Turkish J. Marine Sciences 7:143-152 (2001)

Sources and Distribution of Anthropogenic Radionuclides in Marmara Sea Environment

Marmara Denizi Çevresinde Antropojenik Radionüklilerin Menşei ve Dağılımları

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Abstract
The man-made or anthropogenic radionuclides entered to Marmara Sea marine environment from nuclear explosion tests, Nuclear Power Plants around Black Sea and Chernobyl accident. This paper provides comprehensive information on anthropogenic radionuclide levels in the Marmara Sea marine environment between 1970 and 2001 years. The results will be used as the national or international reference source for future studies in the regional scale.

Keywords: Marmara Sea, radionuclide, monitoring, biota, sediment

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The anthropogenic radionuclides, entered marine environment from nuclear explosion tests. The estimated fission yields are 217 Mt since 1945. At the same time, the fission products of the atmospheric nuclear bomb tests are given to be 6 Mt from Chinese and French tests since 1973 (Holm, 1997). In addition, the estimated fission yields are 194 Mt (139 Mt as air bursts) among 1945 and 1963. The total of 194 megatons corresponds about $2.8x10^{28}$ fissioning atoms (National Academy of sciences, 1971). The fission products are released as radioactive fallout

and deposited worldwide. Some of these are ^{90}Sr, ^{95}Zr, ^{106}Ru, ^{131}I, ^{137}Cs, ^{144}Ce and ^{139}Pu (Eisenbud, 1973).
Environmental radioactivity from a nuclear power reactor can originate not only from low level emissions during normal operation but also from accident. It is well known that the amount of radioactive materials from nuclear power plants that actually reaches the environment is extremely small. During normal operation of the reactor new radionuclides are formed by fission of the nuclear fuel and neutron activation of corrosion products. Liquid wastes of the plants released to the environment include some radionuclides. The principal radionuclides present in coolant water of light-water reactors are ^{3}H, ^{51}Cr, ^{58}Co, ^{60}Co, ^{85}Kr, ^{85}Sr, ^{90}Sr, ^{134}Cs ^{137}Cs, ^{131}I, and ^{140}Ba, (Eisenbud, 1973) .

The Chernobyl accident in early morning of April 26, 1986, had an impact on the marine and terrestrial environments. The released of long-lived radionuclides from the Chernobyl were observed as heavy local contamination and fallout pattern at many sites all over the world. The long-lived radionuclides are ^{134}Cs, ^{137}Cs, ^{90}Sr, ^{106}Ru, ^{144}Ce, ^{110m}Ag, ^{125}Sb, $^{239+240}Pu$ ^{238}Pu, ^{241}Pu, ^{241}Am, ^{242}Pu and $^{243+244}Cm$ (Holm, 1997).

Biologically important of the radiouclides depended on concentration, chemical properties, physical half-life, solubility and oceanographic conditions, etc. It is well known that ^{137}Cs is one of the major dose contributing in the environment. At the same time, the ^{137}Cs radionuclide was the most important contaminant because of its high concentration in the Chernobyl fallout (Talmage and Mayers-Schöne, 1995). Moreover, the distribution of ^{90}Sr and ^{137}Cs radionuclides in the food chain organisms are similar to their stable chemical analogues. Both of the fission products ^{90}Sr and ^{137}Cs radionuclides will behave like calcium and will have properties like to potassium after entered marine environment.

Unfortunately we have not any data of ^{90}Sr, ^{137}Cs, plutonium radionuclides and other fission or activation products in biota and sediment samples of the Marmara Sea before Chernobyl accident. On the other hand, the gamma spectrometric analyses were made in biota and sediment samples of the Küçükçekmece lake between the period of 1970 and 1973 (Ünlü et al., 1974). The results showed that the dominant contribution at the total radioactivities come from natural radionuclides in the 44 samples which have different origins.

Following the Chernobyl accident, the radioactivty concentrations are determined in fish samples from the Marmara Sea (Topcuoğlu et al., 1988). The following fish species cought from the Marmara Sea during the period of 1986-1987: common horse mackerel, chub mackerel, bluefish, seabream, sardine, silverside, picarel, smooth dogfish and bluefin tuna. The total activity levels of ^{132}I, ^{134}Cs, ^{137}Cs, and ^{103}Ru were found among 52 - 65 Bq/kg wet weights during May 1986. The maximum total radioactivy level of Marmara Sea fish samples gradually decreased during first three months after that, Chernobyl radionuclides were not detected, except ^{137}Cs radionuclide. In 1988 samples, the ^{137}Cs radionuclide were found to be 19, 10, and 8 Bq/kg dry weight in common hors mackerel, bluefish and smooth dogfish, respectively (Table 1) (Topcuoğlu et al.,1990). The ^{134}Cs were detected to be below the lower limit detection (< 1 Bq/kg) except bluefish sample. The ^{137}Cs concentrations in common horse mackerel and mullet fish samples were found to be below the lower limit detection in 2000 samples. On the other hand, this radionuclide was found to be 6.4±3.5 Bq/kg dry weight in picarel fish in 2000 (unpublished data).

The similar sized mussels were collected from the same point of the Bosphorus from May 1986 to February 1987. The high level activities found for ^{134}Cs and ^{137}Cs as 141.7 and 289.2 Bq/kg dry weights in soft tissues during May and June 1986, respectively (Table 1) (Topcuoğlu and Van Dowen, 1997). The activity levels are also given both on the counting date and date of Chernobyl in Table 2. These results are also used for determination of depuration rate of ^{137}Cs radionuclides under contaminated field conditions. The depuration kinetic represented by a single component and biological half-life found