ENVIRONMENTAL ASPECTS OF CONTAMINANT TRANSPORT MODELING IN HUNGARY

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SYNOPSIS
The paper gives a short overview on the problems to be solved by the means of contaminant transport modeling in porous aquifers. The presented methods were found an efficient and useful tool for solving such environmental problems although the accuracy of results is very sensitive for the model data input.

1. POSSIBLE FIELDS OF USE OF CONTAMINANT TRANSPORT MODELS

There are several fields of application on which contaminant transport models and/or the coupled groundwater flow models can be used, such as:

- Optimization of extension of water works with special regards on the existing and potential pollution sources
- Determination of protection zones around water discharges using isochrone or seepage velocity calculations
- Determination of the environmental aspects of settlement of different hydraulic structures (Environmental Impact Assesments)
- Optimization of remediation wells at polluted areas, control of the efficiency of planned drains and wells
- Determination of contaminated zone and shape of pollutant plume environ real sources, simulation of contaminant migration with time dependent sources, computation of concentration versus time in different locations
- Preliminary estimation of the effect on the environment of potential pollution sources such as planned waste disposal sites, control of planned clay liners of new waste deposits.

2. COMMON PRACTICAL PROBLEMS OF CONTAMINANT TRANSPORT MODELLING

During modelling we conflicted several problems. We found that the mathematical aspects of GW flow and transport modelling is correctly worked out and the results got by different mathematical procedures correlate very well, that is proved by lot of works of different researchers can be read in the literature. However only a simple geological and hydraulic situation can be modelled by analitical methods, that is why in real cases it is impossible to find any analitical solution of the problem, so the use numerical methods comes into prominence.

However, the occured practical problems focused our attention on the problem of quantity, representativity and precision of input data. In most cases we conflict the geological information was highly limited, because only some deep-drillings was bored, and partially analized. For such investigations due to the heavy economic conditions in our country there is no possibility to make new drillings so the only way is the usage of the very inhomogenous data of preliminary investigations. Recognizing this fact we tried to work out such simplified methods and models that the number of hydraulic, geometric and transport parameters can be limited so the estimated input data number would be reduced. This speciality means the reason why we turned to special 2D solutions.

An other problem is the lack of the geometrical data of the investigated aquifer. This problem can be very serious in case of confined aquifer with oil-like pollution. In this case the multi-phase migration of the contaminant is controlled by the geometry of the upper surface of the aquifer and just modified by the seepage of the water body. The procedure is similar to the migration of natural oil to the traps. In such cases the calculations based on the principles of groundwater flow can be inaccurant. From the anomalies of the real behaviour of the pollution in comparison to the estimated or calculated simulations accurate conclusions can be made for the locations of local "oil-traps" which are the best places for the settlement of de-oiling objects (wells, drains).

In phreatic aquifers it is possible to substitute groundwater flow models for transport models if there is not enough information on the transport properties. In the mentioned situation the hydraulic modelling of the restoration procedure will calculate the effect of water and pollution discharging objects, and the possibility of contaminant-migration from the whole polluted area to the hydraulic objects can be assured.

In lot of cases we do not know the real properties of the contaminant. Since the pollution source can be an illegal deposit it might be impossible to determine the exact composition of the waste. In other cases the contaminant is a byproduct of an industrial technology. and this byproduct vary in chemical composition in time due to the changes of the volume of production, the quality of raw materials, and the used technology, etc.. In such cases we should choose the most dangerous compounds of the waste regarding to the quantity, transport properties, and location of the different chemicals. For such situation the only way of investigation is to make study simulations for the best and worst cases. In some cases important transport properties of the contaminant (viscosity, sorption on clay minerals) is function of the temperature, that means we should use estimated values, which may alter significantly from the real values.

There are some factors neglected during transport calculations. For example the changes of pH are not taken into consideration, although the mobilisation or immobilisation of diffrent matallic cations is determined that factor. In such cases special chemical models should be used.

3. CASE STUDIES

3.1. 2D modelling of salty water infiltration at the Great Hungarian Plain

The problem to be investigated was the simulation of salty water infiltration to the deep formations at the Great Hungarian Plain. Due to oil-industrial activity at the territory a salt-water pond was built where the as byproduct pumped water was stored until it was pressed back to the oil trap's formation increasing its pressure. However, the sealing of the pond was demaged and an infiltration began to the sedimentary rocks of the Plain. The pollution occured 20 years long, and after the finishing of the production when the lake was recultivated the presence salty water was detected in the wells of a village nearby.

