MONITORING THE POLLUTION OF GROUNDWATER IN THE AREA OF INDUSTRIAL WASTE

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Abstract - Monitoring of the underground water pollution in the deposit of waste in industrial area. The paper presents the monitoring of the pollution phenomenon of underground water in the industrial landfill area. Industrial landfill causes pronounced underground water pollution in the operation phase, but also in the conservation phase. The pollution monitoring is carried out on all environmental components: air, soil and underground water. Pollution phenomenon is analyzed in time by using a tracking and data reception characteristic control section. The data taken is processed and interpreted to achieve the best environmental measures in the area of the landfill site. By using simulation models provides a forecast of the pollution in different periods of time. The simulation model is applicable to the operating period taking into account the change in quantities and concentrations of pollutants. This paper presents remediation measures appropriate to the type of industrial landfill analyzed. The results obtained allow modeling of environmental protection measures and especially the subsoil and groundwater.

Key words: industrial waste deposits, pollution flow modeling, pollution phenomenon, protection.

1. INTRODUCTION

Waste is one of the most pressing environmental problems in the current state of economic and social development. In Romania there are large amounts of waste generated each year due to economic development, increase production and consumption.

Handling, transport and storage of industrial waste causes many cases of air pollution, soil and groundwater. The pollution produced by industrial landfill has a negative impact on environment and health. Industrial waste is deposited in warehouses located within or outside entities. Industrial landfills were not always designed and built taking into account the risk of environmental pollution. The design was not considered diverse nature of the harm that would be stored and its evolution over time. Thus, while some landfills by virtue of their design has not succeeded in stopping the pollution of the environment:

- heaps of ash from power plants producing electricity and heat;
- slag heaps from the units in the steel industry;
- deposit of residue from the chemical industry and construction materials industry;
- landfills in the oil industry, etc.

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Landfills produce a groundwater contamination varying durations of time. The phenomenon of underground sources of water pollution affects their removal from the circuit and cause water supplies. One problem is the way of environmental engineering, remediation of groundwater affected by the presence of landfill.

The amount of hazardous industrial waste generated in Romania has decreased continuously in recent years due to reduced activities of large economic units. In this context industrial waste storage dumps in use or in storage, will be collated and made safe.

In areas with industrial waste will be carried out ecological restoration works to reduce and prevent the risk of accidental pollution of the environment.

Rules and new standards governing the protection of the environment in the placement of waste dumps require their cooperation with potting medium.

2. POLLUTION OF GROUNDWATER IN THE INDUSTRIAL WASTE AREA

Industrial waste is deposited at landfills or entities located within or outsider. Industrial landfills were not always designed and built taking into account the risk of environmental pollution. The design was not considered diverse nature of the harm that would be stored and its evolution over time. Industrial waste pollutes the environment during the operational phase and later phase post conservation. Soil is the environmental factor most stable, long trail that keeps pollution. Soil and subsoil determines default and groundwater pollution.

A research program conducted over six years at the site of an industrial landfill highlighted its particular impact on groundwater. Landfill belonging to a Bearing factory opened in 1953. Waste dumps are stored as diverse as nature and environmental risk: myths inert from the treatment emulsions, carbide, ion exchange filters, oil residues, dross, ash, brick, etc., (Fig. 1).

Fig. 1. ***Overview of the old dump***

The landfill has changed over time as a constructive form, a waste treatment, environmental conditions, etc. The phenomenon of pollution produced on site and in particular on groundwater caused the closure of the deposit. It was refurbished with a series of works to limit the pollution. Old warehouse is in the stage of conservation (Fig. 2).

After processing the data collected in monitoring wells conducted in 12 stands of indicators values exceed industry standards required by Table 1, 2 and 3).

Table 1. ***Water quality parameter values taken from drill F 2 - Albie sepsis***

CMA	Cl	NH_4	CCOMn	Extract.	$Cr6^+$	NO_2	pH	MTS
Env. Aut.	*	0,5	*	*	0,05	0,3	8,5	*
Quarter II	60	0.43	21.67	0	0	**0.53**	6.8	56
Quarter III	48	**0.75**	20.16	0	0	**0.61**	7	40
Quarter.IV	55	0.21	22	0	0	**0.58**	7	50
Mean 2004	54.333	0.4633	21.2766	0	0	**0.573**	6.93	48.7

