia a fost proiectat un pod nou, care să susțină trei fire de cale ferată (firele principale I şi II ale tronsonului şi firul III al liniei Medgidia–Negru Vodă).

În prima etapă a construcției infrastructurii podului a fost sesizată alunecarea terasamentului firului I de cale ferată în partea dinspre Medgidia, fiind oprită temporar circulația şi cerută efectuarea unor serii de măsurători topografice în mai multe etape,

pentru determinarea deformaţiilor orizontale şi verticale ale culeei şi stabilirea măsurilor necesare. Astfel a fost evidenţiată o tasare a culeei dinspre Medgidia de aproximativ 5 cm în două ore şi alunecarea acesteia înspre albia râului.

După finalizarea testelor a fost decisă ranforsarea terasamentului, reluarea circulaţiei, urmărirea topografică a comportării culeei şi a podurilor provizorii pe toată durata lucrărilor de execuţie în zona podului.

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MODERN TECHNIQUES FOR MEASURING THE FLOW RATE THROUGH WATER CONVEYANCE PIPES

BY

MIHAIL LUCA and SIMONA-ADINA ALEXANDRESCU

Abstract. This paper presents the importance of knowing the flow rate of water transported through the water conveyance pipes and open channels, the main modern techniques for measuring it, showing the ranges of the pipe diameters, water velocities and precisions that characterize these ones. There were also presented the main characteristics of the Lindley pipeline which is a part of the Timişeşti – Iaşi water transport pipelines, indicating the places where the flowmeters are installed and their type.

Key words: flowmeter; flow; pipe; measurement; water.

1. Introduction

The water adduction constitutes a part of the water supply system, consisting of constructions and installations, which are designed to carry water from the intake constructions to the reservoirs [1]. In terms of pressure, the adductions can be operated with free level, in which case they may be closed or open and are called *channels*, or can work under pressure, operating by gravity or by pumping and those are called *forced piping* [2]. The pipes can be made of the following materials: prestressed reinforced concrete (PREMO), high density polyethylene (PEHD), polyvinyl chloride (PVC), sand insertion glass fibers reinforced polyester (PAFSIN), reinforced concrete, stoneware ceramic, steel protected on inside and outside, cast iron [3]. Ranges of the diameters are normally found between 100 mm and 2,000 mm.

The accurate measurement of water flow on the water adductions is of particular importance for the proper and efficient operation of installations and hydraulic equipment components, to know the quantity of water distributed to towns supplied from the adduction, and also to identify the water leaks. Flow measurement errors can generate negative economical effects that would be passed on the water supplier and its customers.

The flowmeters industry was developed along with technological progress in electronics. Starting from the mechanical flowmeters, which obstruct the section of the liquid flow generating significant load losses and numerous problems in their operation, today come to the flowmeters which do not affect the flow and provide high accuracy.

2. Modern Methods for Measuring the Flow Rate

Flowmeters to be purchased and installed in an adduction must be chosen depending on the flow regime (with free level or under pressure), on how are the elements through which water is transported (pipes, open or closed channels), on the required accuracy, size of channels and pipes and the prices of purchasing and maintaining the flow measuring devices.

The modern measuring instruments usually used on pressure lines are electromagnetic, vortex and ultrasonic flowmeters.

Ultrasonic flowmeters measure fluid velocity through the ultrasonic sensors, using ultrasound properties, to calculate the flow that passes through a pipeline with known diameter. The operation of ultrasonic flowmeters is based on the change of ultrasonic propagation velocity in a moving fluid due to the fluid's velocity [4]. These instruments are influenced by the fluid's temperature, density and viscosity, but don't disrupt the flow section and require low maintenance and operating costs because they don't use moving parts to determine the flow, unlike the mechanical flowmeters.

There are two main types of such flowmeters: those measuring the transit time and those that operate using the Doppler Effect. The first use pairs of ultrasonic sensors that can alternately send and receive ultrasonic signals. The transit times of these signals are measured. When the fluid is in motion, the speed of ultrasonic signals increases in the direction of the flow and decreases in the opposite direction, registering different transit times. It follows that the signals have different transit times: shorter in the direction of flow, and longer in the opposite direction. The difference between the recorded transit times is directly proportional to the average velocity of the fluid that passes through the pipeline. Doppler flowmeters are not recommended for measuring the drinking water's flow rate, because in view to obtain accurate results the liquid must contain suspension particles that reflect the sound waves emitted by the sensor.

Ultrasonic flowmeters can use wet sensors, when installed with flanges or clamp-on sensors applied on the pipe, without affecting the pipe's structure. The first can be applied on a range of diameters between 50 mm and 600 mm, the velocities between 0 m/s and 7 m/s with measuring accuracy of ±0.5…

±1.5%. These types of flowmeters are generally with 15…20% cheaper than the electromagnetic flowmeters. The instruments that use clamp-on sensors have the advantage of being portable, capable of measuring flow rates in different locations, and can be applied to a wider range of diameters, between 13 mm and 12,000 mm, and for velocities from 0.03 m/s up to 16 m/s, but with lower accuracy within ±0.5…±5% of the measured value, depending on pipe diameter, calibration and location.

Electromagnetic flowmeters do not affect the flow of liquid, so don't cause head losses, their results are not influenced by the fluid's temperature, pressure, viscosity or velocity profile. Operation of electromagnetic flowmeters is based on the law of electromagnetic induction, which involves the appearance of an electric voltage when a conductor moves through a magnetic field for which the measuring can be accurate only if the liquid is conductive. When the liquid is at rest, there is no electric voltage between the device's electrodes, and electrically charged particles are distributed uniformly in the conductor. When liquid begins to flow, the magnetic field exerts a force on the electrical charged particles, resulting in the separation of positive and negatively charged near the tube walls in the opposite sides. This produces an electromotive force detected and measured by the two electrodes. This voltage is directly proportional to the fluid velocity, and together with the known cross sectional area the flow rate can be calculated.

Electromagnetic flowmeters can be installed with flanges or by pipe insertion. The flange may apply for diameters between 1 mm and 3,000 mm, for velocities from 0.5 m/s to 10 m/s, with accuracy ranging from ±0.2% to ±1%. Insertion flowmeters are used for diameters from 50 mm to 8,000 mm, at velocities between 0.1 m/s to 10 m/s and accuracies of ±1.5% to ±2% of the measured value.

Vortex flowmeters are volumetric flow measuring instruments easy to maintain, as there are no moving parts. Their operation is not influenced by the fluid's density, viscosity and conductivity. The peculiarity of these devices is the presence of an unstreamlined object in the middle section of the flow stream. The fluid splits into two branches and flows around the body, forming vortices downstream. They occur alternately on both sides of the barrier, having a predictable evolution. The distances between each two consecutive vortices are equal. The frequency of vortex formation is directly proportional to fluid velocity. Vortex flowmeters are fitted with flanges on pipes with diameters from 15 mm to 600 mm, at velocities from 0,3 m/s to 9 m/s, with an accuracy of ±0.75% to ±2% of measured value, depending on the flow regime.

The modern flowmeters that can be used for open and closed channels are the electromagnetic and ultrasonic flowmeters. There are only a few companies that have managed to create electromagnetic flowmeters for partially filled pipelines able to measure with high accuracy rates. These tools have in addition to the classical electromagnetic flowmeters a level sensor and the electrodes are below 10% filling. They apply to the pipes with diameters between 150 mm and 2,000 mm, measured velocities of 0.3 m/s to 12 m/s, with accuracies between ±0.5 % and ±5 % of the measured value, depending on water velocity and the filling. Ultrasonic flowmeters used on partly filled channels and pipelines have in addition to the speed sensor a sensor that measures the water level. They can be applied on pipes with diameters from 150 mm to 15 m and channels up to 200 m, with an accuracy of ±0.5% for full pipes and up to ±2.0% for partially filled pipes or channels.

Electromagnetic flowmeters have the highest accuracy of all devices presented in this paper, but, in exchange, for large diameters have high acquisition costs. Vortex flowmeters are the cheapest, but have the lowest precision and can be applied only to diameters up to 600 mm. For the flow rate measurement on large diameter water adductions are recommended the ultrasonic flowmeters because they offer a high accuracy and prices of maintenance and purchase that can be damped in a reduced time.

