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# 1 The concept on ecosystem self-clearing after a man-caused impact

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Theoretical generalization of radiogeochemical researches within the area contaminated with artificial radionuclides after Chernobyl Catastrophe lead to a new methodological approach of *environmental self-clearing* based on synchronization between biogeochemical migration and abiogenic speciation of radionuclides in the unsaturated zone of soils. This approach is founded on the balance assessment of the intensity of contaminant biogeochemical migration using the Geochemical Transfer Factor (GTF), which represents the radionuclide transfer between soil and vegetation per a unit of area. In contrast to *natural attenuation* and *intrinsic bioremediation*, which considered decontamination of abiogenic constituent of landscape, *environmental self-clearing* has covered all natural processes leading to reduction of contaminant concentration in trophic cycles, including immobilization of pollutant in soil without its removing outside the landscape. The main thesis of the concept of speciation in geochemistry of artificial radionuclides consists in synchronism of pollutant's biogenic migration and abiogenic speciation. The conjugation between these processes defines intensity of biogeochemical flux and landscape-geochemical conditions by mobile species dynamics. Biogeochemical flux to the first chain of a trophic cycle includes from 20 to 100 % of mobile $^{137}$Cs and between 4 and 60 % of mobile $^{90}$Sr. Biogeochemical flux to higher chains involves from 1 to 6 % of $^{137}$Cs mobile species in soil. The rate of $^{137}$Cs biogeochemical flux increases with the growth of biomass production from dry meadows at soddy-podzolic soil to over-damped peaty soils within flood-lands. The intensity of $^{90}$Sr biogeochemical flux rises in opposite direction that

is determined by the bioavailability of $^{90}$Sr and corresponds to regularities of natural Sr isotope bioaccumulation in geochemically conjugated landscapes. Self-clearing ability of ecosystems increases in opposite direction to intensity of biogeochemical flux. Intensity of $^{137}$Cs biogeochemical flux in a forest ecosystem increases exponentially to radionuclide mobile species dynamics and grows in correspondence with biomass production. The rate of meadow ecosystem self-clearing is 3 and 15 times higher than the decay rate of appropriative radionuclides. The half-time of biological self-clearing of a pine wood is between 15 and 250 years depending on landscape-geochemical conditions. The self-clearing of a pine wood mainly corresponded to radionuclide decay. The self-clearing of a freshwater ecosystem is defined by the sedimentation of radioactive particles, radionuclide speciation and migration within contaminated columbines and bottom deposits and radionuclide transportation with stream. Dynamics of water contamination within River Dnieper waterfall is described by exponential regularity that is in close accordance with the temporal changing of radionuclide speciation in soils of columbines. Substantial redistribution of radionuclides between migration species has been observed during 18 years. The part of radionuclides, which corresponds to suspended particulate matter (SPM), decreases and the part of conditionally dissolved form increases. Radionuclide transformation from SPM to conditionally dissolved form is described by exponential regularity. Annual radionuclide transport of dissolved radionuclides from contaminated columbines of the Chernobyl Exclusion Zone to the Black Sea is assessed as $6{\cdot}10^{11}$ Bq of $^{137}$Cs and $7{\cdot}10^{12}$ Bq of $^{90}$Sr. Bottom deposits play a role of virtually inexchangeable depot of $^{137}$Cs. Transformation of $^{137}$Cs from solid phase of bottom sediment to water soluble form is described by logarithmical normal regularity. The leaching of $^{90}$Sr from sediments occurs accordingly to the first order kinetic law. Ecological safety of bottom deposits as the source of river water secondary contamination with radionuclides is determined by complete removal of $^{90}$Sr and fast immobilization of $^{137}$Cs by solid phase of sediments. Total radionuclide transport into the Black Sea Basin during 15 years is assessed as $2{\cdot}10^{14}$ Bq of $^{90}$Sr, and $2{\cdot}10^{13}$ Bq of $^{137}$Cs. The correspondence of the rates of radionuclide speciation within aqueous and terrestrial ecosystems testifies to common geochemical mechanism of contaminants migration in natural environment.