



MODELLING OF MIGRATION OF RADIONUCLIDES AND TRACE ELEMENTS BETWEEN THE COMPONENTS OF THE BLACK SEA ECOSYSTEMS

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As it is known, forecasting evaluation of the levels of hydrobionts and waters radioactive and chemical pollution, received with the help of mathematical models can be objective only when the structure and parametric base of the models depict with enough level of adequacy mechanisms of interaction under studies. Here an objective complexity of the model must correspond to the time and space scales, in which dynamic characteristics of the studied processes reveal themselves. This report considers peculiarities of the mathematical description of radionuclides migration between water environment and biotic and abiotic components of the Black Sea ecosystems at different periods of averaging, from the time scale of metabolic processes, taking place in hydrobionts, to the large-scale description of radionuclides migration in the Black Sea.

It is shown that kinetic peculiarities of radioisotope and mineral exchange in hydrobionts at the time scale of metabolic processes are described with sufficient level of adequacy by the equations, depicting zero and the first order of metabolic reactions. When radionuclide (tracing element) is absorbed directly from water medium and from food, kinetic of change in its content in hydrobiont's exchange fund is described correspondingly by equations:

$$dC_g / dt = C_v K_c p - C_g (p + B'); \quad (1)$$

$$dC_g / dt = R(C_f q - C_g q_f) - C_g p, \quad (2)$$

where: C_v , C_g and C_f - concentration of radionuclide (or tracer element) in water, hydrobiont and its food correspondingly, K_c and p - stationary meaning of accumulation coefficient and index of the rate of radionuclide (element) exchange by hydrobiont, R and B' - ration and specific rate of hydrobionts specimens growth, q and q_f - level of food digestion and level of radionuclide uptake from the food, correspondingly, t - time.

According to the results of comparison of modelling data and experiments with radioactive marking it was stated that K_c value can depend on physical-chemical form of radionuclide, on the content of its isotope and non-isotope carriers in water environment, corresponding to Lengmur and Michaelis-Menten equations, and on size characteristics of hydrobiont specimen as well. It is shown, that equations of (1) type, written separately for reflection of the processes of physical and chemical sorption can be used for evaluation and forecasting the levels of ^{137}Cs concentrating by the Black Sea bottom sediments under changes of this radionuclide content in water environment.

Concentration and transfer of radionuclides by hydrobionts at the scale of the season and year ways of biogeochemical processes was considered on the examples of models creation according to the data of the Sevastopol bays radioecological monitoring and to the mathematical description of the flow of biosedimentational self-purification of the Black Sea photic layer, as a result of functioning of pelagic ecosystem in its Western halistatic zone. According to the data of mathematical description of the results of measurements of ^{90}Sr and ^{137}Cs concentration changes in the Sevastopol bays algae after Chernobul accident it was revealed, that the laws of changes in these radioisotopes content in algae were sufficiently described by (1) type equations. With this dynamics of the system «radionuclide in marine environment - hydrobiont» was determined only by the change in ^{90}Sr and ^{137}Cs contents in marine environment.

When studying water biosedimentativ self-purification, two-measure ecosystem model «phytoplankton - bacteria - zooplankton - dissolved organic matter - suspended organic matter in the photic layer of marine environment» was locked by balance in organic matter, biogenic element and water pollutant, which could attain the surface layer of the sea. Concentration of radionuclides (or tracing elements) by hydrobionts, and transfer of pollutions with trophic chains were described by (1) and (2) types equations. Stability of calculative scheme for model realization was studied, its hydrological, hydrochemical and biotic parameters verification was fulfilled according to the results of the scientific cruises works in the region of the Black Sea western halistatic zone. The analysis of numerical solutions on the model has shown, that dynamics of the system as for pollutants was determined by the content concentrating function of hydrobionts relatively to pollutants and by correlation between an intensity of bioproductive and destructive processes in the photic layer ecosystem. It is established, that relatively to tracing elements it is possible to reach an extreme biosedimentational self-purification of waters, at which stationarity of the level of tracing element content in water environment can not be stated, as the flow of its getting into water environment can not be balanced by the flow of sedimentational elimination.

We studied peculiarities of modelling the large-scale processes of radionuclides migration on example of description of ^{137}Cs vertical migration in the upper layers of the Black Sea after Chernobyl accident. To reflect an action of the main averaged in the large-scale time and space imagination, abiotic and biotic factors on migration and the time of ^{137}Cs availability in the Black Sea the model was locked by water, salinity and radioisotope balance with consideration of radioactive decay. According of the model with hydrophysical parameters was carried out by water balance of the sea with consideration of river discharges, rains over the sea, evaporations and water exchange through the straits, and considering as well stationarity of the profile of vertical distribution of salinity. Verification of the model relatively to ^{137}Cs was carried out by comparison of the results of observations, beginning from 1986, of averaged distribution of this radioisotope in the sea layers from the surface to 500 m depth. Radiocesium inflow with Dnieper and Danube and biosedimentational self-purification of water also were taken into account. Model studies have shown that the process of vertical water mixture is the main important factor of ^{137}Cs vertical migration in the Black Sea. It was revealed, that as a result of common effect of hydrophysical processes, transfer through the straits and sedimentational depositing in the bottom sediments, the time of ^{137}Cs availability in the Black Sea makes about 70-80 years, which is two times less than average time of existance of this isotope atoms.

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