3. Case Study

The Timişeşti – Iaşi water adduction (Fig. 1) is part of the regional water supply system of the Iaşi County, with the aim to transport the drinking water from the sources Verşeni and Timişeşti to the reservoirs that supply a series of settlements on its route. It transports water by gravity from sources to the reservoirs from Păcurari district, where is pumped in steps to Breazu

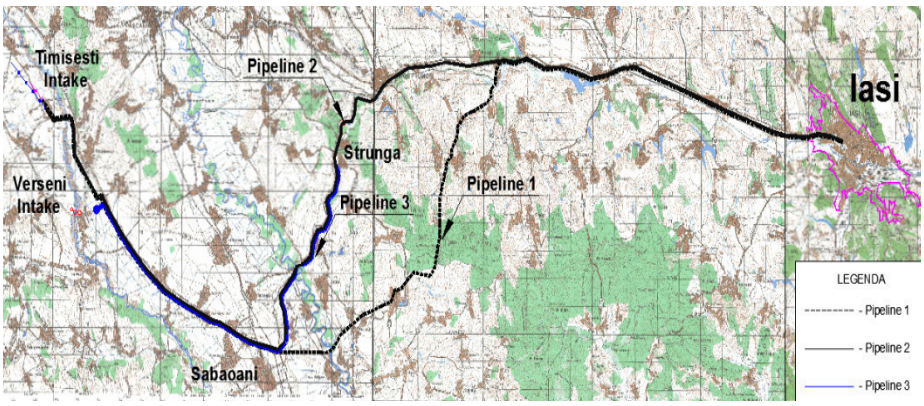

Fig. 1 – Timişeşti – Iaşi water adduction.

reservoir. Gravitational sector consists of three pipelines, two start in Timişeşti intake, supplying Păcurari reservoirs, and one that connects the Verşeni intake to Strunga gallery. Line 1 is also called Lindley, named after the engineer who designed it in the early twentieth century. The geometrical characteristics of the lines are shown in Table 1.

Table 1
Geometric Characteristics of the Line 1

No.	Section	Nominal diameter mm	Material	Length m
1	Timişeşti Intake – Săbăoani Piezometric Tower	Ov 700/1,200	Reinforced concrete	4,452
2		Dn = 800	Reinforced concrete	27,386
3		Dn = 800	Steel	1,069
4	Săbăoani Piezometric Tower – Oțeleni Canton	Dn = 800	Cast iron	14,504
5		Dn = 800	Steel	380
6		Dn = 800	Reinforced concrete	3,944
7	Oțeleni Canton – Brăieşti	Dn = 600	Cast iron	5,967
8	Brăieşti – Rezervor Tank 5,000 m^3	Dn = 600	Cast iron	40,766
9		Dn = 600	PREMO	1,409
10	Păcurari Tank 5,000 m^3 Aurora Tank 2 × 3,500 m^3	Dn = 600	Cast iron	1,410
11	Aurora Tank 2 × 3,500 m^3 – Mijlociu Tank 2 × 4,000 m^3	Dn = 600	Cast iron	988
12	Mijlociu Tank 2 × 4,000 m^3 – Breazu Tank 2 × 2,000 m^3	Dn = 400	Cast iron	3,300

Flow measurement on Lindley adduction is performed with ultrasonic flowmeters located as follows: on a pipe having Dn = 800 mm at Săbăoani piezometric tower, at the Păcurari pumping station on a branch with the nominal diameter of 600 mm, on Aurora station upstream the reservoirs, on a Dn = = 600 mm pipe, on Mijlociu station, where three flowmeters are mounted: one upstream the tanks on a Dn = 600 mm pipe, and two of them on the pumping branches which transport the water to Breazu tank: one mounted on a Dn = = 400 mm pipeline that crosses the Carol Boulevard, and another on a Dn = = 300 mm pipe that passes through the Petre Andrei Street. There are also a flowmeter on a Dn = 400 mm pipe located on the Sărărie Street and another one on a Dn = 300 mm pipe that crosses the Copou Boulevard. Electromagnetic flowmeters have a very good accuracy, but require high costs for purchasing the ones with large diameters. Even if the ultrasonic flowmeters have a lower accuracy than the electromagnetic ones, they are better suited for large diameter pipes, because offer a good accuracy with a lower price. The route that transports water by pumping from Păcurari Station to Breazu Water Tank is represented in Fig. 2.

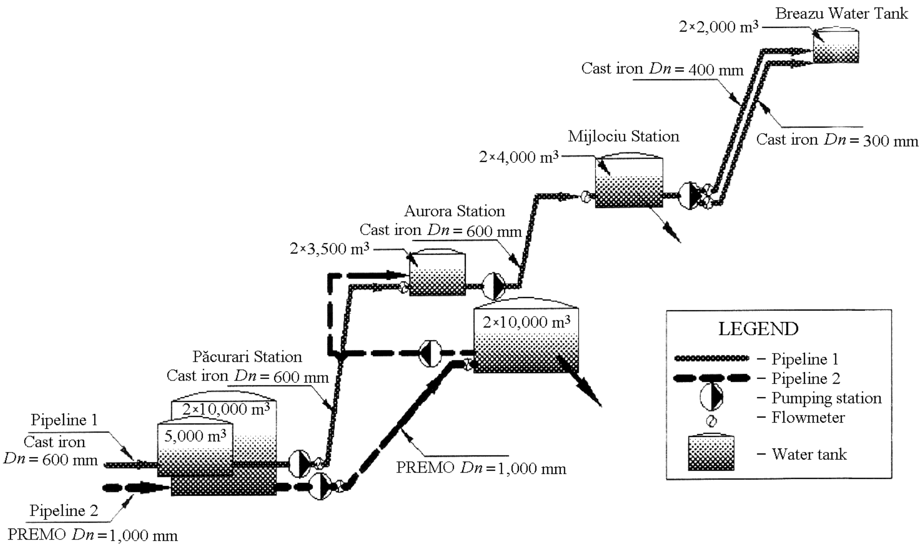

Fig. 2. – Scheme of pumping water adduction Păcurari – Breazu.

4. Conclusions

1. The water adduction is an important part of a water supply system and its bad maintenance can lead to failures and shortcomings of the whole system.

2. Knowing the flow rate is particularly important in the operation and maintenance of the water adductions. Flow measurement with instruments that don't provide high accuracy over time can lead to significant financial losses, negative effects on both the water providers and the consumers.

3. The best way to measure flow rate in the water adductions consisting of large diameter pipes is with the ultrasonic flowmeters.

4. On the Timişeşti – Iaşi water adduction, the flow rate is measured with ultrasonic flowmeters.

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TEHNICI MODERNE ÎN MĂSURAREA DEBITULUI PE ADUCȚIUNILE DE APĂ

(Rezumat)

Se studiază importanța cunoașterii debitului de apă transportat prin conductele şi canalele aducțiunilor, principalele tehnici moderne de măsurare a acestuia, indicându-se intervalele diametrelor, vitezelor şi preciziilor ce le caracterizează, iar în final au fost prezentate caracteristicile principale ale Magistralei Lindley, ce face parte din aducțiunea Timişeşti – Iaşi, indicându-se locurile în care sunt amplasate debitmetrele şi tipul acestora.

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THE HAROLD BLACK MODEL FOR TROPOSPHERIC REFRACTION ERRORS DETREMINATION AT GPS MEASUREMENTS

BY

D. ILIOI, ANCA-ALINA LAZĂR and C. BOFU

Abstract. The main models for the estimation of the errors that characterize the phenomenon of tropospheric refraction in GPS measurements are presented and then a practical example of the corrections determination based on the Harold Black model, corrections that need to be applied to the GPS measurements.

There will be presented the main mathematical formulas for the tropospheric refraction and will be determined how the elevation angle of the observations influences the measurements.

Key words: GPS; satellite; geodesy; troposphere; refraction errors; corrections.

1. Introduction

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.

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.

2. The Main Models for Tropospheric Refraction

The index of refraction does not depend on the of the signal’s frequency. It depends instead 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 refraction along the signal propagation path is then not feasible. Therefore various models for a description of the height-dependent behavior of the refraction have been developed.

The first model that is presented is that obtained by Helen H o p f i e l d [4], who has done the most important research in this field. Input parameters are mostly the meteorological surface data near the observation site.

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

$$\partial d_t = \partial d_d + \partial d_w = \frac{k_d}{\sin\sqrt{E^2 + 6.25}} + \frac{k_w}{\sin\sqrt{E^2 + 6.25}}. \quad (1)$$

where k_d and k_w describe the total effect of the tropospheric refraction in the zenith direction, 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.

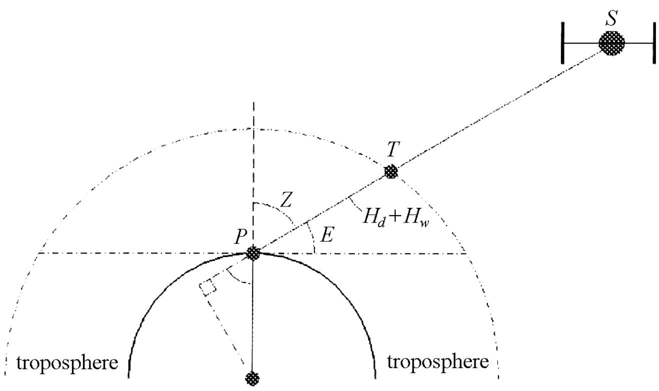

Fig. 1 – The tropospheric model.

