THE UTILIZATION OF NUMERICAL MODELS IN INDUSTRIAL POLLUTION OF GEOLOGIC ENVIRONMENT DATA PROCESSING AND INTERPRETATION

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ABSTRACT

Impact assessment methodology of industrial waste, implies not only the research of the geological environment, but also the determination of the most accurate dynamics and complex processes of pollution.

In most of the cases, the primary data which describe the geological environment show a discontinuous image of the real investigated (natural) system. Often, increase in date volume, from in situ determinations or from laboratory, means a proportional and substantial increase of expenditures. Generally, the costs of direct geological investigation are high.

The numerical model is the tool used by the environmental protection or environmental geology specialist, to replace this inconvenient.

The numerical modeling is the main stage of the interpretation of the primary data and represents the base of the decisions making process. Also, processing of primary data and interpretation, using the water flow and transport models of pollutants, represent an important component of the investigation methodology for contaminated sites.

INTRODUCTION

This approach, allow the connection of the specific processes from the unsaturated zone with the ones which are taking place within the aquifer.

The methodology is based and developed on the Pantelimon industrial area, East from Bucharest city.

The pollution is manly generated, by the industrial land field (slag dump with surface of 15800 m^2) of the industrial Pantelimon area, represented by S.C. NEFERAL S.A., which recover and process lead, copper, aluminum etc. from waste and S.C. ACUMULATORUL S.A., which use the lead for car batteries, made by electrolytic led.

The slag dump resulted from the technological processes which are taking place at S.C. Neferal S.A since 1965 to present.

The raw materials used within the production process are manly non-ferrous metals waste. Final products are: bars (bronze, brass**,** battery composition, zamak, secondary aluminum and aluminum composition), antifriction composition and agglutinated composition (such us wire and brich) and also metallic powder.

Heavy metal pollution with Neferal – Acumulatorul area (**Figure 1**), involves all the environments, in a very complex correlation: air, water and soil. The main source for pollution is the Neferal – Acumulatorul **dump,** from which the heavy metals are being transport like pounders by the air drafts into the atmosphere and like chemical compounds into the water.

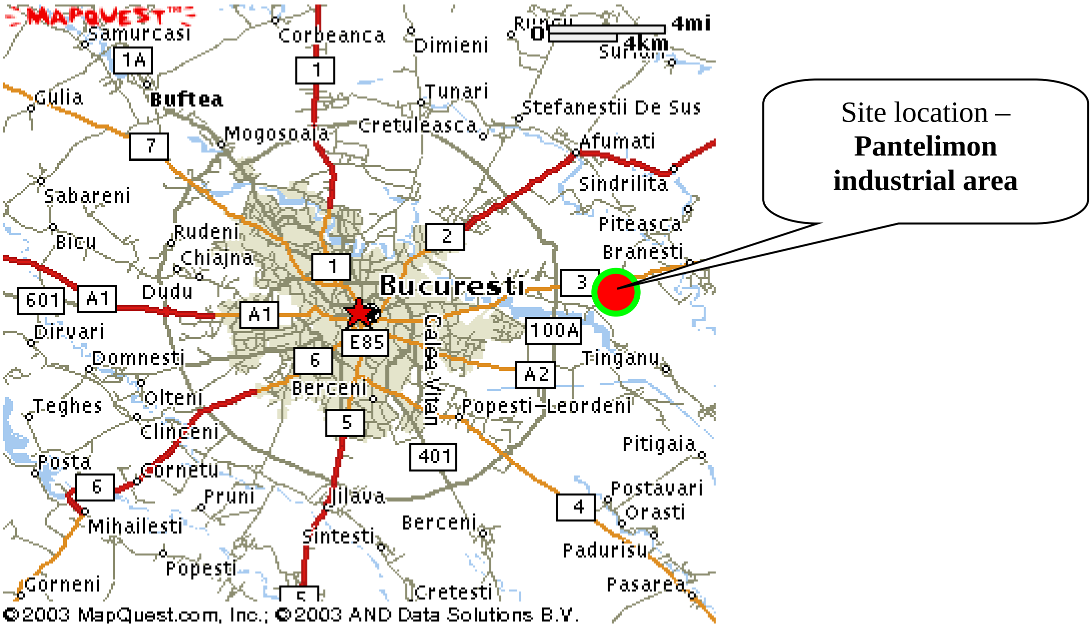

Figure 1 Site location map.