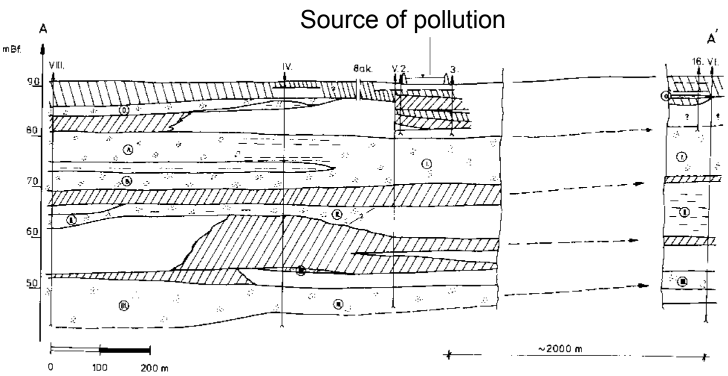

Fig.1. A geological cross section at the investigated site

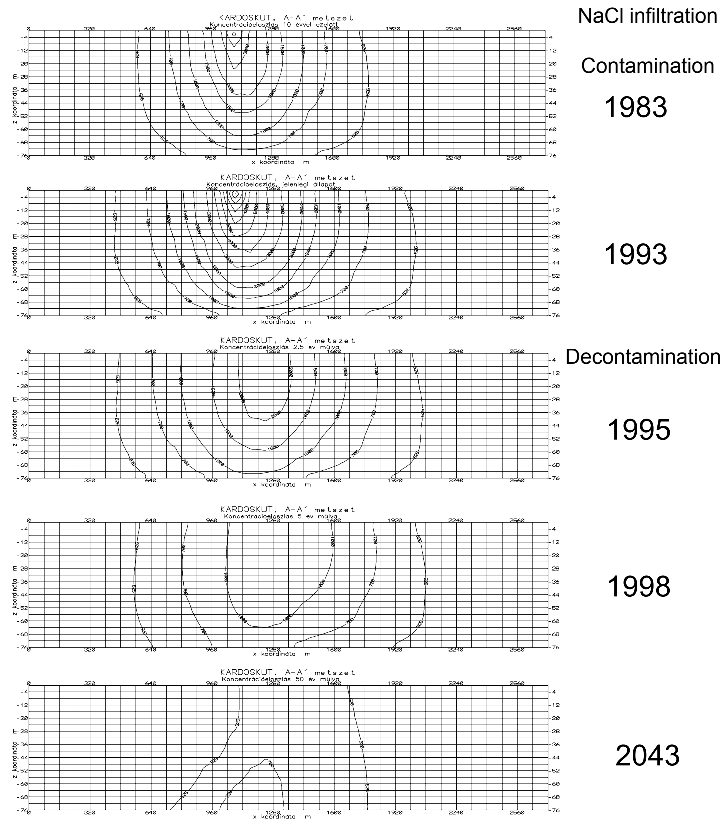

Fig.2.The contamination-decontamiantion process

The aim was the determination of the shape of salt water plume and the estimation of the concentration versus time. Being the source of contamination eliminated we should estimate the spreading of pollutant in time and we could take into consideration that the region is an infiltration zone of the plain that means the characteristic direction of seepage is vertical and the pollutant horizontally transported mostly due to dispersion.

Our bigest problem was to build up the model from few data since the information of about ten oil research drillings was available. The information was so heterogene that we made two simulations in vertical sections (Fig.1.). For this work we developped a new PC program using FDM. On the basis of a geological section we divided the section into 34x19 nodes and coordinated one of ten different soil physical and hydraulic character to each node. The program is made on such way that the results of laboratory coloumn experiences can be used for vadose zone modelling. In our case we hadn't any information on the saturation.

For calibration we made calculations for the 20 years long period of contamination and verified the concentration detected in the observation wells. Later we tried to simulate the shape of plume in the next 50 years. Fig.2. shows the change of shape of calculated plume in several moments of contamination and decontamination. The concentration versus time was calculated in different depth under the pond and we determined the concentration along the investigated section in different depth and time as well.

As result of investigation we can pre-establish that the rate of increase of concentration will be lower and in about 10 years it is very likely to begin to decrease. It seems to be too expensive and uneffective any technical intervention s.a. pumping, so the best solution is to wait the spreading of salty water wich is supported by the vertical infiltration of precipitation.

3.2. Preliminary investigation of waste deposit site of the Regional Refuse Destructor (Szuhogy, NE Hungary)

It is planned to build a regional refuse destructor in Rudabánya, NE Hungary. Its waste will be deposited cca. 5 km from Rudabánya near Szuhogy village. It is planned to use the SOLIROC method, what means the covering of waste in glas-like material which has a very low surface and high resistance against the inclemencies of weather. The hydraulic conductivity of the waste in cemented state is very low, it is about $10^{-9} \div 10^{-10}$ m/s, it means the quantity of leachate is low and hardly polluted. Under the waste 2 x 20 cm thick clay liner is planned, with a drainage system on the top.