Table 2. ***Water quality parameter values taken from drill F 4 - Stana***

CMA	Cl	NH_4	CCOMn	Extract.	$Cr\ 6^+$	NO_2	pH	MTS
Env. Aut.	*	0,5	*	*	0,05	0,3	8,5	*
Quarter II	300	**1.01**	20.62	0	0	0.032	6.5	86
Quarter III	290	**1.23**	24.52	0	0	0.016	6.5	100
Quarter IV	310	**1.12**	21.64	0	0	0.09	6.5	80
Mean 2004	300	**1.12**	22.26	0	0	0.046	6.5	88.7

Table 3. ***Water quality parameter values taken from drill F 5 - East waste dump***

CMA	Cl	NH_4	CCOMn	Extract.	$Cr\ 6^+$	NO_2	pH	MTS
Env. Aut..	*	0,5	*	*	0,05	0,3	8,5	*
Quarter II	280	0.47	24.69	0	0	**0.81**	6.5	63
Quarter III	300	0.41	25.61	0	0	**0.79**	6.5	60
Quarter IV	280	0.36	23.72	0	0	**0.8**	6.5	36
Mean 2004	288.67	0.4133	24.673	0	0	**0.8**	6.5	53

Fig. 2. ***Overview of the dump of old and new.***

Groundwater in the area is used for water supply to villages in the area. Pollution it had imposed restrictions on use. Given the lack of sources of water pollution requires a process for obtaining water quality parameters.

Data-analysis shows significant overshoot in nitrites (NO_2) and ammonium (NH_4). Such pollutants have adversely affected groundwater quality in the area. The phenomenon spread to underground pollution imposed closure of old landfill and industrial waste in postutilzation passing.

New waste-storage facility was equipped with a monitoring system for groundwater quality parameters, air and soil.

3. PROGNOZIS OF THE POLLUTION AND/OR DEPOLLUTION PHENOMENOM OF THE GROUNDWATER

Transport of pollutants in the underground industrial waste was examined using a mathematical model. Transport model was designed to be used in solving the following problems:

A. The flow processes through porous unsaturated/saturated media, in the stationary/transitory regimes.

B. The processes of miscible/non-miscible pollutants transport from porous unsaturated/saturated media, in transitory regime.

The mathematic models of the transport of pollutants consisted in:

1. Non-governing equations (also called basic) of the flow and/or transport processes.
2. Contour conditions.
3. Initial conditions (only for the processes dependent of the time *t*).

The equations governing the flow consist of the equations of the fluid mass balance – named also the continuity equation and, respectively, moment equation, the famous Darcy's equation, generalized to non-saturated porous media. These can be presented under the following general form [Voss, C.I., 1984]:

$$\frac{\partial\left(n \cdot S_w \cdot \rho\right)}{\partial t} = -\nabla \cdot \left(n \cdot S_w \cdot \rho \cdot \mathbf{v}\right) + Q_p \rho \qquad (1)$$

$$\mathbf{v} = -\left(\frac{\underline{\underline{\mathbf{k}}} \cdot k_r}{n \cdot S_w \cdot \eta}\right) \left(\nabla p - \mathbf{g} \cdot \rho\right) \qquad (1)$$

where the symbols present the following significations:

$n = \mathrm{n}\left(x, y, t\right)$, porosity [1];

$\rho = \rho\left(T\left(x, y, z\right)\right)$, water density, [$ML^{-3}$], temperature dependency *T*;

∇ = *nabla* differential operator, [L^{-1}];

$\mathbf{v} = \mathbf{v}\left(x, y, t\right)$, the average speed vector of the fluid (water) through the pores of the porous medium [LT^{-1}];

$Q_p = Q_p(x, y, t)$, the intensity of the distributed (punctiform) source of volume (specific debit) of fluid, $[T^{-1}]$;

$\eta = \eta(T(x, y, t))$, the dynamic viscosity of water, $[ML^{3}T^{-1}]$, dependent on the *T* temperature;

$p = p(x, y, t)$, fluid pressure from the pores, $[ML^{-1}T^{-2}]$ (the relative pressure in relation with the atmosphere pressure; the manometric pressure for $p \geq 0$ or the vacuum manometer pressure $p \leq 0$);

$g = g(x, z)$, gravitational acceleration vector, $[LT^{-2}]$.

The definition relations for each of the classical types of contour conditions are [Luca, M., 2010]:

1º *type 1 contour conditions* (Dirichlet);

2º *type 2 contour conditions* (von Neumann), where are given the values of the H size flow, according to the ***n*** direction of the normal to the Γ frontier.