METHODOLOGY

Sampling

The samples were collected from the pollution source, but also from the studied aquifer.

For heavy metals concentrations determination, water samples were taken from the drain, which collects the surface water from the industrial waste dump and also from the lake which drain the shallow aquifer (Figure 2).

The laboratory analysis was made at Rurh University from Bochum, within the Geology Faculty.

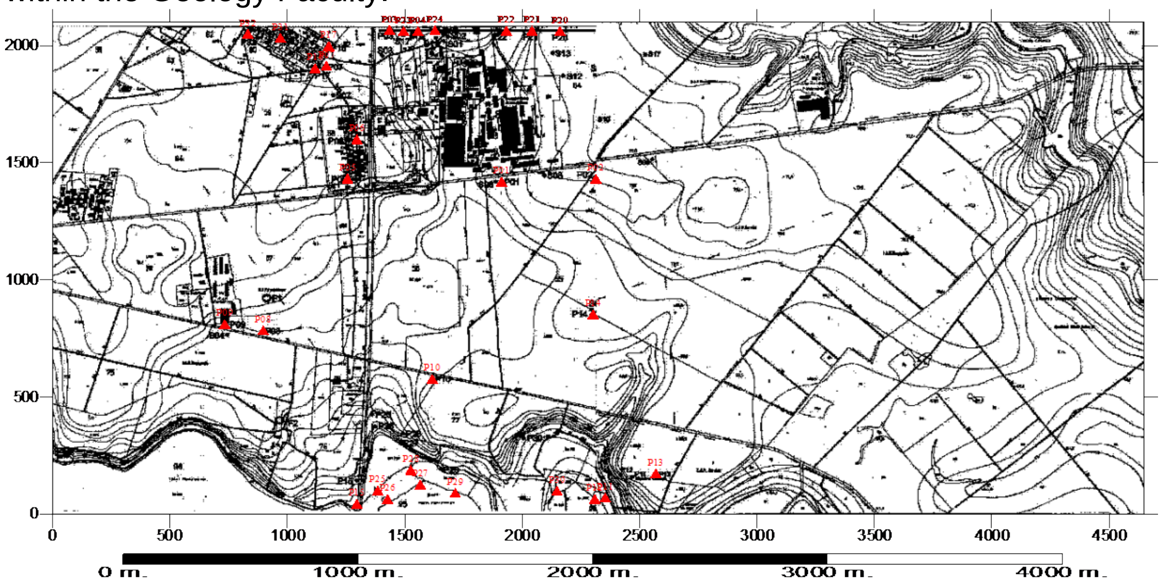

Figure 2 Map with samples location.

RESULTS AND INTERPRETATIONS

Pollution source:

7 water samples were collected **from the drain**, with the highest concentration reported for: Cu, Al, Pb (Figure 3).

The domain of variation is different for concentration of each element:

- Cu between 0,04 mg/ liter to 28,00 mg/liter;
- Al between 0,77 mg/ liter to 59,00 mg/ liter;
- Pb between 0,02 mg/ liter to 0,90 mg/ liter.

