Geophysical Research Abstracts, Vol. 9, 00606, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-00606

The fate of long-lived radionuclides 137Cs and 90Sr in the Black Sea after Chernobyl NPP accident: role of hydrophysical factors and tracer applications

N.A. Stokozov (1) and V.N. Egorov (1)

(1) Institute of Biology of the Southern Seas (IBSS), National Academy of Sciences, Sevastopol, Ukraine (stokozov@mail.ru / Fax: +38 0692 557813 / Phone: +38 0692 479294)

The poster summarizes studies of 137Cs and 90Sr contamination of the Black Sea Basin carried out by Institute of Biology of the Southern Seas during 1986-2005 following the Chernobyl NPP accident. Inflows of 137Cs and 90Sr from the Dnieper and the Danube Rivers, outflow through the Bosphorus Strait, temporary evolution of 137Cs and 90Sr profiles and inventories in the Black Sea water column and inventories in bottom sediments were estimated over the period 1986-2005.

It has been estimated that atmospheric fallout deposited after 26 April 1986 1.7-2.4 PBq of 137Cs on the surface of the Black Sea - nearly 2 % of total 137Cs release into the environment. Consequently the 137Cs inventory increased by a factor of 6-10 in the 0-50 m layer and in the whole volume of the Black Sea - by a factor of at least 2 in comparison with pre-Chernobyl value of - 1.4+/-0.3 PBq. The contribution of Chernobyl-origin 90Sr from atmospheric fallout was estimated as 0.1-0.3 PBq. Pre-accident 90Sr level around 20 Bq m-3 was reached by 1988 except NW Black Sea. The subsequent 137Cs input from the Danube and the Dnieper Rivers was very insignificant in comparison with the short-term atmospheric fallout. In contrast to this, total amount of 90Sr delivered by the two rivers into the Black Sea was closed to amount of 90Sr fallen on the Black Sea surface after Chernobyl NPP accident. The results of observations and mathematical modelling testified that in the surface layers 0-50 and 0-200 m of the Black Sea in 1986-2000 an exponential decrease of the 137Cs inventories with an effective half-lifes of 5-7 years and 9-13 years respectively have been observed. Under conditions of relatively unimportant river inputs and depletion by sedimentation from the water column, the decrease of the 137Cs inventory in the

surface layer has been influenced mainly by three processes: vertical water mixing, release through the Bosphorus Strait, which accounts for 2-2.5% of the 137Cs inventory in the 0-50 m layer being depleted annually, and radioactive decay. In the case of 90Sr, these processes have been compensated essentially by river inputs from the Dnieper and Danube Rivers. The outflows from the Black Sea to the Mediterranean are interesting for estimating of radionuclides budgets in the Mediterranean Sea and for better quantifying the Chernobyl signal.

The ratio 134Cs/137Cs in surface water with a decay corrected value of 0.53+/-0.1 at 1 May 1986, showed clearly that radiocaesium had Chernobyl origin. This ratio proved to be a very useful tool for identifying Chernobyl derived 137Cs, which can be used for estimation of physical mixing processes in the Black Sea. During the subsequent years Chernobyl derived 137Cs distributed relatively rapid into the permanent Black Sea pycnocline. Further development of this approach had shown that in the Central Black Sea Basin about 50% content of the surface water in the low permanent Black Sea pycnocline reached during 3-5 years. Consequently, total ventilation time of low permanent Black Sea pycnocline by surface waters can be estimated as 15-25 years.

The process of vertical 137Cs and 90Sr transfer has been observed mainly in the 0-200 m layer of the Black Sea. Temporary evolution of 137Cs and 90Sr profiles in the Black Sea Deep-Water Basin was used for further estimations of a large-scale vertical water mixing. All 137Cs and 90Sr profiles included three parts: the high-concentrations surface mixed layer, the gradient layer and the low-concentrations layer underneath. After 1986 the increase in the surface mixed layer's thickness up to the upper boundary of the halocline and the sinking of the gradient layer for 137Cs and 90Sr profiles have been observed. The downward velocity of the gradient layer was used as an indicator of the vertical water mixing intensity. 137Cs and 90Sr profiles have been modelled by sigmoid functions with following differential analysis. The results shown that in the course of the first year after the Chernobyl NPP accident the lower boundary of the gradient layer and the depth of maximum gradient reached the permanent Black Sea pycnocline. Subsequently, up to 1988-1990, these boundaries continued to sink into the Black Sea pycnocline with a velocity of 10-12 m per year in the Black Sea Central Basin, with a velocity of 30-35 m per year in the region of Main Black Sea Current and more slowly essentially in the subsequent years. On a base of the obtained velocities and 137Cs flux at the upper boundary of the gradient layer the vertical turbulent mixing coefficients in the permanent Black Sea pycnocline were calculated using the diffusive one-dimensional equation. In the upper strongly stratified part of the permanent Black Sea pycnocline calculated values ranged between 0.1-0.2 cm2 sec-1. The values obtained for Kz were similar to those based on physical oceanography evaluations The results of this study indicate that the Black Sea halocline is the main limiting

factor of the intensity of vertical water exchange between surface waters and deeper layers. The obtained result, based on radiotracer studies, allows to evaluate the velocity of "self-purification" of Black Sea surface waters from any dissolved pollutants and the velocity of ventilation of the deeper waters.

Besides, the 90Sr signals from the Danube and the Dnieper Rivers were used for estimations of Black Sea shelf water mixing processes with using “salinity - 90Sr”mixing model. Using this approach mixing ratios and hence river transport values can be reliably derived which are of interest to more general questions of pollution transport in the NW Black Sea.

Keywords: The Black Sea, 137Cs, 90Sr, vertical and shelf water mixing, ecological half-lifes.