3° *type 3 contour conditions* (Cauchy), when the values of the flow q_{nH} (*x*, *y*, *z*) depend also on the *H* variable, according to a law considered as linear.

The numerical simulations achieved for different scenarios and for a certain period can appreciate the dispersion of a pollutant in a carrier of water.

The observation period regarding the underground water layer was between 2005…2009. In his period, we collected data regarding the pollution phenomenon parameters. For the prognosis, we considered a period of 10 years, respectively 2010…2019. The analysis carried out on the main pollutant substances indicated for the first prognosis stage the consideration of the anion from the NH_4 ammonium.

For solving the proposed problems, we achieved a conceptual model, for which we elaborated a mathematic model of pollutants transport. The mathematic model represents the flow and transport of pollutants from one layer of underground water from the analysis field. For the numerical simulation, we used the FEFLOW program package.

In the analysis, we used a complex of basic data specific to the case study. The data introduced in the calculation model come from systematic measurement in 13 observation wells positioned in the location of the industrial waste deposit.

We successively treated a flow problem in four scenarios and two flow and transport problems (therefore, in total, 6 calculation variations) [Luca, M., 2010]:

1. The flow problem for the study duration, $t \in [0, 1825]$ days in four scenarios regarding the functioning of drillings from the area of the closed deposit (for establishing the optimal scenario)

- without pumping;
- with pumping from the drillings.

2. The flow and transport problem for the study duration, $t \in [0, 1825]$ days, in the scenario established as being optimal within the flow problem (for monitoring the pollution phenomenon in all the interest points from the domain Ω.

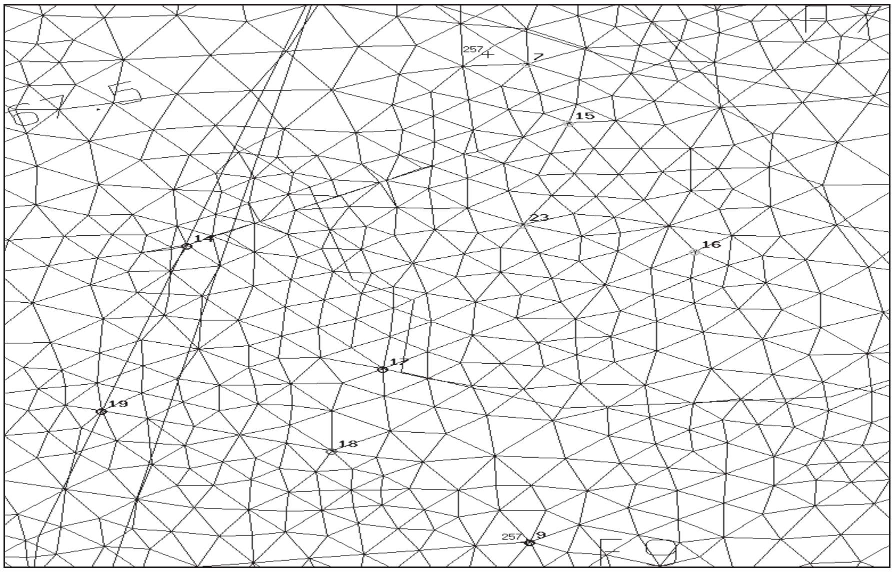

Fig. 3. ***EF scheme in the study area waste industrial dump.***

3°. The flow and transport problem in the perspective of the following decade, $t \in [0, 1825]$ days (2010 - 2019), in the scenario established as being optimal within the flow problem 1° and through the simulation of the contour conditions and variation of the material parameters.

