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MODELLING BY NUMERICAL METHODS OF GROUNDWATER NETWORK IMPURITY FROM NEIGHBOURHOOD OF CHEMICAL WASTES DEPOSITS

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Abstract. In order to obtain necessary data for modelling, water samples from four wells were gathered in. These wells are used by people and are placed in villages from neighbouring of organic and inorganic waste deposits. Numerical modelling of groundwater network was realised for COD, HCH isomers, Ca, Na and Cl. Equations of flowing through non-homogeneous layers used for modelling were developed by numerical network method in the form:

$$\frac{c_{i,j+1} - c_{i,j-1}}{2p} = D\,\frac{c_{i+1,j} - 2 \cdot c_{i,j} + c_{i-1,j}}{h^2} + c_i$$

where c_i is concentration in point i; D is total diffusion coefficient. The program used for solving of flowing equation, by finite difference method was realized in Turbo Pascal, with the following steps for the space and concentration axis: integrating step along concentration axis, h = 1mg/l; integrating step along space axis, p = 1m. This program was developed to take into account the quantification of incoming values by control functions (deep of wells, distances, diffusion coefficients by layers with different porosity, volumes of water due to tributaries) and obtained numerical values are plotted after their computing.

Keywords: modelling, groundwater, waste deposits.

AIMS AND BACKGROUND

In the case of non-stationary flow of water, the moving of layers between them takes place together with appearances of friction forces. For laminar flow with continuous pollution, differential equations are used in different particular forms, as follows:

(a) for total density ρ and molecular diffusion coefficient $D_{A,B}$ with constant values, equations with definite form is used for solutions with infinite dilution, at constant temperature and pressure;

(b) for constant values of total molar density (concentration) C and of diffu-

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sion coefficient $D_{A,B}$ equations of field concentrations in different coordinate systems may be definite in the following manner[1-2]:

- in the fluxes form;
- in the molar concentration form;
- in the form of stationary flow, without pollution.

The solving of differential equations that describe the field of concentration means the solving simultaneously and alternatively of flowing equations (with conservation of moment and mass).

EXPERIMENTAL

In order to find particular solutions, a simplified form of turbulent equation was used for integration[3]:

$$-\overline{w}_x \frac{\partial \overline{C}_A}{\partial x} = (D_{A,B} + D_T) \frac{\partial^2 \overline{C_A}}{\partial x^2} + R_A . \tag{1}$$

Equation was developed by numerical network method with central finite differences, in the form[5]:

$$\frac{c_{i,j+1} - c_{i,j-1}}{2p} = \frac{c_{i+1,j} - 2c_{i,j} + c_{i-1,j}}{h^2} + c_i \tag{2}$$

and for flowing through non-homogeneous layers[5]:

$$\frac{c_{i,j+1} - c_{i,j-1}}{2p} = D \frac{c_{i+1,j} - 2c_{i,j} + c_{i-1,j}}{h^2} + c_i \tag{3}$$

where c_i is local concentration in point "i", D – total diffusion coefficient.

The program for solving flowing equations was realised in Turbo Pascal, with the following steps for the space and concentration axis:

- integrating step along concentration axis, h = 1 mg/l;
- integrating step along space axis, p = 1 m.

This program was developed to take into account the quantification of the incoming values by control functions (deep of wells, distances, diffusion coefficients by layer with different porosity, volumes of water due to tributaries) and obtained numerical values are plotted after their computing. As an application, a base of dates was used. This base was created in year 2000 by analytical manner, concerning the pollution of Olt river in zone of organic and inorganic waste deposits, near "Oltchim" platform, Ramnicu Valcea. The used values are presented in Tables 1, 2.

Table 1. Control wells around the Ramnicu Valcea organic waste pond, August 2000

Symbol	Well depth (m)	Water layer depth (m)	Chloride (mg/l)	Calcium (mg/l)	COD (mg/l)	Sodium (mg/l)	HCH isomers (mg/l)
P2	10	2.3	5672.4	2845.6	2133	1518	0.2055
P2'	8.0	4.4	13827.0	3507.0	2591	3128	-
P6	8.0	6.4	13294.5	3046.1	14220	5060	-
P6'	6.5	5.5	5849.7	741.4	4772	4130	4.5400
P7	6.3	3.5	3545.3	80.1	1738	9200	-
P8	11.0	5.5	17549.2	5410.8	708	4830	-
P9	12.5	5.8	21271.8	6513.0	224	5980	-
Stolniceni	6.5	2.5	92.2	68.1	9.5	51	0.0046
Stuparei	4.0	4.0	220.0	43.2	25.3	143	0.1580
Cazanesti	13.5	2.0	113.4	250.0	9.5	34.5	0.0017
Copacelu	9.5	1.5	531.8	216.4	6.3	165.6	0.0020

