ON A MATHEMATICAL MODEL TRANSPORT AND TRANSFER OF THE RADIONUCLIDES IN DANUBE RIVER, ROMANIAN SECTOR

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Abstract

The attention has been focused on those radionuclide species which are the most frequently encountered into the radioactive polluted waters or laboratory and many results about their behaviour are reported.

Key words : Danube river, mathematical model, radionuclides transport in river , Black Sea.

Introduction

The movement of radionuclides throughout water body (streams, lake, sea, estuary, etc) is a hydrodynamic transport process depending, additionally, on many, interaction between the radionuclides and physical, chemical and biological components of environmental system. These interactions cause the retention of certain quantities of radionuclides into the system and decrease the fraction transported by flow. The intensity and time duration of the radionuclides retention depend on many features of the environment. A large fraction from the detained radioactivity is then gradually restituted to the flowing water and is transported hydrodynamically downstream. It is obvious that a mathematical model governing such processes may be developed making use of mass-transfer Equations [1, 2] .

The governing equations

Assuming that there is only one radionuclide specie which joins the system, but there are more types of sorbants into the natural stream. Then, the mathematical model for general transport and retention of radionuclides could be the following:

$$\frac{\delta(AC)}{\delta t} - \frac{\delta}{\delta x}\left(AE\frac{\delta C}{\delta x}\right) + \frac{\delta(QC)}{\delta x} = -\lambda CA + \sum_{n=1}^{N} S_n \qquad (1)$$

where C - the radionuclide concentration in water expressed as radioactivity ($dis.s^{-1}.L^{-1}$);

λ - the radioactivity decay constant;

S_n - the rate exchange of the radionuclid between the sorbant n;

N - the total number of sorbant interacting with the radionu clides

Taking into account that the bed of the Danube river after Turnu Severin Power Dam till Cervavoda is made of silty clay, the following interaction between the bed river and the water may be written:

$$S_b = B\frac{\delta s_b}{\delta t} \qquad (2)$$

where B - the water width at water free surface

$\partial s_b / \partial t$ - the exchange rate upon the unit area of bottom .

But, the term $\partial s_b / \partial t = k_b F_b$ where kb is the mass-transfer coefficient between water and bottom sediment; F_b must have the dimension of the radioactivity (disintegrations per unit time unit)

Then, $S_b = Bk_b (R_b - K_b C)$ (3)

K_b - the equilibrium distribution coefficient of the radionuclide. This, can be explained by the following equation :

$$\frac{\delta R_b}{\delta t} = k_b (K_b C - R_b) - \lambda R_b \qquad (4)$$

The radionuclides uptaked by the animals and plants are calculated by analogy with bed load sediments.

For the radionuclide interaction with the aquatic plants attached of the bed river, if one accepts that these belong to only one species and therefore react in a similar manner with the radionuclides, it seems acceptable to assume that the intensity of such reaction is proportional with the weight of plants. Denoting as Mp and Sp the weight of plants and the corresponding bottom, relatively, then from Eq. (1), there:

$$S_p = B\, M_p R_p F_p \qquad (5)$$

Substituting the relationships for S_b and S_p into Eq. (1) is obtained the mathematical model governing the radionuclides transport and transfer. The equations systems are composed by three simultaneous equations with the unknown C, K_b and C_p. Any of these systems can be solved using a finite scheme designed for one efficient time step (based on the splitting technique mode) on a compound vector .

Results and discussion

The model has been tested for the simulation of the radionuclides transfer and transport along the Danube river (Romanian sector) to the Black Sea. [3].

It must be outlined, that a similar mathematical model has been applied even to the entry of the Danube river in Romania, till the Turnu Severin Iron Gates dam, in different cases of the flow water [1]. The hydrodinamic parameters are taken for the cross-sections of Danube river at Bechet, Turnu Magurele, Giurgiu, Ceatal Izmail. Into these sections the cross-section flow discharge Q[mc/s] and the top width at water-surface B[m] are 4440 mc/s ÷ 6220 mc/s and 427 m ÷ 757 m [3].

The flow parameters of the Danube from the entrance in Romania, at Bazias, till the beginning of the Danube delta at Ceatal-Izmail for years 1996-1997, are discussed .

The mass-transfer k_b and distribution K_b were selected by experimental data for bottom sediments for natural stream (30 % clay, 40% quartz , 22% calcite) for the specified radionuclides (^{85}Sr, ^{90}Sr, ^{137}Cs, ^{144}Ce, ^{65}Zn).

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