The dry and the wet terms, (∂d_d and ∂d_w), are determined separately because their parameters are formulated as distinct functions of height:

$$K_d = 155.2 \times 10^{-7} \frac{P}{T} H_d, \; K_w = 155.2 \times 10^{-7} \frac{4{,}810e}{T} H_w, \quad (2)$$

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

Generally, for H_d a mean value is accepted (H_w = 11,000 m), but the parameter H_d was determined by Helen Hopfield empirically from globally distributed balloon data:

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

For elevations E > 30°, Harold B l a c k [3] has proposed the simple correction formulas:

$$\partial d_t = \partial d_d + \partial d_w = 2.31 P \operatorname{cosec} E + K_w \operatorname{cosec} E, \tag{4}$$

where P is the air pressure in atmospheres, [1 atm. = 1,013.25 HPa], and k_w is 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 Constant 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 Tropospheric Refraction Errors for GPS Measurements Made in Suceava County

The measurements were performed both in the summer at temperatures of 22°C near the observation site and during the winter at temperatures around –15°C, with an atmospheric pressure of 1,003.15 HPa and 1,025.32 HPa, respectively, as presented in Table 2.

Table 2
The Parameters of the Tropospheric Refraction Errors for the Measurements Performed in Suceava County

Parameters	Summer	Winter
Temperature, T, [°C]	22	–15
Atmospheric pressure, P, [HPa]	1,003.15	1,025.32
Harold Black regional empirical constant, K_w, [m]	0.28	0.06

The total tropospheric refraction errors were determined with eq. (4), separately for the dry and wet components and distinctively for different zenith angles, and then tabulated in Table 3.

Table 3

The Tropospheric Refraction Rrrors for Suceava County, Black

E		90°	60°	45°	30°	15°	10°	5°
∂d_d, [m]	Summe	2.29	2.65	3.24	4.58	8.85	13.19	26.28
	Winter	2.34	2.70	3.31	4.68	9.03	13.46	26.82
∂d_w, [m]	Summe	0.28	0.32	0.40	0.56	1.08	1.61	3.21
	Winter	0.06	0.07	0.08	0.12	0.23	0.35	0.69
∂d_t, [m]	Summe	2.57	2.97	3.64	5.14	9.93	14.81	29.50
	Winter	2.40	2.77	3.39	4.80	9.26	13.81	27.51

From the analysis of those values one can observe that the resulting range error, for GPS signals, because of the tropospheric refraction, can vary from less than 3 m to more than 27 m.

On the other hand, one can see that the effect of tropospheric refraction increases severely for GPS observations at low elevation angles.

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 pseudo range at GPS signal propagation are also within 8…10%. In the same time when station distances are smaller (<50 km) and when the height differences are small (in non mountainous regions, as Suceava county), the atmospheric conditions are sufficiently correlated with one another which means that the water vapour content of the air is almost identical horizontally. As regards the situation when the stations are close together the tropospheric residual error disappears almost completely by differencing in the relative observation mode.

4. Conclusions

The effect of tropospheric refraction increases with increasing zenith angle (z) or, in other words, with decreasing the elevation angle (E). For elevations, $E < 10°$, the influence easily exceeds 10 m.

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 of the tropospheric refraction over GPS measurements.

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MODELUL HAROLD BLACK PENTRU DETERMINAREA ERORILOR DATORATE REFRACŢIEI TROPOSFERICE LA MĂSURĂTORILE GPS

(Rezumat)

Se stabilesc expresiile corecţiilor care trebuie aplicate observaţiilor GPS astfel încât sa fie eliminate erorile datorate fenomenului de refracţie troposferică la măsurarea pseudodistanţelor.

În ultima parte sunt determinate, cu ajutorul relaţiilor simplificate ale lui Harold Black, pe un caz concret, corecţiile care trebuie aplicate măsurătorilor GPS, efectuate pe raza judeţului Suceava.

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THE MINING FIELDS FROM MOLDOVA NOUĂ AND THEIR INFLUENCE ON SOIL QUALITY

BY

V. NEAGU

Abstract. The mining fields from Moldova Nouă strongly affected environment by degrading soil quality.

Surface and underground mining, ore flotation, the presence of dumps/tailings ponds, etc., lead to the removal of soils and soil pollution on large surfaces. The high concentration of heavy metals in soils cause the decrease of soil fertility and the reduction of microbiological processes in the upper layers of soil.

Grass/trees were planted on the slopes of tailings ponds since the late 1980s, resulting in their complete afforestation and the stoppage of wind erosion.

Key words: tailings; heavy metals; tailings ponds.

1. Introduction

Moldova Nouă is a town located in the southern part of Caraş-Severin county in a small depression of the Danube Gorge (Moldova Veche Depression).

The temperate continental climate with submediteranean characteristics has allowed the development of southern origin plants (as tulichina – a tertiary relict) and the presence of passage and sedentary bird species (cormorans, egrets, herons, storks, etc.). Two natural reservations were established – Valea Mare Natural Reservation and Moldova Veche Islet Natural Reservation, the latter included in the Iron Gates Natural Park in 2000 – to protect the special elements of flora and fauna in the area of Moldova Nouă.

The copper deposits from the Suvarov-Valea Mare area, north-east of Moldova Nouă, were formed at the contact between the crystalline and limestone rocks of Locvei Mountains, as a result of the processes of contact metamorphism. The mining fields have made strong footprint on the environment resulting in the degradation of all its components, but particulary soils.

2. Moldova Nouă Mining Perimeter

Moldova Nouă mining perimeter contains both crystalline, sedimentary, igneous and contact rock. The deposit mineralization presents itself as compact objects quartered in the contact rocks (the underground exploitable ore bodies) and as mineralization of impregnation diffusely arranged in the body or the cracks of banatites.

The mining company with underground operations (Florimunda, Suvarov, Valea Mare and Vărad mines) and surface operations (Moldova Nouă quarry) was established in 1965.

Since 1990 the mining company started to face problems related to the usage of technical means of extraction and processing, the lack of investment funds, etc. This situation leads to the continuous decrease of ore production.

Curently the deposit operations is conducted only in the banatites quarry. The operation consists in dislodging the ore by filling the blast holes drilled vertically on the steps of the quarry with explosives and detonate the explosives. Then the ore is loaded onto trucks and transported to the primary crusher located in the southern part of the quarry. From there, tailings is stored in waste dumps while the useful ore is transported by belt carriers to the Processing Plant (P.P.) no. 2.

The wet grinding of the ore takes place in the P.P. no. 2. It is followed by the copper sulphides cell flotation in order to get the final concentrate. The copper concentrate is then transported hydro-gravitationally to the draining station, where water is removed. Eventually, it is stored in the copper warehouse or the berth of the industrial port. From here it is loaded by cranes into barges or trucks in order to be sold.

Tailings resulted from the P.P. no. 2 is transported hydro-gravitationally through gutters and pipes to the unified tailings pond.

3. Sources of Soil Pollution

The sources of pollution/degradation of soils in the area of Moldova Nouă are the extraction and processing of copper ore (Fig. 1).

The main sources of pollution/degradation affecting the soil quality in the area of Moldova Nouă are the following:

a) the quarry and the waste dumps (activities involving the removal of topsoil, the firing of boreholes, the excavation of rocks and the storage of tailings in waste dumps, the slide of waste dumps, the runoff on the slopes of waste dumps, etc.);

b) the underground mining galleries (the waste rocks resulting from mining processes);

c) the P.P. no. 2;

d) the tailings ponds (the extension on a large area and changing the initial use of the land, the deflation of tailings up to several kilometres away);