Table 2. Control wells around the Govora Chlorosodic Plant organic waste pond, second quarter 2000

Symbol	Well depth (m)	Water layer depth (m)	Chloride (mg/l)	Calcium (mg/l)	COD (mg/l)	Sodium (mg/l)
F7	25.0	3.8	2127.0	681.5	29.7	874
F8	4.0	2.5	35453.0	13026.0	12.6	9060
F9	6.5	2.5	17726.0	6413.0	63.2	4620
Stolniceni	6.5	2.5	92.2	68.1	9.5	51
Stuparei	4.0	4.0	220.0	43.2	25.3	143
Cazanesti	13.5	2.0	113.4	250.0	9.5	34.5
Copacelu	9.5	1.5	531.8	216.4	6.3	165.6

Modelling conditions were as follows:

– multi-annual mean flow of Olt river, 150 m^3/s;

– water intake, upstream, in north part of waste deposits and evacuation points 1 km away from deposits and 5 km away from evacuation points, in direction north-south of river flow;

– Cremanari section, 7 km away from deposits and 2.5-3 km away from evacuation point;

– Babeni-Marcea section, downstream, 15 km away from waste deposits and evacuation points.

Numerical modelling of river Olt pollution was realised for mean values of the three trimester of year 2000, for COD, HCH isomers, Ca, Na, Cl.

RESULTS AND DISCUSSION

For modelling of groundwater pollution, the incoming values were the concentrations of the same pollutants, measured both in control wells of waste deposits and for four wells, the distance from deposits and between them, geomorphologic aspects appreciated by mean value of diffusion coefficient, established by means of proper coefficients.

Modelling was realised on the most probable lowing direction of undergroundwaters, NNE-SSE, for two depths considered to be relevant 25 and 50 m, till a distance up to 10 km from waste deposits.

Value of organic compounds concentration, expressed as COD (Fig. 1) decreased for the depth of 25 m from 6000 mg/l in wells within controlled zone of organic wastes to 300 mg/l up to 2 km from this point; up to 8 km for initial point, the value of this parameter is smaller than that accepted for drinking water. For the depth of 50 m, the value of accepted for drinking water is reached at 4.5 km. A similar situation is for HCH isomers (Fig. 2); the concentrations for the two depths are identical at 4.5 km away from the organic waste deposit.

The results of modelling for Cl ions (Fig. 3) shows values of 8000 mg/l near waste deposits (about 25 mg/l and 80 mg/l) at very high distances, 6.5 km, with a tendency of decrease. The abatement of concentrations of the two depths from ideal curves is due to porosity conditions of geological layers, introduced with

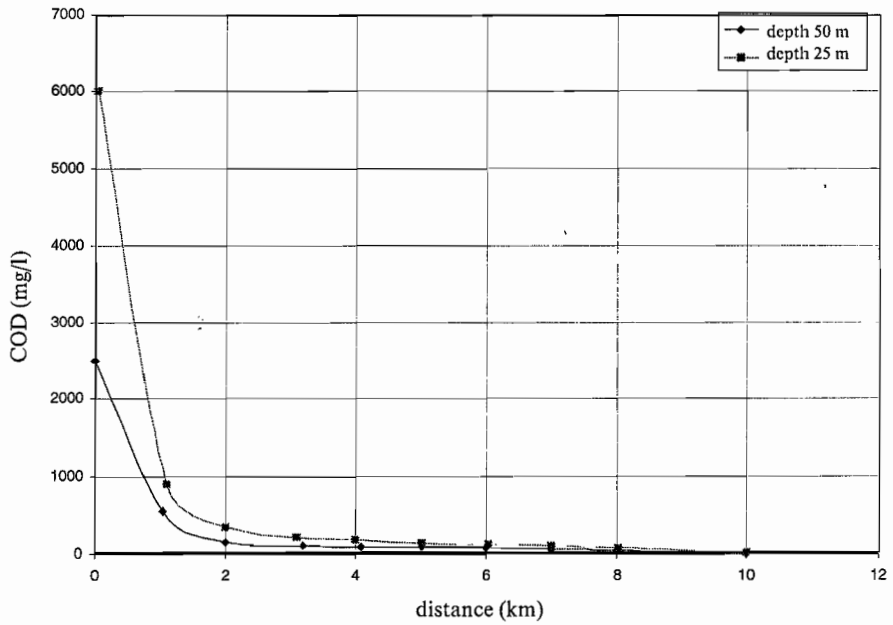

Fig. 1. COD versus distance in groundwater near "Oltchim" platform, Ramnicu Valcea