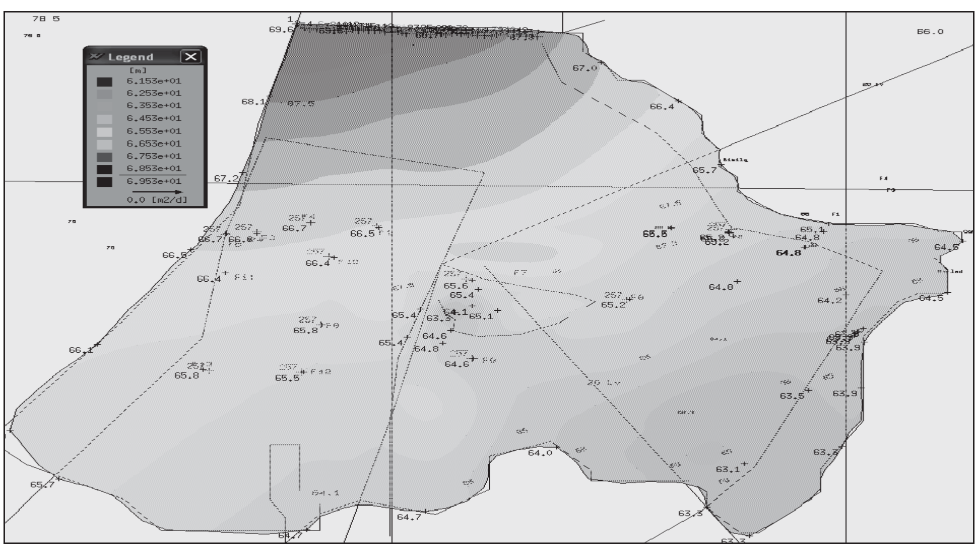

Fig. 4. ***The initial piezometric load field for the flow problem represented through the colour code (numbers in black colour represent the piezometric load of the support points).***

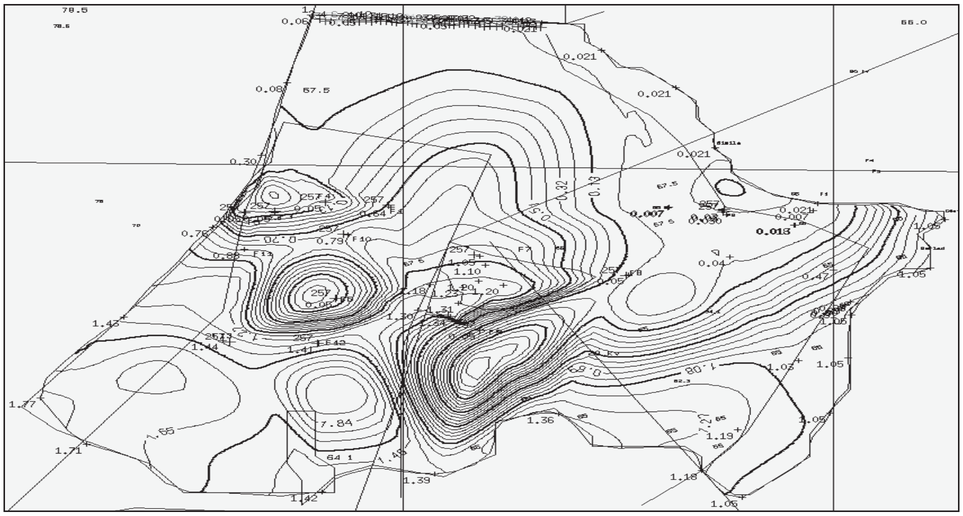

Fig. 5. ***The NO_4 initial concentration represented by isolines of equal concentration.***

A part of the accidentally polluted water sources can be subject to a depollution process, of certain duration, in order to be reintroduced in the circuit of water supply for either industry, or population. Through the analysis and prognosis model conceived, we attempted a response to this problem that has been affecting, lately, the underground medium, more and more stringently.

In order to determine the evolution of the pollution process in the entire interest field, we can only make interpolations on bi-dimensional fields, according to certain mathematic techniques accepted in this field.

The intensity of the evacuation process of a pollutant soluble in water through pumping, at a constant debit, decreases to the diminishment of its concentration in the carrier of water, and in order to obtain /maintain an acceptable intensity of this process, the pumped debit must be increased, or certain processes of the pollutant biotransformation be activated.

4. CONCLUSIONS

The interpretation of the data obtained allows the enunciation of the following general conclusions:

- Monitoring the transport of pollutants in industrial waste must become a compulsory activity of the waste producer.
- Modeling the transport of pollutants in the soil in the area of industrial wastes deposits has a special importance for the protection of underground waters.
- The simulation model elaborated allows the analysis of the pollutant transport in the area of underground waters by emphasizing the variation of concentrations in time and space.

- The simulation model through the FEFLOW program package has allowed the analysis and the methods of underground waters depollution for a certain determined period of time.
- Using the numerical simulation techniques, we can solve both the problems regarding the monitoring of the pollution process for the entire duration of the experimental measurements (approached problems, but insufficiently solved through the current monitoring techniques), but also the future evolution, on the extended periods, in different scenarios, of the pollution and/or depollution processes.

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