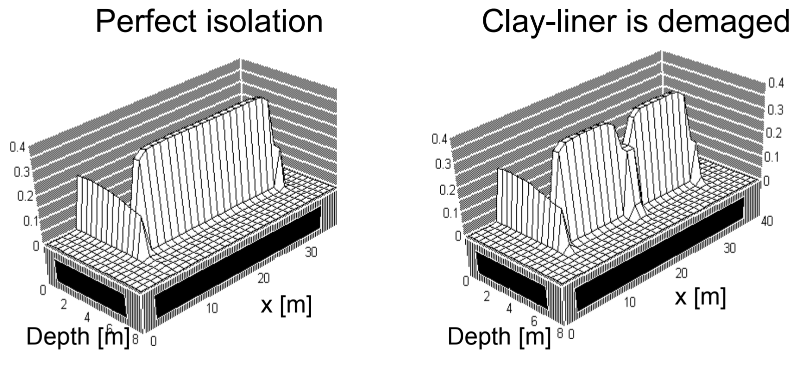

Fig.3.: The comparison of calculated concentrations to the US EPA standards at the waste deposit site of the Regional Refuse Destructor at Szuhogy village

Our task was the verification of the thickness of clay liner and the estimation of the effect of waste deposit on its environment in case of damage of clay liner. The source of pollution was determined on the solubility of SOLIROC blocks, the results were compared to the US EPA (Enviromental Protection Agency) standards. The whole deposit is divided in separated blocks, each block is filled up in 2,5 years. As the worse case we investigated the case of a damaged clay liner with 2,5 year period of contamination. We made the simulation for another 30 years - equal to the planned lifetime of the deposit. We proved that the isolation is insured if the hydraulic conductivity is lower then 10^{-9} m/s. (Fig. 3.)

3.3. The investigation of temporary hasardous waste deposit site of Chemical Works of Budapest (Garé, South Hungary)

At the deposit site mentioned derivatives of monochloro-benzene were stored in iron barrels. The barrels were partially covered with earth. Due to the corrosion of the barrels these hasardous chemicals infiltrated the soil. Since the deposit site is on the top of a hill and there are springs in the valley nearby the hill the problem was to determine the time the chemicals need to reach the spring. The transport phenomena of the chemicals could be divided in two steps. The first is the dominantly vertical seepage in the vadose zone, the second one is the convective-dispersive transport in saturated porous medium after the pollutant reaches the water table in 20-25 m depth. The problem was solved with help of 2D program mentioned at section 3.1.. The investigation was made in a 40 m deep and 700 m long vertical section through the deposit and the spring. The input data of the model were partially estimated because direct geological information was only available about the upper 14 m of the section. From the deeper part we estimated the values using indirect information. Calculating the concentrations versus time we proved that there is no natural hydraulic barrier to avoid the pollution of the spring. The chemicals can reach the spring in 5-10 years depending on the representativity of estimated data.(Fig.4.)

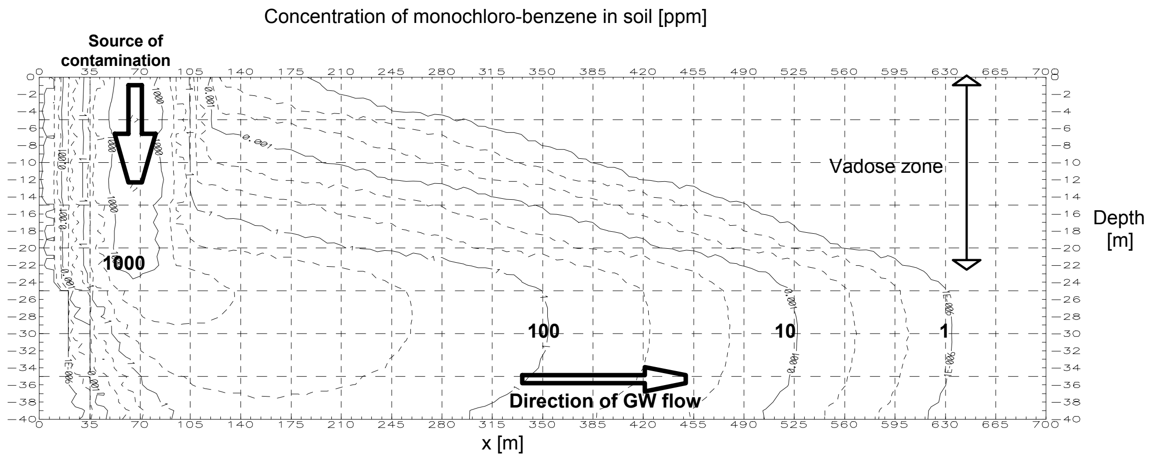

Fig.6.: The calculated concentration-distribution of monochlor-benzene along the investigated profile

3.4. Investigation of a planned slurry wall round a waste deposit site

A hasardous waste deposit was made on a river terrace formations in the early 60's. Since there was some contamination observed in the wells nearby the deposit, a slurry wall was planned to build for the isolation of the site. Inside the slurry wall permanent water-level is assured by water water discharge (normal situation). Because of technical reasons in very rare and special cases, for a duration of maximum 5 days it is possible that the water level inside the wall is higher then around it (special situation) (Fig.5.) . This situation means that there is a disadvantageous outflow from the depony to the environment.