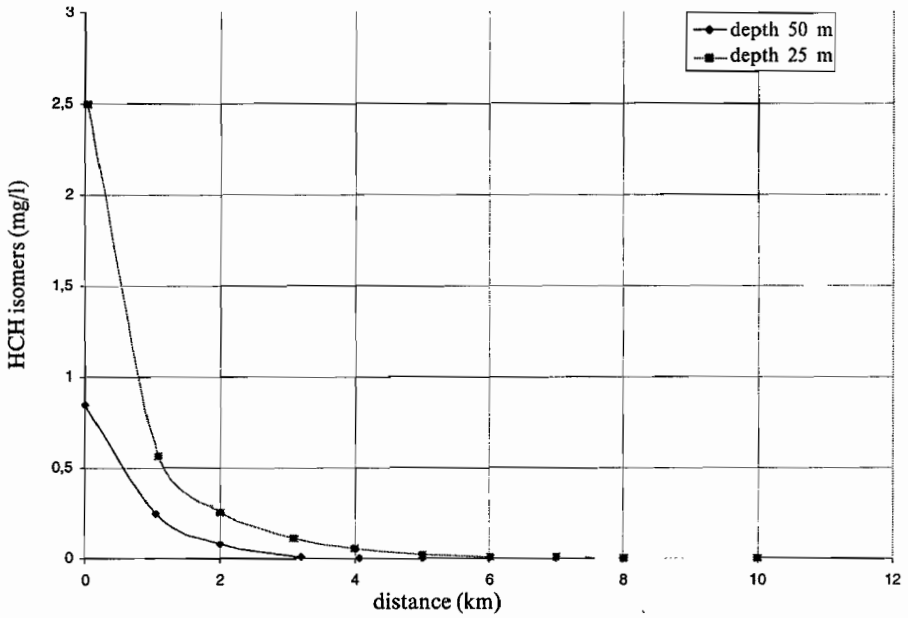

Fig. 2. HCH isomers content versus distance in groundwater near "Oltchim" platform, Ramnicu Valcea

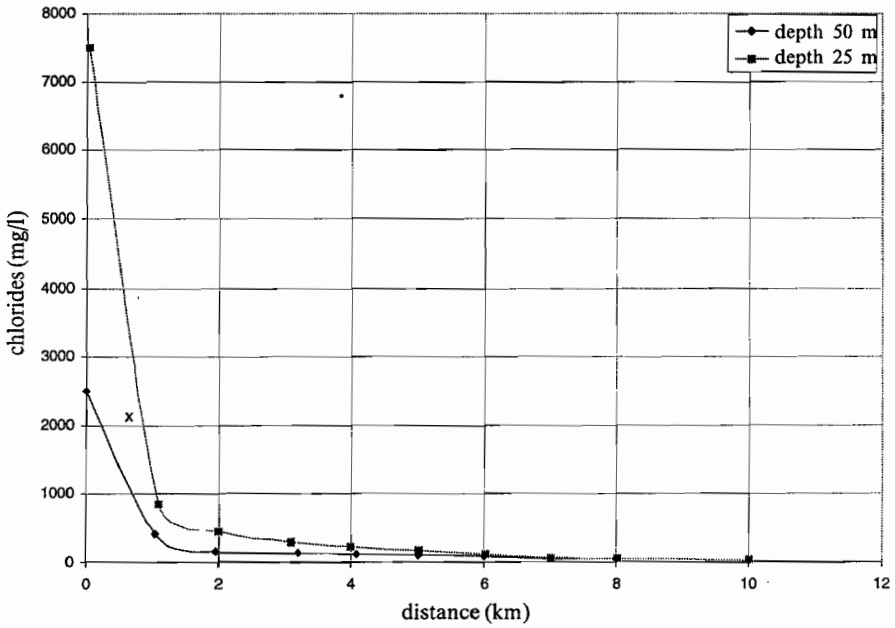

Fig. 3. Chlorides content versus distance in groundwater near "Oltchim" platform, Ramnicu Valcea