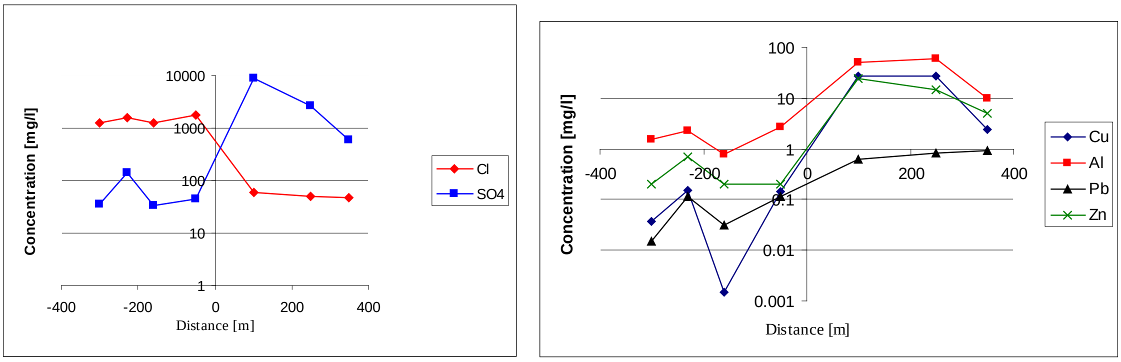

Figure 3 Concentration distribution along the drain (distance marked with 0 m. is the dump position)

The domain of variation for the Cl^- si SO_4^{2-} ions are very high in comparison with ones from the shallow aquifer:

- Cl decrease from 1750,00 mg/liter to 47,70 mg/liter, due to the immobilization in the waste dump such as $PbCl_2$, insoluble (*$Pb^{2+}(aq)$ + 2 $Cl^-(aq) \rightarrow PbCl_2(s) + H_2O(l)$*);
- SO_4 increase from 33,80 mg/liter to 8770,00 mg/liter, due to generating of the soluble sulphate ($PbSO_4$, $ZnSO_4$, $CuSO_4$) and their mobilization in the drain.

The shallow aquifer

The heavy metal content within the shallow aquifer is from two (for Al, Pb, Zn) to four (Zn) orders of magnitude smaller than the one from the drain:

- Cu between 0,0021 mg/ liter to 0,0074 mg/liter;
- Al between 0,84 mg/ liter to 1,89 mg/ liter;
- Pb between 0,02 mg/ liter to 0,45 mg/ liter.

For Cernica Lake, the concentration for Pb, Zn, and Cu are below the maximum admissible concentration. The only exceeded concentration is for Al in all samples.

The variability of Cl^- and SO_4^{2-} ions is law, with concentrations between 68,4 mg/liter to 122 mg/liter for Cl and from 28,4 mg/liter to 61,8 mg/liter for SO_4, with one order of magnitude smaller than the ones from the shallow aquifer.

For the distribution and dynamics evaluation of the metals within soil and groundwater, numerical models were elaborated, especially for the vadose zone and shallow aquifer.

The objective of the pollution modeling with heavy metals is the quantitative assessment of the heavy metals transportation into air and water, on the following way:

- The vadose zone of the shallow aquifer, composed by loess deposits, crossed by precipitation and surface water (ponds, channels etc), loaded with more or less heavy metals, depending on the crossed surfaces (uncontaminated soil, contaminated soil, dump);
- Shallow aquifer with a horizontal leak, orientated on North-South;
- Cernica Lake situated on the south part of the dump placement, the final receiver of the heavy metals migrations.

For modeling of heavy metals pollution, two different models were being made: the first one for unsaturated zone and the second one for the shallow aquifer.

The period for transfer assessment of the heavy metals is: 1965-2010. The transfer model for the unsaturated zone it was made for a 20 years period (from 1965 to 1985), from the moment Neferal company was established, and the model for shallow aquifer for a 25 yeras period (from 1985 to 2010).