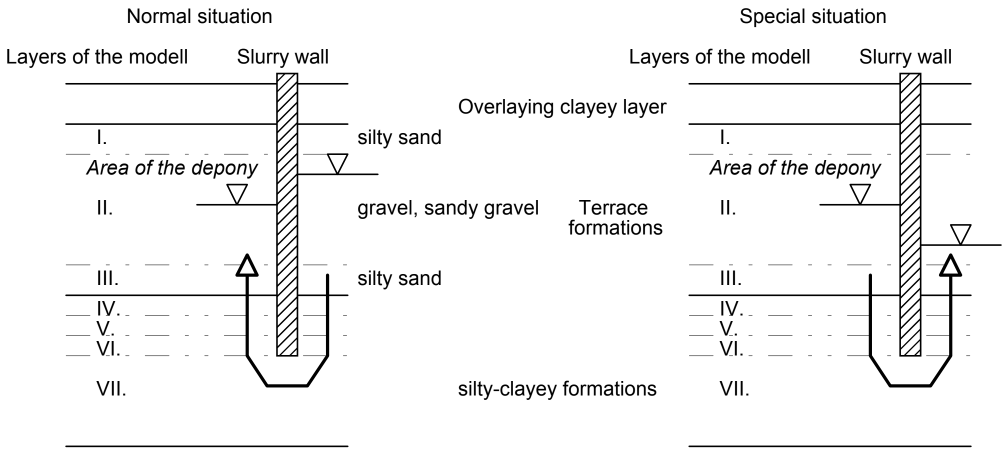

Fig.5. The normal and special situation at the slurry wall

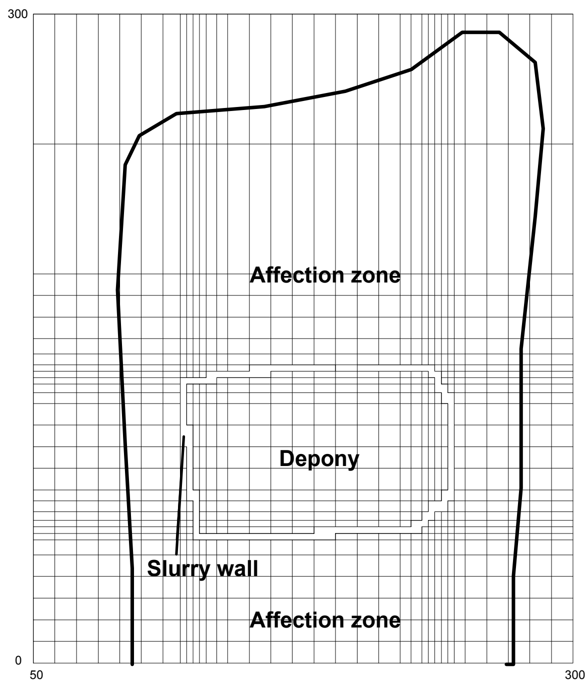

Fig.6. The determined affection zone of the contamination round the planned slurry wall

Our task was to determine the posible rate of pollution of the environment on occurance of the mentioned situation. First we determined the water fluxes from the deponi to the environment and vice versa for both cases. Knowing the main and time variing directions of groundwater flow we determined the affected area of the possible pollution. Since the duration of contamination is less then 5 days and the decontamination period is supposed to be significantly longer, the spreading of the pollutant due to diffusion and hydraulic dispersion will strongly decrease the concentrations in the aquifer. As result of the investigation we can say that the risk of pollution outside the determinated affection zone can be neglected (Fig.6.). The size of the affection zone can be sharply reduced by lowering the water table inside the slurry wall.

Summary

The experiences of our works demonstrated that groundwater and transport modelling is an efficient tool for solving different problems on the field of environmental protection. We think that the weak-point of modelling is the building of representative input data system. In Hungary in most cases there is no possibility to make additional research s.a. drilling, chemical analysis etc. so the only way is to use simplified models. In that case we can strictly reduce the number of input data, it means we can minimize the data estimation. However this simplified, mostly 2D models cannot give so detailed results as that in 3D. In case of missing data we suggest to make analysis for the best, worse and intermedier (avarage) cases. This can result a series of possible situations among them it is easier to choose the most representative later, when people is in posession of more information.

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