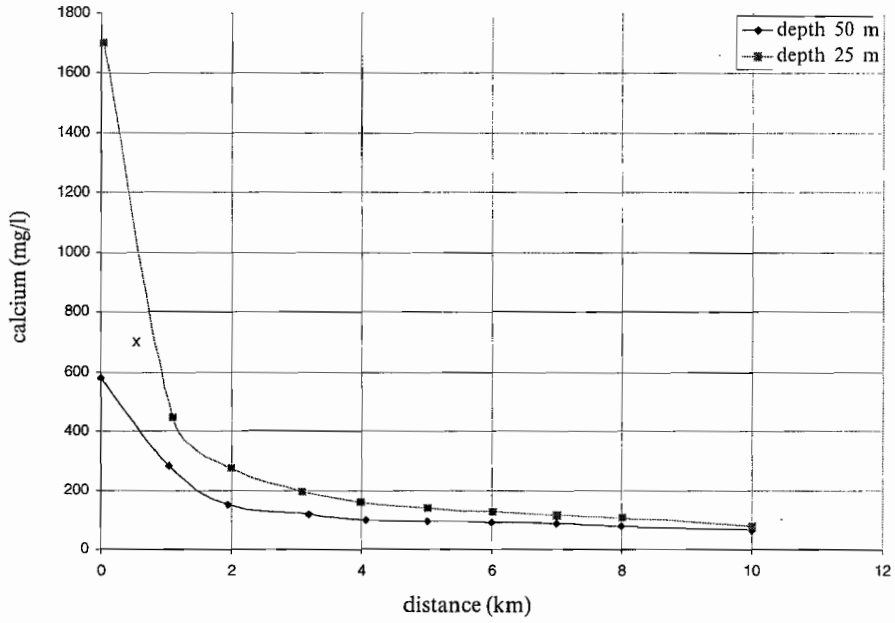

Fig. 4. Calcium content versus distance in groundwater near "Oltchim" platform, Ramnicu Valcea

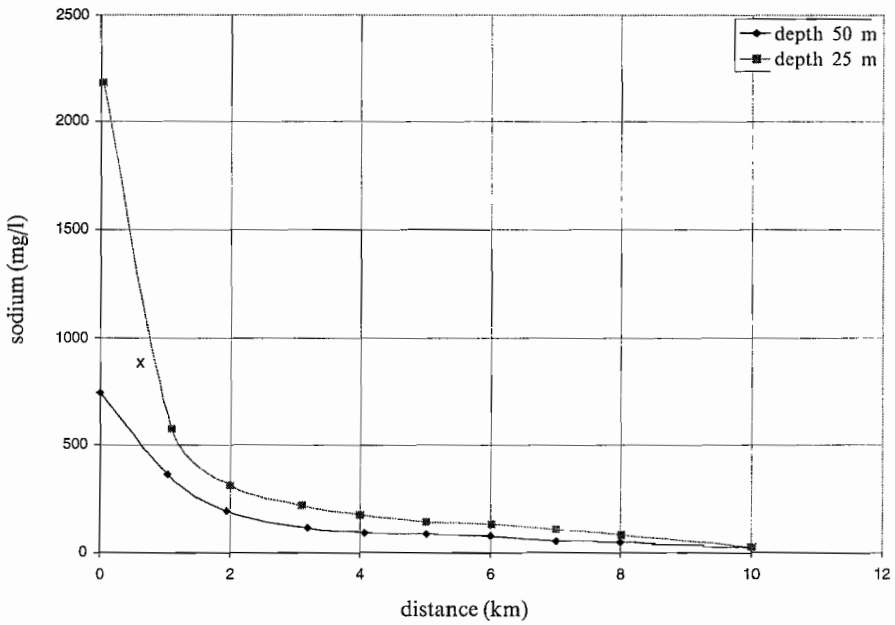

Fig. 5. Sodium content versus distance in groundwater near "Oltchim" platform, Ramnicu Valcea

modelling values. The point noted with × in Figs 3-5 represents measured value in well 7, at 25 m depth, on the flowing direction of water and represents a good correlation with results obtained by model used.

For the content of Ca and Na (Figs 4 and 5), the same aspects like those presented above are recorded: the concentration of Ca is so insignificant at 6.5 km and for Na at 8 km from initial point.

The results for wells used by people to obtain flowing direction for groundwater can not be used, because they are considered by model outside the flowing direction.

CONCLUSIONS

Correlation between the values obtained by numerical network modelling of groundwater from waste deposits zone from "Oltchim" platform, Ramnicu Valcea with analytical values from the field is good; the abatements are due to non-quantifiable aspects, because of large surface area of the region and a great number of pollution sources.

The model may be improved by investigation of all local pollution sources, and thus the errors will be eliminated.

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