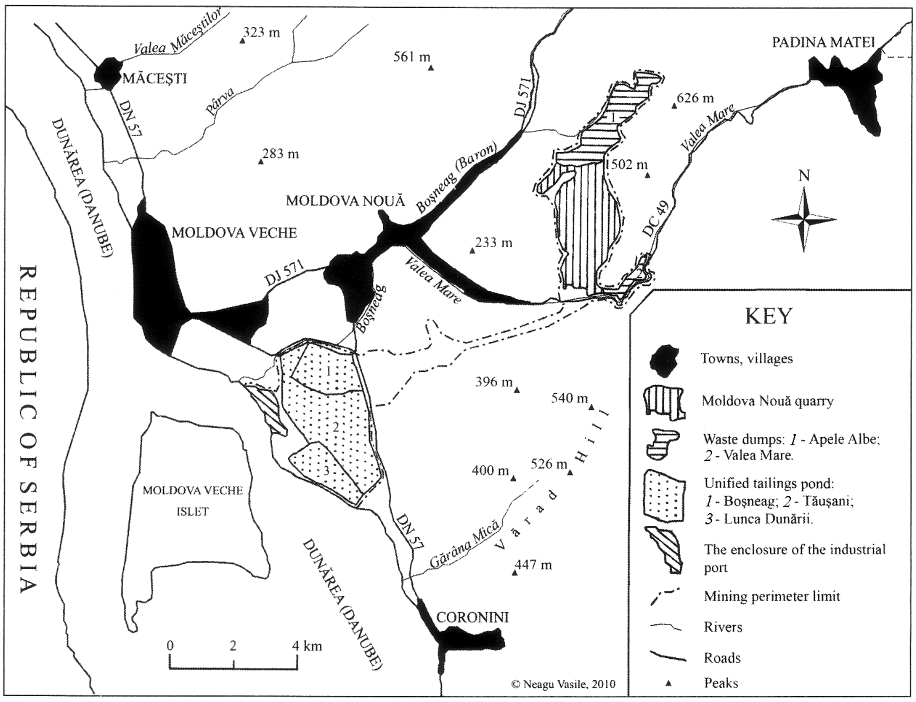

Fig. 1 – The area of Moldova Nouă (by E.P.A.C.S., 1999-2008).

e) the networks of roads and lanes (the losses of tailings during transportation);

f) the networks of gutters and pipes (the losses of tailings during hydro-gravitational transportation to the unified tailings pond);

g) the industrial port (the large areas of degraded land).

4. The Influence of Pollution Sources on Soil Quality

The main activities that pollute/degrade the soils are presented bellow.

Many activities that affect the soil quality take place in Moldova Nouă quarry. We can mention the following [3]:

a) Stripping the surface layers of soil – a necessary operation to get to the orebody. It is achieved by excavating significant volumes of rock and depositing them on other land, thus leading to a multiple assault and degradation of the original land. Moldova Nouă quarry (including the surrounding waste dumps) is the main source of pollution/degradation of soil by stripping the surface layers of soils (Fig. 2).

b) Blasting operations can cause a number of effects of variable intensity on the stability of the surrounding terrain (where the underground galleries are) or they can accelerate some unstable pre-exiting natural phenomena (rockfalls, landslides, collapses, etc.).

Fig. 2 – Moldova Nouă quarry seen from
the north-east (E.P.A.C.S., 2006).

c) The excavation of valuable rock determines significant changes to that area reflected in the impressive size and shape of the void created. Open-pit mining may have negative effects of different amplitudes and forms manifested in the area or may accelerate natural phenomena (landslides, subsidence, etc.) [3]. Rock slumps and flow phenomena occur both on the slopes of the quarry (Fig. 3) and on the batters of waste dumps.

Fig. 3 – Flow processes on the eastern slope of
Moldova Nouă quarry (Neagu, 2006).

d) The transportation of tailings by trucks to the waste dumps entails losses during transportation.

e) The storage of tailings in waste dumps affects other areas outside the quarry by removing them from the original circuit and by forming an anthropogenic soil around them due to the dispersion of tailings under the influence of uncontrolled rainwater [3].

The waste dumps (Apele Albe and Valea Mare) cover important areas and are landscapes as barren as the quarry itself.

The gutters/pipes for the hydro-transportation of tailings from the P.P. no. 2 to the unified tailings pond leaks large amounts of tailings forming puddles which also appear along the National Road 57 (Fig. 4).

Fig. 4 – Soil pollution by tailings along
National Road 57 (Neagu, 2006).

The tailings ponds (Tăuşani, Boşneag, Lunca Dunării – the unified tailings pond) (Fig. 5) are also a major source of soil pollution/degradation due to the large areas covered with tailings and the side effects that are generated by these deposits (the phenomenon of deflation caused by Coşava).

The unified tailings pond (306 ha) (Fig. 6) is founded directly on natural terrain without *prior* waterproofing works. The alluvial foundation soil contributes to water drainage from the pond so that the contour slopes of the dam are perfectly dry and they do not have pond seepage (springs, griffins, wetlands or local collapses, etc.) [4].

The enclosure of the industrial port includes large areas of degraded land. The copper concentrate dewatering and the settling of sewage are done here.

The types of waste resulting from the mining activities can be grouped as follows [3]:

1. Technological exploitation waste resulting from stripping the topsoil and processing operations.

2. Technological exploitation waste resulting from the operations taking place at the P.P. no. 2.

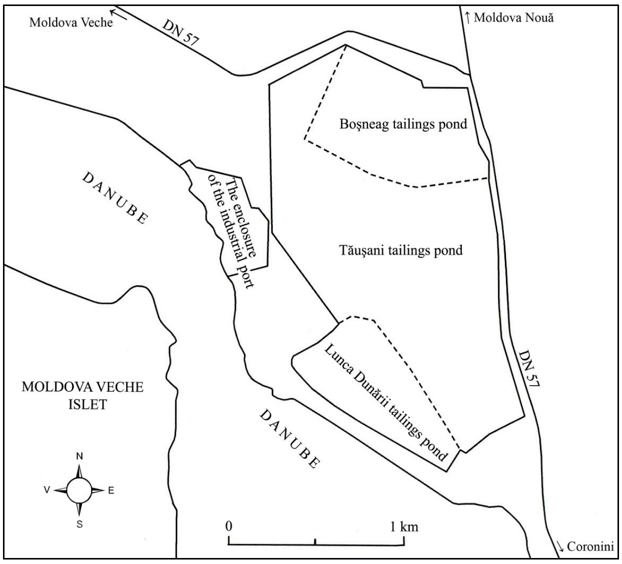

Fig. 5 – The location of tailings ponds along the Danube (by B.R.B.A., 2008).

Fig. 6 – The unified tailings pond (E.P.A.C.S., 2006).

Tailings from the tailings ponds has the consistency and appeareance of a medium and fine grain, falling within the category of inert waste because it does not undergo any significant physical, chemical or biological transformation with the passage of time. It cannot be dissolved. It does not burn and it is not biodegradable. It does not affect the materials that come into a direct contact in a way that could lead to environmental pollution or harm human health [4].

C h i s ă l i ţ ă [1], considers that the size of composition of the tailings from the tailings ponds from Moldova Nouă is the following: gravel (10%), coarse sand (25%), fine sand (55%) and silt (10%).

The chemical composition of the tailings from the tailings ponds is complex and diverse, as it can be seen in the Table 1.

Table 1

The Chemical Composition of the Tailings from the Tailings Ponds [1]

No.	Chemical substances, [% from total]											Total *)
	Fe	S	TiO_2	V	Pb	Zn	Cd	Ra	CaO	SiO_2	Al_2O_3	
1.	7.23	2.2	0.15	0.02	1.0	0.09	0.01	0.104	20	31.6	–	61.2
2.	5.87	1.8	0.23	0.03	1.0	0.05	1.0	–	24	31.5	–	63.4
3.	5.56	3.8	0.77	–	–	0.12	1.0	1.0	18	33.7	–	60.3
4.	6.40	0.4	0.37	0.02	traces	0.01	0.01	0.002	15	32.7	–	54.5
5.	3.83	0.6	0.31	0.02	0.01	0.06	traces	0.003	24	32.7	–	61.0
6.	4.40	0.7	0.24	–	0.01	0.06	1.0	–	4	30.4	–	40.2
7.	5.28	1.0	0.36	–	–	–	–	–	–	32.1	5.67	43.4
8.	4.40	0.7	0.24	–	–	–	–	–	–	30.4	4.32	39.3
*A***	5.32	1.4	0.33	0.01	0.25	0.05	0.38	0.14	13.1	31.9	1.25	54.2

*) the difference toll 100% is water and inert materials, which are very difficult to identify;
** the average of chemical components [%].

Therefore, the compounds of silicon (31.89%), calcium (13.13%), iron (5.32%) and aluminium (1.25%) have the highest concentrations. The remaining compounds are poorly represented or appear as traces [1].

3. The secondary waste resulting from mining related activities and domestic waste.

As regards the soil analysis from the mining perimeter, measurements revealed significant copper concentrations (Table 2 and Fig. 7).

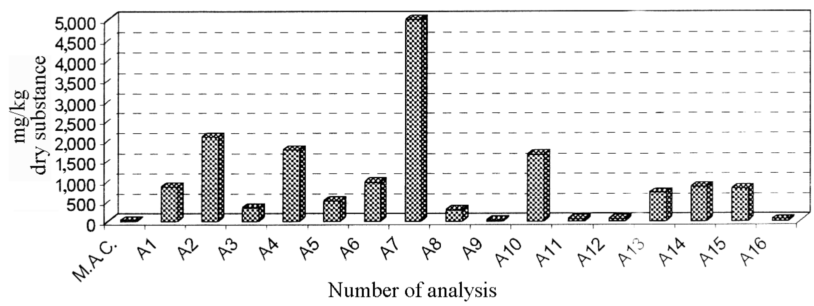

Fig. – 7 Copper concentrations in soils within the mining perimeter:
A1 – Vărad enclosure; A2 – Vărad waste dump; A3 – Valea Mare waste dump; A4 – Suvarov enclosure; A5 – Quarry enclosure; A6 – Apele Albe waste dump; A7 – Enclosure of the Processing Plant no. 2; A8 – Terezia waste dump; A9 – Lake Tisa-Potoc; A10 – between the concentrates draining station and the tailings pond; A11 – upstream the tailings pond, on eastern side; A12 – upstream the tailings pond, on northern side; A13 – eastern extremity of the tailings pond; A14 – south-western side of the tailings pond; A15 – western side of the tailings pond; A16 – north-western side of the tailings pond.

