Humic substances as radioprotective agents

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It is known that microorganisms of soils and aqueous media are sensitive to the presence of humic substance (HS), which play a role of natural attenuators of environmental toxicity. We studied bioeffects of alpha- and beta- emitting radionuclides (americium-241, uranium-(235+238), thorium-232, and tritium) in the presence of HS under the conditions of low-dose exposures (<0.1 Gy). Luminous marine bacterium Photobacterium phosphoreum was applied as a model unicellular water microorganism to monitor toxicity and activation ability of the radionuclide solutions. To imitate the marine environment for bacterial cells and to balance osmotic processes, the 3% NaCl solutions were used. The bioeffects of the radionuclides were compared to those of salts of heavy metals (salts of Ce, Sm, Gd, Eu).

The bioluminescence response of the marine bacteria to the radionuclides corresponded to the "hormesis" model: it included stages of bioluminescence inhibition and activation, as well as the absence of the effect. HS were shown to decrease the inhibition and activation effects of the radionuclides on the bacterial luminescence. The correlations between the bioluminescence intensity and the content of Reactive Oxygen Species (ROS) were found in the radioactive bacterial suspensions in the presence of radionuclides, thus revealing an involvement of ROS to radiomodifying effects of the radionuclides and HS.

The results demonstrate an important role of HS in natural processes in the regions of low radioactive contaminations: HS can mitigate radiotoxic effects and adaptive response of microorganisms to low-dose radioactive exposure of alpha- and beta- types. The involvement of ROS to these processes was demonstrated.

The results can provide a basis for predicting a response of living organisms to radiation at large territories infected with low-intensity radiation after accidents, discharges of nuclear plants, or underground mining of natural resources.

The radioprotective effect of HS was found in the organism of higher level of organization – agricultural animals, rabbits, under low-dose exposure to tritiated water: HS neutralized the toxic effect of tritiated water by bringing rabbit' physiological parameter (phagocytic activity of leukocytes) closer to the control. Hence, the bacteria-based bioassay can be applied to predict (1) changes in rates of cellular processes in higher organisms under low-dose radiation exposures, and (2) radioprotective activity of HS in different radiation environments.

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