The model of unsaturated zone in the Neferal area is built taking into account the following:

- The maximum period of simulation was 20 years, including specific intervals: 90 days, 180 days, 270 days, 1 year, 2 years, 3 years, 4 years, 5 years, 6 years, 7 years, 8 years, 9 years, 10 years and 20 years;
- Infiltration of water with an constant rate of 150 mm/year;
- At the bottom of unsaturated zone (8 m. depth) constant piezometric head;
- Constant concentration source of pollution throughout the simulation at the upper limit: *copper* – 2,36 mg/l; 28 mg/l; 0,144 mg/l; *lead* – 0,908 mg/l; 0,619 mg/l; *zinc* – 5 mg/l; 25 mg/l; 0,713 mg/l; *aluminum* – 59 mg/l; 2,25 mg/l;

Moisture profile used corresponds to lithological sequence consists of 8 m: topsoil (0.4 m), clayey loess (1.7 m), loess powder (0.9 m), clayey loess (2.9 m), loess powder (1.5 m), sand (0.6 m), medium sand with gravel (Fig. 5). Hydraulic conductivity of deposit forming unsaturated zone, in saturated state, is 3.5×10^{-4}cm/sec, for loess deposits, with a few values of 10^{-2} cm/sec, for fine sands.

Model for shallow aquifer

The schematization of the structural, parametrical and hydrodynamic conditions conducted to a homogenous and isotropic shallow, with a constant thickness and with a horizontal, stationary and neoconservative leak. The leak in the shallow aquifer is was considerate stationary for the entire model period, due to the fact that the variations of the piezometric level are very small in comparison with its thickness.

The studied are is being limited:

- Horizontally:
  - On the North part by a line of constant piezometric head , orientated V-E, along the 63 m equipotential line**;**
  - On the South part by a line of constant piezometric head, represented by Cernica Lake.
- Vertically:
  - In the bottom, impermeable formation (without supplied by drainage)
  - In the top, (supplied by infiltration through loess deposits from the vadose zone, with values of 150 mm/year).

The hydrodynamic spectrum resulted indicate a main flow direction, orientated North-South. A global statistical analysis of a flowing speed leads to an average value of 15.4 m/day, with extreme values between 0.07 m/day to 17.95 m/day.

The type of the pollution source is the linear one (along the drain) and the concentration is constant during the whole calculation period. The hydraulic bond between the **drain** and shallow aquifer is being made by vertical infiltration through a 8 m within vadose zone. The concentrations took into account are the ones that reached the shallow after 20 years of infiltration through unsaturated zone

The parameter used for modeling the variations of the heavy metals concentrations are the following:

- The initial concentration of the pollutant 0.0 mg/liter;
- A diffusion coefficient 1 m^2/day;
- The dispersivity - 100 m, with 0.1 anisotropy ratio between longitudinal and transverse components;
- Langmuir type isotherm for all the metals, the parameters for the isotherms being set in cut out stage:
  - For aluminium 0.15 m^3/kg and 0.01 kg/kg;
  - For copper 0.15 m^3/kg and 0.039 kg/kg;
  - For lead: 0.15 m^3/kg and 0.029 kg/kg;
  - For zinc: 0.09 m^3/kg and 0.0228 kg/kg.

CONCLUSIONS

The importance of the diffusion processes are emphasized by the small circulation speed of the groundwater within the pollution source area (~ 0.1m/day), which are determinates not only by the specific parameters of the porous media, but also by the low value of the hydraulic gradients. Due to these specific conditions, it is important to develop a model of pollutions transfer within unsaturated media for long period of time, in order to highlight all the developed objectives processes. Taking into account the historical pollution of the area and the features of the aquifer system the processes modeling in two stages was chosen:

- For the first, which has a period of time of 20 years and begins with the establishment of the company (1965), a model of water flow and transfer of the metals within unsaturated zone was developed;
- For the second one, 25 years, starting by 1985, a forecast until 2010 was made, using the flow and transfer within shallow aquifer model from the area (Figure 4).

