EXPERIMENTAL MODELING OF THE PROCESS OF MIGRATION OF TOXIC AND RADIOACTIVE CONTAMINATION IN PLACES OF DEPOSITION OF INDUSTRIAL WASTE

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The Laboratory of Geological Environment Protection at Moscow State Lomonosov's University has been developing since 1986 a technique of experimental modeling of the process of migration of toxic and radioactive contamination in natural soil strata. The received results allow consideration of soil strata as a geochemical barrier in the migration path of harmful substances that, in turn, can be used for estimation of the degree of safety of subsoil waters in areas of near-surface deposition of industrial waste.

A series of field, office, and laboratory studies are necessary for quantitative estimation of soil stratum as a geo-chemical barrier.

Engineering-geological materials for estimation of soil stratum as a geo-chemical barrier.

Basing on field and office studies, soil strata of the tested territory are to be divided into quasi-similar areas with regard to composition, structure, genesis, and lithological layers. The number of test pits for core sampling is determined in the course of solution of the following problems:

1) All lithological layers are to be found in the territory;

2) For each lithological layer data on the change of its power within the territory of storage are necessary;

3) Soil samples are to be taken from all lithological layers for specialized investigations; prior to this determination of mineral and granulometric composition, as well as other engineering-geological parameters are to be determined.

Laboratory experiments for obtaining initial data for estimation of the efficiency of a geo-chemical barrier.

All parameters that characterize mass-transfer of solutions of toxic and radioactive elements in soils are to be obtained under laboratory conditions for all lithological layers and for each model contaminate (that is present in wastes).

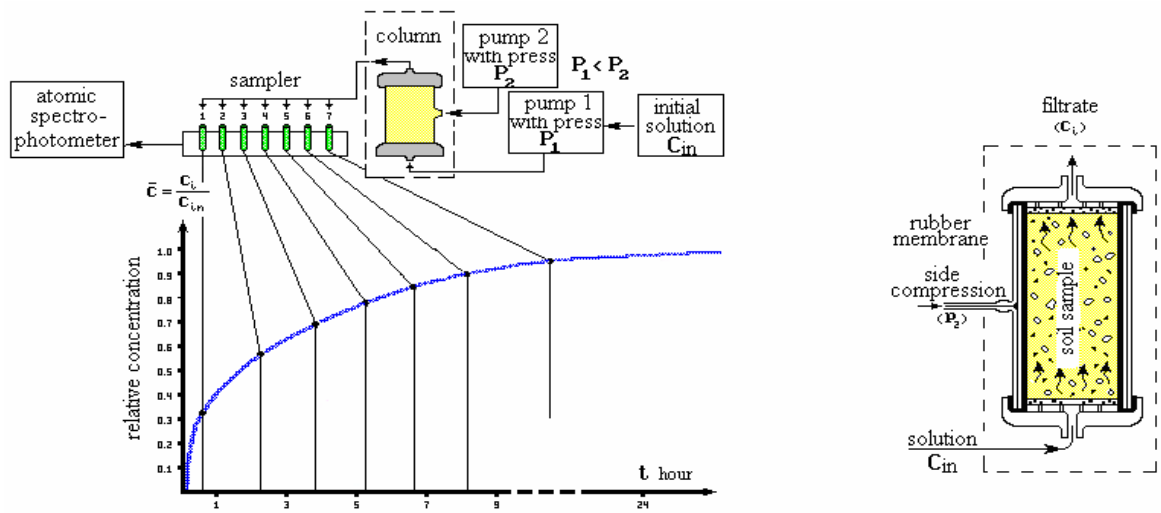

Fig.1. Diagram of the laboratory-scale plant

Investigations of absorption ability of soil with regard to waste elements are carried under dynamic conditions out with wastes of an existing object or with solutions that simulate its chemical composition. At determination of soil absorption solution of tested element is filtered through soil samples with undisturbed or close to natural structure (Fig. 1). Successive samples of an infiltrate are collected at the outlet; concentration of an element or elements is determined in these samples. Curves of de-

pendency of the relative element concentration on the volume of filtered solution (or time)—so called outlet curves—are the base for further calculation and forecast modeling. An obligatory condition at dynamic experiments is a constant rate of filtration of tested solution through the sample. In this case outlet curves can be used for further mathematic modeling of mass-transfer in soils.

Calculation of migration parameters of mass-transfer of toxic and radioactive elements in soil stratum

Previous studies showed that describing element mass-transfer in soil, the necessary reliability is observed at the use of a system of equations and boundary conditions that correspond to the microdisperse mathematical model of mass-transfer:

$$n\frac{dc(x,t)}{dt} = D\frac{d^2c(x,t)}{dx^2} - v\frac{dc(x,t)}{dx};$$

where t is the time, t>0; x is the path of filtration, $0<x<\infty$, n is the effective porosity, D the coefficient of microdispersion, ***v*** is the rate of filtration. Initial condition: $c(x,0)=c^0$- phone concentration.

Limited conditions:

$c(\infty,t)=c^0$- initial concentration at point $x=\infty$

$c(0,t)=c_o$ – initial concentration at point x=0

Approximate solution:

$$\bar{c}(x,t) = \frac{c(x,t)-c_0}{c^0-c_0} = \frac{1}{2}erfc(\xi)\ ;\ \xi = \frac{vt-nl}{2\sqrt{Dnt}} \qquad (*),$$

where *l* - thickness of soil strata.

The solution permits to determine pollutant's concentration at any time moment in any point of pore space of soil strata on the base migration parameters obtained in laboratory experiments. Migration parameters are calculated using the graphic-analytical method.

For quantitative estimation of the efficiency of soil strata as geo-chemical barrier the term «maximum permissible time (T_{max}) of exploitation of it» is introduces. It is the time during which a soil stratum would absorb all pollutants preventing their penetration in a water-bearing horizon. Maximum permissible time (T_{max}) of exploitation of geo-chemical barrier may count up with formula:

$$Tnp = \frac{n}{v^2}(2\xi^2D + mv - 2\xi\sqrt{\xi^2D + Dvm})$$

where m – c, ξ - ξ =*inferfc* ($2ПДК_{эл}/C_0$), where ПДК – preventing pollutants penetration, C_0 – initial concentration of pollutant in waste

So, aforesaid procedure of experimental modeling of the process of migration of toxic and radioactive contaminants permits to get quantitative estimation of the degree of safety of subsoil waters at a specified anthropogenous load from wastes disposal.

Reference

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