Table 2

Copper Concentrations in Soils within the Mining Perimeter

(by E.P.A.C.S., 2000, with changes)

No. of analysis	Sampling point	Copper mg/kg dry substances
A1	Vărad enclosure	850
A2	Vărad waste dump	2,100
A3	Valea Mare waste dump	340
A4	Suvarov enclosure	1,760
A5	Quarry enclosure	500
A6	Apele Albe waste dump	960
A7	Enclosure of the P.P. no. 2	5,100
A8	Terezia waste dump	280
A9	Lake Tisa-Potoc	30
A10	Between the concentrates draining station and the tailings pond	1,650
A11	Upstream the tailings pond, on eastern side	55
A12	Upstream the tailings pond, on northern side	61
A13	Eastern extremity of the tailings pond	705
A14	South-western side of the tailings pond	856
A15	Western side of the tailings pond	805
A16	North-western side of the tailings pond	48
Admissible values according to ordinance no. *756*/1996 of the Ministry of Water, Forests and the Environment		20

The analysis of the data above reveals that copper concentrations in soils are above admissible limits (20 mg/kg dry substance according to Ordinance no. *756*/1997 of the Ministry of Water, Forests and the Environment) in all sampling points within the mining perimeter. Thus, the highest recorded values, which are well above admissible limits, are in the soils within P.P. no. 2 (5,100 mg/kg dry substance), Vărad waste dump (2,100 mg/kg dry substance), Suvarov enclosure (1,760 mg/kg dry substance), etc.

Therefore, the data above shows that soils in the mining perimeter from Moldova Nouă contain high concentrations of copper. Along with these copper presences in the soil occur concentrations of other heavy metals (lead, zinc, manganese, cadmium, cobalt, etc.) both in the soils of the mining perimeter and in those located at distances of up to several kilometres from it [1]. The situation is caused by the deflation of tailings from the tailings ponds due to Coşava wind. The consequence is the low fertility of these soils due to the settling of tailings and contamination of surface horizons which determines a significant reduction of microbiological processes [6].

The landscape of the area is distressing as a result of the mining operations, the presence of ponds, waste dumps as well as the lack of grass and forests.

5. Measures to Prevent and Control Soil Pollution/Degradation

The early works of designing the slopes, re-establishing vegetation and afforestation were performed in the late 80's. The purpose was to reduce the deflation of tailings and to restore the natural beauty of a distressing and barren landscape.

Plantations were carried out on land covered with borrowed earth and in pits where nutrients were added. The main species used were: the Russian silverberry (*Elaeagnus angustifolia*), the black cherry (*Prunus serotina*), the black locust (*Robinia pseudoacacia*), the common sea-buckthorn (*Hippophae rhamnoides*), the lilac *(Syringa vulgaris*), the purple smoke bush (*Cotinus coggyria*), etc. These species are characterized by resistance to dryness, they meet the conditions required to ensure a better protection of soil and to create an appropriate landscape. The black locust, the common sea-buckthorn and the black cherry adapted very well to the environment.

The trees planted in the area quickly created a specific environment (shade, plants remainings, wind speed reduction, water retention, etc.). The afforestation of the slopes of tailings ponds as well as bringing wind erosion to a complete stop, regardless of terrain inclination, were carried out soon after that.

For a better protection of soils in the area of Moldova Nouă, it is necessary to apply a set of measures such as: regular checking of the technical condition of gutters/pipes, slope stabilization and afforestation of waste dumps, deforestation and grazing ban within the mining perimeter, complete afforestation of the tailings ponds/waste dumps which are not longer in use, permanent monitoring of soil quality, etc.

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EXPLOATĂRILE MINIERE DE LA MOLDOVA NOUĂ ŞI EFECTELE ACESTORA ASUPRA CALITĂŢII SOLURILOR

(Rezumat)

Exploatările miniere de la Moldova Nouă şi-au pus puternic amprenta asupra mediului înconjurător, afectând negativ calitatea solurilor.

Exploatările subterane şi cel de la suprafaţă, flotaţia minereurilor, prezenţa haldelor/iazurilor cu steril etc., au determinat îndepărtarea/poluarea solurilor pe suprafeţe însemnate. Concentraţiile mari de metale grele în soluri au produs scăderea fertilităţii acestora şi reducerea proceselor microbiologice din orizonturile de suprafaţă.

Începând cu sfârşitul anilor ’80 s-a trecut la înierbarea/împădurirea taluzurilor iazurilor de decantare, reuşindu-se împădurirea completă a acestora şi oprirea eroziunii eoliene.

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INTEGRATED INFORMATION SYSTEM DESTRUCTIVE WATER ABATEMENT AND CONTROL OF WATER DISASTERS (DESWAT)

BY

IONUŢ-CLAUDIU PRICOP and *FLORIAN STĂTESCU

Abstract. The importance and objectives of DESWAT (DEStructive WATer) are studied having in view that the designed system is intended reduce flood impact, aiming at the modernization of existing hydrological monitoring networks in Romania. The system uses the latest information technology products and increases the public awareness for floods.

Key words: DESWAT; hydrological forecast; modeling; hydrological parameters; automatic stations.

1. Introduction

By implementing the DESWAT project, the hydrological activity and the water management will enter in a new and modern stage of development and modernization of the following systems: the rivers monitoring by using of automatic stations with water levels measurement sensors, rainfall, air and water temperature, and the main water quality parameters; short and medium range hydrological forecasting hydrological forecasting for short and medium term through the acquisition purchase of performant forecasting models and through the integration of forecasting Romanian models forecast VIDRA, CONSUL and UNDA in the hydrological forecast models platform at the national level, with the goal to elaborate hydrological forecasts of medium and long term, taking into account various scenarios for the evolution of the weather situation; to assess potential damage in the flooded areas in various scenarios, for selecting the least unfavourable scenario.

This project is particularly important for flood management and warning in real time, and it has the next main objectives:

a) Use of NIMS (National Integrated Meteorological System) project.

b) The assessment of potential damage costs in case of floods and the reduction of them.

c) The development of hydrological forecasts for medium and long terms taking into account various scenarios for the evolution of the weather situation.

DESWAT project will integrate communications and radar system from NIMS (National Integrated Meteorological System) project.

2. Model Implementation

The ”DESWAT PROGRAM” is a national scale project and the main purpose is the automation of the existing hydrological and rainfall stations and implementation of new stations in the National Flood Forecasting System in Romania.

The “DESWAT PROGRAM “ proposes the automation of a number of 877 stations of which 627 are water stations, located along water courses and are usually equipped with sensors to measure water level, water and air temperature and rainfall; 250 are basic precipitation stations, usually located on the slopes and records only the rainfall (Fig.1).

For “PRUT-BÂRLAD” catchment area are provided 86 automatic stations of which 60 automatic hydrological stations (AHSS) and 26 rainfall stations (APSS) provided with sensors.

“DESWAT PROGRAM” is a complex system of modeling and hydrological forecast based on automatic integration, radar estimations, numerical weather forecasts, physically based models with distributed parameters, conceptual models with global parameters, models dedicated to rapid flood assesment.

The radar information are obtained by interface with NIMS (National Integrated Meteorological System) from NMA (National Administration of Meteorology) (Fig.2).

Processing is carried out automatically at the national level servers (INHGA - CNPH) (National Institute of Hydrology and Water Management/ National Center of Hydrological Forecast)

The model will be implemented throughout the country, with servers running automatically installed at the national level, using available data in the system on rainfall recorded/forecast and other weather variables needed to provide estimates of the situation likely hydrological evolutions.

Fig. 1 – Map with rainfall and hydrometric stations in the Prut-Bârlad Water Basin Administration.

