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Radioecological assessment of radionuclide permissible levels and low-level releases in the seas

T. Sazykina, I. Kryshev

SPA "TYPHOON", Obninsk, Kaluga Region, 249038 Russia ecomod@obninsk.com / Fax:+7 4843940910

The objective of the paper is development of a general methodology for radioecological assessment of permissible levels and releases of radionuclides in sea waters ensuring the radiation protection of the human population, as well as marine biota. The following problems are considered:

- Methodology for radiation protection: hygienic and radioecological criteria.
- Calculation of permissible levels of radionuclides in seas of Russia.
- Assessment of permissible releases of radionuclides into the marine environment.

The permissible concentrations of radionuclides in the seas of Russia were calculated under the following conditions: exposure from consumption of marine foodstuffs should not exceed 10 % of the permissible dose limit; dose is assessed for a population group characterized by a considerable consumption of marine foodstuffs; doses to marine biota of lower than 1 % of the lethal dose or significant dose of chronic exposure are assumed not to lead to a significant impact on populations or communities; as several radionuclides are present in sea water, it is necessary to calculate permissible levels of the radionuclide mixture, taking into account the permissible concentrations of individual radionuclides and the activity proportion of the total activity of the mixture. It is shown that the radionuclides ^{241}Am, ^{239}Pu, ^{59}Fe, ^{60}Co, ^{65}Zn and ^{137}Cs, which are characterized by high values of accumulation in individual marine foodstuffs, have the lowest control concentrations. Permissible concentration for ^{137}Cs in sea water are more rigid than those for ^{90}Sr, since ^{137}Cs accumulates in edible parts

of marine foodstuffs to a greater extent. Fish and mollusks are the critical groups of marine organisms for most radionuclides. Hygienic criteria are more rigid than radioecological ones for most radionuclides. Real concentrations of radionuclides (^{90}Sr, ^{137}Cs, ^{239}Pu, and some others) in sea water are 10^3-10^4 times lower than permissible concentrations.

The dynamic two-compartment model is used for assessment of permissible low-level releases of radionuclides. The compartment "aquatic environment" describes the content of a radionuclide in the sea water, with consideration for the following processes: the radionuclide intake with process waters, its removal to the sea as a result of water exchange, the radionuclide settling to bottom sediments, and its radioactive decay. The compartment "bottom sediments" describes the radionuclide accumulation in bottom sediments. The assessments are performed in such a way that the resulting concentrations of radionuclides in the sea water and bottom sediments do not exceed the established permissible concentrations.

The proposed radionuclide permissible concentrations and low-level releases in sea waters, ensuring the radiation safety of the population, ensure the radiation safety of marine flora and fauna as well, i.e. satisfy both hygienic and ecological criteria of protection from radioactive contamination of the marine environment. The methodology of the radioecological assessment can be refined for practical use, taking into account the existing values of radioactive contamination of specific regions, coefficients of hydrological dilution, as well as catches and consumption of marine foodstuffs in specific regions.