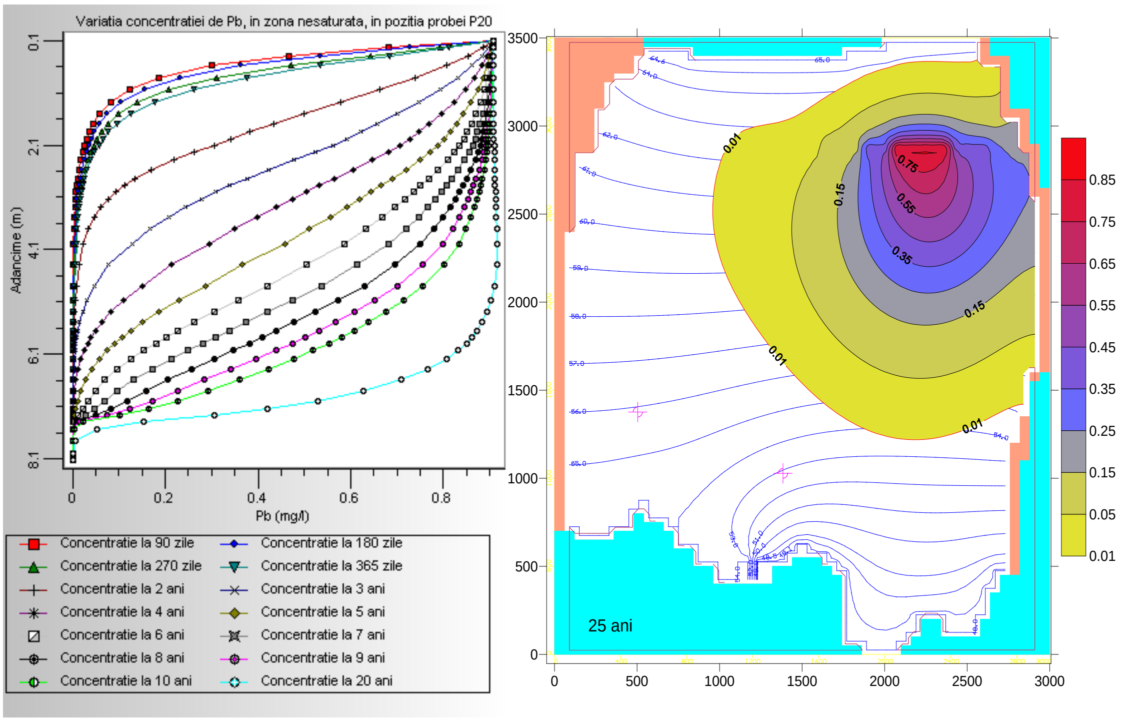

Figure 4 Lead distribution in unsaturated zone and in the shallow aquifer

The pollution source is located in a very populated area, where the shallow aquifer is being used as the main drinking water provider. Also it is important to mention that the whole area has a high touristic and leisure potential – Pantelimon Lake and Cerica Lake, forest, Cernica Monastery etc).

Taking into consideration the period of time of the models (until 2010) it can be estimated that the population, who used the groundwater form the shallow aquifer, has not been critically affected. It is important to point out that for the next 10-15 years the present situation would be changed and the metals pollution will reach a critical stage, when the maximum concentration will be found in the lakes, population's wells and spring and wells form Cernica Monastery.

REFERENCES

Healy, R.W., *Simulation of Solute Transport in Variably Saturated Porous Media with Supplemental Information on Modification to the U.S. Geological Survey's Computer Program VS2D*.

Jackson, E.P., *Ion Chromatography in Environmental Analysis*, Encyclopedia of Alalytical Chemistry, pp. 2779 – 2801, JohnWiley & Sons Ltd, Chichester, 2000.

Karpinet Daniela, Vasiliu, A., *Studiu pedologic TC Pantelimon, jud. Ilfov,* 1992.

Kelly, W.E., & Mares *(editors), Applied geophysics in hydrogeologiccal and enginnering practice,* Elsevir, Amsterdam, 1993.

McLean, E. J., Bledsoe, E. B., *Behavior of Metals in Soils*, Ground Water Issue, EPA/540/S-92/018, 1992.

Pascu, M., *Apele subterane din Romania*, Editura Tehnica, Bucuresti, 1983.