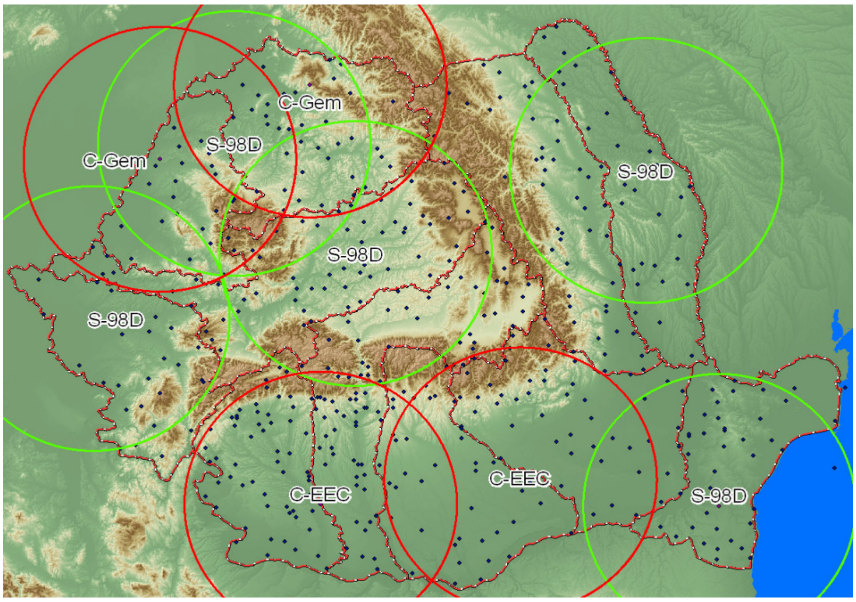

Fig.2 - National territory radar coverage of the stations belonging to the NIMS

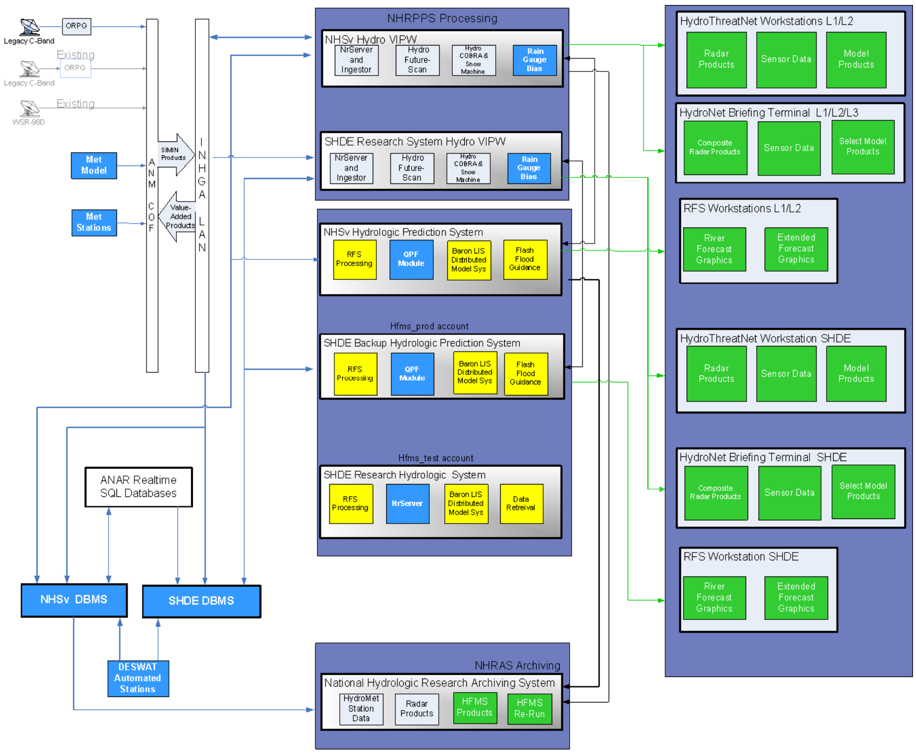

Fig. 3 – Hydrological Monitoring and Forecasting System (HFMS).

Ensuring operational hydrometeorological data flow (Fig.3):

a) Observations from classical gauging station network

a_1) Required to ensure the transmission in a short time, involves the use of modern technology, preferably with redundant solutions (*e.g.* Radio + GSM);

a_2) Download in the Microsoft SQL database, automatic replication.

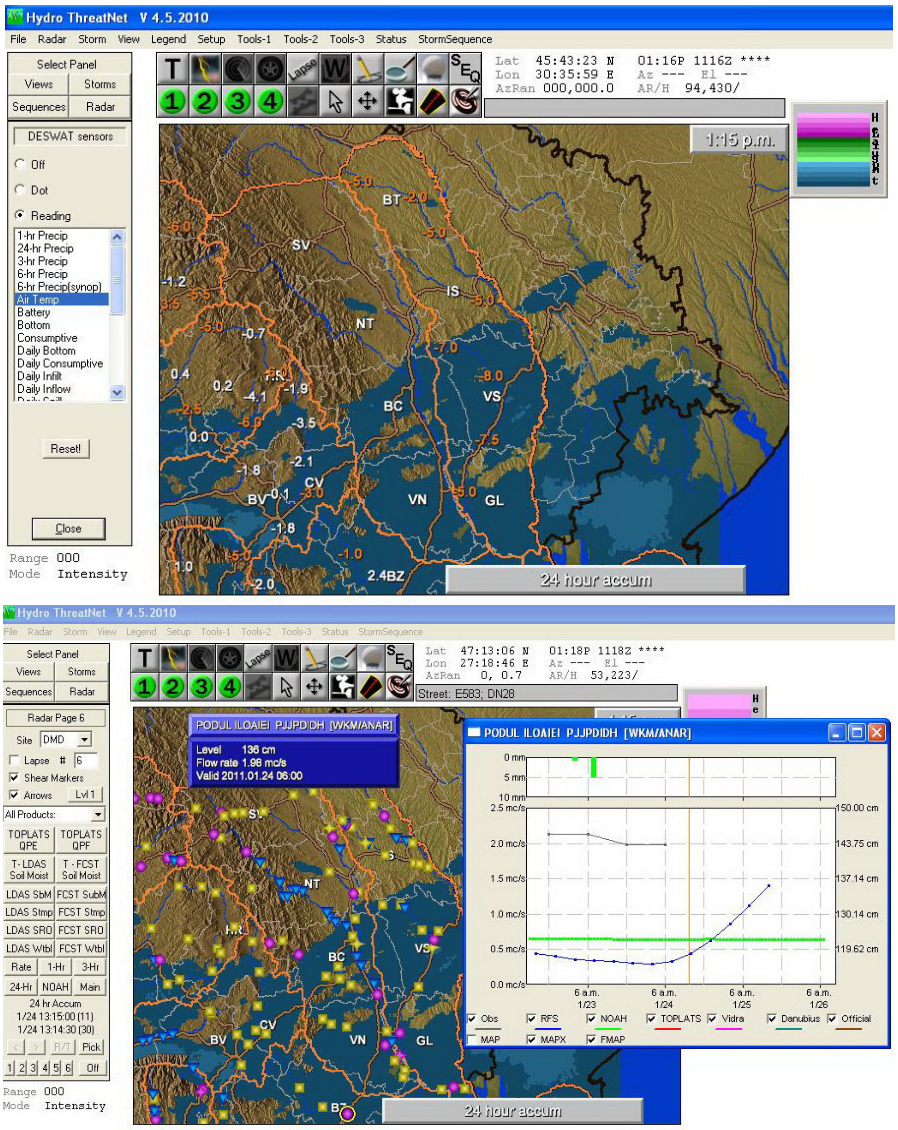

Fig.4 – Images containing the viewing application interface of HydroThreatNet (HTN).

b) Automatic gauging stations installed or to be installed within DESWAT (10 min maximum time resolution, hourly rate automatic transmission, interrogation possibility for the station which have GSM comunication)

b_1) It will automatically take over the operational database Microsoft SQL, automated replication at all levels.

c) Automatic gauging stations already existing or to be installed in other projects (requires query)

c_1) Required to ensure automatic takeover of intelligence data in Microsoft SQL database, automatic replication at all levels.

d) Achieving validation / adjustment / correction operations in real time of the values from automatic stations.

The modeling and hydrologic forecasting applications DESWAT presents visualization applications like HydroThreatNet (HTN) and HydroNet Briefing Terminal (HBT) (Figs. 4 and 5).

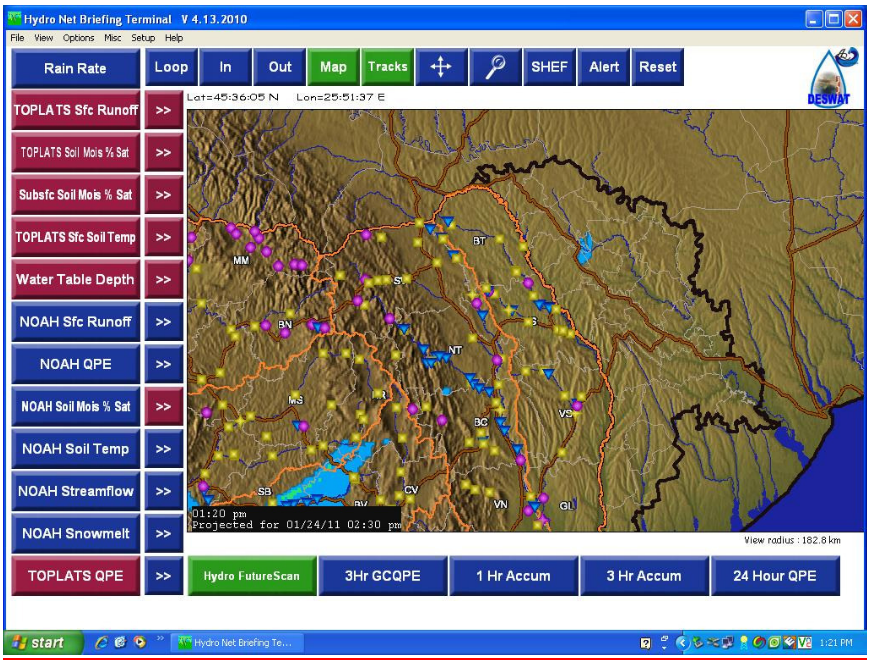

Fig.5 – Image HydroNet Briefing Terminal application interface (HBT).

These applications allow the visualization and analysis of products generated by processing and modeling components of the system. Both applications are installed at the National Center of Hydrological Forecasts and on the Basinal Hydrological Forecasting Center of the Water Basin Administration, to be installed at all the Basinal Centers.

These are the main internal dissemination applications of the major system products, inside the National Administration “Romanian Waters”.

Briefing HydroNet Terminal Applications (HBT) will be installed also even at the Water Management System (SGA) level or meteorological stations within the Water Basin Administration (ABA).

3. Results and Discussions

The “DESWAT PROGRAM” through the National Radar Information Processing System provides instant estimates of rainfall intensity and rainfall quantities recorded, cumulated within different time intervals (1, 3, 6, 12, 24 h), throughtout the country (on a grid network with a spatial resolution of 1 km).

Through the use of extrapolation of the weather evolution algorithms based on radar informations, the system provides an estimate of rainfall which can occur in the next two hours.

Estimates are automatically integrated in the hydrological forecasting models, at the scale of 1 km, in the physically based distributed models, and, respectively under the form of sub-average values in the conceptual models with global parameters.

Hydrological forecasting model with distributed parameters NOAH-R automatically updates data every 30 min on: the state of the river flow, soil moisture and temperature, equivalent snow in the water (during periods of snow), surface runoff, intermediate (sub-surface) and groundwater.

Also, there are prognostic estimates, automatically updated every 6 h, on hydrologic situation developments for the next 48 h, providing the following product categories: forecast hydrographs in sections identified as prediction points, changes in general flows of the hydrographic network and development of other hydrological variables of interest: moisture and soil temperature, water equivalent of snow (in periods with snow), surface runoff, sub-surface and groundwater.

Hydrological forecasting model with distributed parameters TOPLATS provide the same kind of information as NOAH except informations regarding the evolution of the snow layer, due to the fact that TOPLATS model is missing the snow modelling component of the snow component.

The model will be implemented for a subset of hydrographic basins, generally with areas under 500 km^2, where it’s considered to obtain better results than NOAH model.

This model also runs automatically, and the products generated are used compared to those generated by NOAH model.

4. Conclusions

The DESWAT project will allow the coverage of a wide range of applications, with obvious economic benefits: flood generation production control and areas likely to be flooded, anticipation of chemical pollutants dispersal in the aquatic environment, anticipation of severe minimum flow occurrence that would affect water supply services , anticipation of extreme flows and volumes for the proper management of large reservoirs, thermal pollution control; commercial applications (maps of the areas in which the forecast alert thresholds are exceeded, hydrological information telephone service, made for the televisions) that will make a profit from fees charged both by the INHGA / NMA (National Institute of Hydrology and Water Management /National Administration of Meteorology), as well as the National Administration "Romanian Waters".

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SISTEM INFORMATIC INTEGRAT DESTRUCTIVE WATER ABATEMENT AND CONTROL OF WATER DISASTERS (DESWAT)

(Rezumat)

Studiul efectuat prezintă importanța şi obiectivele proiectului DESWAT "Destructive Water" conceput pentru reducerea impactului inundațiilor, având ca scop final modernizarea actualei rețele de monitorizare hidrologică în România, utilizând tehnologia de ultimă oră şi crearea de produse de informare a publicului în cazul viiturilor.

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CONSIDERATIONS CONCERNING THE EVOLUTION OF THE SIRET RIVER QUALITY IN THE HUȚANI MONITORING SECTION

BY

MIHAIL LUCA and ANDREEA MĂNESCU

Abstract. Water is an important element for life and development of human communities. For a more accurate assessment of the Siret River water quality there is required a monitoring and a physico-chemical verification of the indicators having in view to not exceed the quality standards. The paper presents studies results concerning the Siret river water quality monitoring. Water samples used in the study were taken from Huțani monitoring section. For these samples were measured several water quality parameters as: the content of nitrate ions and nitrite. It was found that the maximum permissible values exceed for a range of parameters concerning the relevant standards established for each.

Key words: quality parameters; water quality; nutrients.

1. Introduction

For a more accurate assessment of the Siret River water quality monitoring and verification is required that the physico-chemical indicators not to exceed the quality standards. According to UN statistics, increased water consumption in the world occurs in geometric progression, some areas being affected by low water availability.

The statistics demonstrates that the high water consumption would not decrease natural resources that are recoverable, but their use is limited due to pollution [8]. After the UN definition, water pollution is the direct or indirect changing of water natural composition, as a result of human activity [8].

Pollution can be differentiated into several types [6] namely

a) *Biological pollution* – microbiological, virological and parasitological, the oldest type of pollution directly linked to human presence.

b) *Physical pollution* – concerns in particular the pollution with radioactive substances. There is a thermal pollution and a pollution caused by floating or depositing insoluble elements, regarded as the most recent type of pollution, characteristic of highly developed areas.

c) *Chemical pollution* represents the consequence of penetration of chemicals in water, ranging from the easily degradable organic, to the persistently high toxic.

Water pollution sources are classified according to several criteria, taking into account their diversity, as follows:

1. by their origin: domestic and industrial activities, agriculture, transport;

2. by the range of pollutants: local sources (sewage pipes, landings) or diffuse (when pollutants are spread over a wider area);

3. by their position: fixed or mobile (cars, housing, moving equipment).

Waste water pollutants may be generated by: domestic sewage, industrial waters from mining, metallurgy, chemical and petrochemical, food, water agricultural buildings, and polluted storm water [2].

Pollutant activity depends, in a large measure, on the source and if the source is continuous and intense, effects will be a significant pollutant, and if the source is, by contrast, discontinuous or of low intensity, the effects will be correspondingly insignificant [5].

The dynamics of water pollution and self-purification generate a series of phenomena such as: diffusion, dispersion and dilution.

Adaptation and interpretation of the basic equations of these phenomena are due to P h e l p s [8].

Diffusion is a slow process that takes place according to Fick's laws.

A mass of fluid suddenly discharged in a stream moves downstream as a concentrated mass. Once mixed with the receiver waters it results a larger volumes and lower concentrations of substances. The pollutants dispersion decreases of the pollution degree. Because receptors are generally a small width, the dispersion is primarily in the longitudinal direction so the mixture is called *longitudinal* or *longitudinal dispersion*. With the discharge of waste water and dilution occurs too, at first, partially and then completely.

Dilution (degree of dilution) represents the ratio of receiver flow, Q, and waste water flow, q_i, after complete mixing

$$d = \frac{Q}{q_i}. \tag{1}$$

If the mixture has not been completed, the actual dilution is determined by the relationship

$$d' = \frac{a^Q}{q_i}, \tag{2}$$

where a represents the mixing coefficient, dimensionless, which can be calculated by knowing the distance of the mixture.

If the mixture reaches a large distance this one leads to the formation of a receiver strips off the waste water, which in addition to its unpleasant look, prevents normal development of self-purification processes.

Water pollution is reduced substantially from its initial value due to its self-purification capacity. Treated or untreated waste water, after evacuation processes are subjected to physical, chemical and biological processes that lead, finally, to water self-purification of the receiver [7].

2. Parameters Monitoring in Huţani Section

Between years 2006…2008 was surveyed Siret River water quality assessment in section Huţani by monitring surveys and measurements of general water quality parameters. Samples were collected to determine Huţani section nitrate and nitrogen concentration. Samples were taken once a month for three consecutive years from 2006 to 2008. Physico-chemical analyses were carried out for nitrate and nitrite indicators, according to maximum admissible value [6].

Fig. 1 shows the observed mean values of nitrite ion. In section Huţani, Siret River, losses water quality indicators due to the presence of nitrate ($N\text{-}NO_2$-) with a value of 0.39 mg /L in July 2006, lowering water quality status of Siret River.

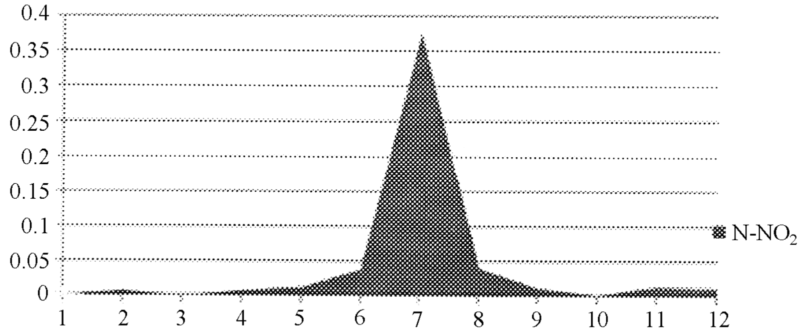

Fig. 1 – Mean nitrate ion concentration in the river Siret [16], in Huţani section, in 2006.

In Huțani section Siret river waters reaches the highest value of nitrite ion concentration, of 0.26 mg/L in August 2007. There is an improved Siret River water quality compared to 2006 (Fig. 2).

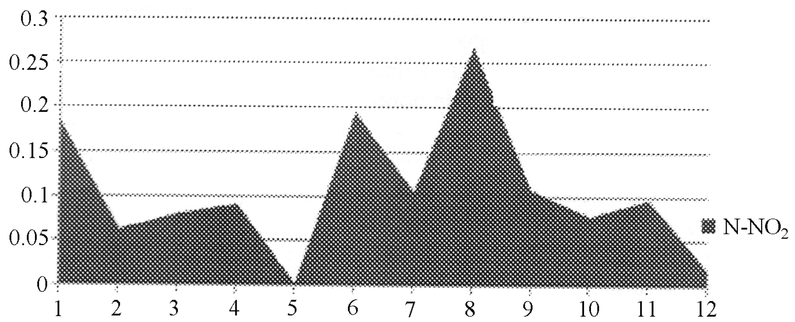

Fig. 2 – Mean concentrations of nitrite ion in Siret River [16], Huțani section, 2007

Fig. 3 shows the mean values of ion nitrite. Indicator ($N\text{-}NO_2^-$)nitrite in November 2008 reached a maximum of 0.13 mg/L. Siret River water quality in the monitoring Huțani section improved compared with previous years (2007 and 2006).

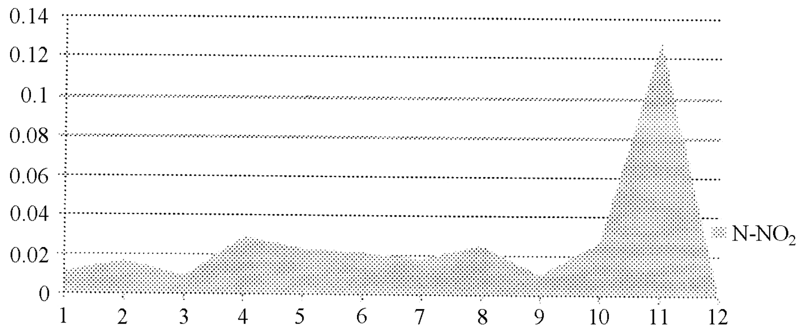

Fig. 3 – Mean concentrations of ion nitrite in Siret River [16], Huțani section, 2008.

During monitoring of February and April 2006, in Huțani section, Siret River water state quality indicator "good" under the influence of indicators of nitrate $N\text{-}NO_3^-$, reaching a value of 1.45 mg/L (Fig. 4).

In Huțani section Siret river water reaches the highest value of ion nitrate concentration of 0.055 mg / L in June 2007. There is a Siret River water quality improved in Huțani section compared to those determined in 2006 (Fig. 5).

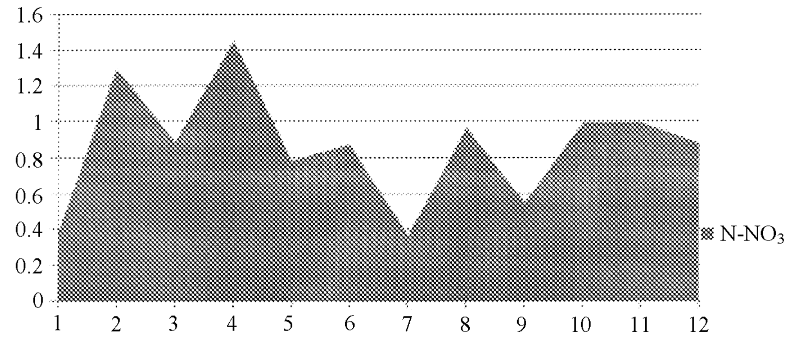

Fig. 4 – Mean nitrate ion concentration in the river Siret [16], Huțani Section, 2006.

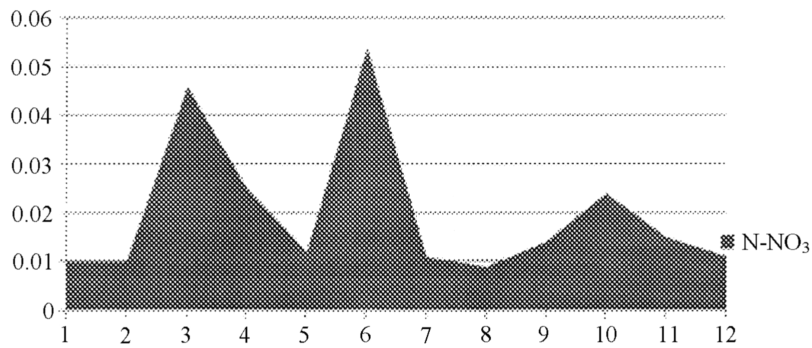

Fig. 5 – Mean ion nitrate concentration in the river Siret [16], Huțani Section, 2007.

Fig. 6 shows the mean observed ion nitrate concentration in the Siret River. Indicator nitrate in February 2008 reached a maximum value of 1.1 mg/L. Siret River water quality in the Huțani monitoring section worsened compared to last year.

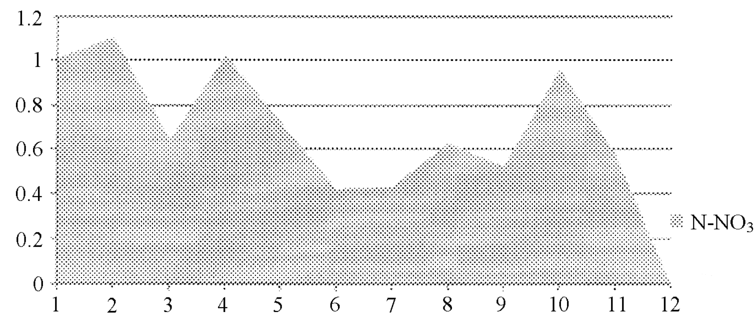

Fig. 6 – Mean ion nitrate concentration in the Siret River [16], Huțani Section, 2008.

3. Conclusions

According to the monitoring's results the development of water quality parameters in the Huţani monitoring section of the Siret River, there was an improvement in water quality due to the reduction of nitrogen and nitrate concentration observed during the period when samples were taken once a month for three consecutive years from 2006 to 2008.

Siret River water quality during the Huţani section monitoring in 2006 lost its quality due to the presence of indicators of nitrite and nitrate.

During 2007…2008 Siret River monitoring, water quality improved compared to 2006, as the concentrations of nitrate and nitrite ions decreased significantly.

After measurements and data presented in this paper, the authors conclude that due to the reduction, namely the closure of industrial activities over the years, Siret River water quality has improved significantly.

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CONSIDERAȚII PRIVIND EVOLUȚIA CALITĂȚII APEI RÂULUI SIRET ÎN SECȚIUNEA DE MONITORIZARE HUȚANI

(Rezumat)

Apa reprezintă un element important pentru existența vieții şi dezvoltarea colectivităților umane. Pentru o evaluare cât mai corectă a calității apelor râului Siret este necesară o monitorizare şi verificare a indicatorilor fizico-chimici pentru a nu depăşi standardele de calitate. Se prezintă rezultatele unui studiu privind monitorizarea calității apei râului Siret. Probele de apă utilizate în studiu au fost prelevate din secțiunea de monitorizare Huțani. Pentru aceste probe au fost determinați o serie de parametri de calitate ai apei potabile: conținutul de ioni azotat, azotit. S-a constatat o depăşire a valorilor maxim admise conform standardelor în vigoare pentru o serie de parametri.