RADIOECOLOGICAL RESEARCH OF THE TURKISH MARINE ENVIRONMENT

Sayhan TOPCUOGLU, Deniz KUT, Nurdan GÜNGÖR,
Nur ESEN, Emine ÖLMEZ and Çigdem KIRBASOGLU
TAEK, Çekmece Nuclear Research and Training Cente, P.O. Box 1, Atatürk Airport, 34831,Istanbul, Turkey

ABSTRACT

The monitoring study for determination of radioactivity levels in biotic and abiotic environmental samples is the main subject of the radioecology. In cases where information on potential radiation dose to the seafood-eating population is required, specific edible marine organism in the region that should be selected based on bioindicator criteria. The investigations on the behaviour of the radionuclides in aquatic environment such as biogeochemical and biokinetic studies are other important subjects for radioecological research. The biokinetic results are important component of many radiological dose assesment studies. These kind studies are being made by the Radioecology Laboratory of Çekmece Nuclear Research Center. This paper reports the results of the radioecological monitoring in marine organisms and sediment samples collected from Turkish marine environment. In addition, the kinetic results and K_D values of some radionuclides in biota and sediment samples are also presented.

Monitoring

It is well known that after Chernobyl accident many radionuclides entered to the Turkish marine environment. Following the accident, the fallout radionuclides in the Black Sea and Marmara Sea fish samples were determined every month for three years. The high levels of total activity (iodine-131, ruthenium-106, cesium-134 and cesium-137) in fish samples were found between 37-55 Bq kg^{-1} wet weight during May 1986 (Topcuoglu et al., 1988). The Chernobyl radionuclides were also investigated in mussel, sea snail and macroalgae species collected from the Black Sea and Marmara Sea after the accident. The similar sized mussels were collected from the Rumeli station in the Bosphorus from May 1986 to February 1987. The highest activities found for cesium-134 and cesium-137 are 142 and 289 Bq kg^{-1} dry weight in soft tissues of mussels during June 1986, respectively (Topcuoglu and Van Dowen, 1997). The silver 110m was detected at low levels in sea snail during 1986 and 1987. The strontium-90 activity was found to be below 0.1 Bq kg^{--1} dry weight in all samples (Bulut et al., 1993).

Güven et al., (1990) have not detected rutenium-106, cesium-134 and 137 in macroalgae samples collected from the Black Sea before the Chernobyl accident. Hoever, the cesium-137 was found to be at below detection limit in *Coralina rubens* and *Phyllophora nervosa* at Sile station among the tested algae. On the other hand, the cesium-137 was detected in all macroalgae samples after the accident. The highest activity concentration of cesium-137 was

detected in *Chaetomorpha linum* as 34 Bq kg^{-1} dry weight at Sinop station during July 1986. The activity levels of the rutenium-106, cesium-134 and cesium-137 were reached to a peak value in all algae samples collected soon after the accident in 1986 and were gradually decreased in the samples of 1987 and 1988. The cesium radionuclides in different macroalgae species have also been investigated by Güven et al., (1993) from Marmara and Black Sea stations during the period of 1987-1989. Their result showed that cesium-137 radionuclides was not detected tested a macroalgae species. Similar type of studies for algae species at some staions of the Mediterranean Sea, Black Sea and Bosphorus were carried out during the period of 1989-1995 (Topcuoglu et al, 1993; 1996; 1998; Topcuoglu and Güngör, 1999). The results showed that the eastern Black Sea region was more contaminated than western Black Sea and the effect of the Chernobyl accident was not apparent in Turkish coast of the Mediterranean Sea.

Portakal and Varinlioglu (1992) determined the activity levels of cesium-137 in the Black Sea surface sediment in fluffy layers after Chernobyl accident. The values were within the range of 52 to 234 Bq kg^{-1} dry weight. Varinlioglu et al., (1995) reported the concentrations of cesium-134 and cesium-137 in eastern Black Sea sediment samples in ranges of <1 to 6 and 8.5 to 142 Bq kg^{-1} dry weight, respectively. The lowest concentrations of cesium-137 were reported in western Black Sea in 1993 (Topcuoglu et al., 1995). Cesium-134 and cesium-137 levels reached peak values in Sariyer sediment samples among the Bosphorus stations (Topcuoglu and Güngör, 1999).

During the period of 1997-1998, fish, mussel, sea snail, macroalgae and sediment samples were collected from different stations of Turkish Black Sea coast. The range of the cesium-137 concentration in anchovy fish muscle was found between 4±2 – 10±5 Bq kg^{-1} dry weight. This radionuclide concentration in the whiting fish muscle was found below the lower limit of detection (< 3 Bq kg^{-1}). However, this activity found in shad fish mucle to be 25±10 Bq kg^{-1} dry weight. Cesium-137 activity in soft parts of mussel, sea snail and macroalgae samples were found to be below the lower limit detection. On the other hand, cesium-137 concentration in muscle tissue of the sea snail samples found from 6±2 to 19±7 Bq kg^{-1} dry weight. Cesium-137 in the Black Sea sediment samples were found within the range of 11 – 138 Bq kg^{-1} dry weight. At the same time, the cesium-137 contents increased from Igneada to Persembe and decreased from Persembe to Rize regions. Cesium-137 activity in Marmara Sea sediment samples detected to be within the range of 3 – 17 Bq kg^{-1} in 2000.

Nowadays, the study of natural radionuclides in marine environment has received increasing attention due to the enhanced levels of some natural radionuclides from use of fertilizers, fossil fuel industry, detergent or phosphate industry and use of pesticides. For this reason, we have been working on the determination of polonium-210, lead-210, uranium-235,238, thorium-232 and potassium-40 in biota and sediment samples in the Black Sea and Marmara Sea environments since 1997. The preliminary results showed that the polonium-210 and uranium-238 concentrations in anchovy fish were within the ranges of 94-112 and 68-124 Bq kg^{-1} dry weight, respectively. This result confirms that the dominant contribution of radioactive

contamination in fish comes from natural radionuclides and the contribution of anthropogenic cesium-137 is negligible.

Biokinetic

Recently, radioecological studies in our laboratory have begun to adress the biokinetics of Chernobyl radionuclides beside of the monitoring investigations. In the previous works carried out in the laboratory conditions, americium-241, silver-110m, cesium-134 and cesium-137 were used in mussel, limpet, sea snail and gastropod species (Onat and Topcuoglu, 1999; Onat et al., 1999; Güngör, et al., submitted). In addition, the depuration rates of cesium-137 in mussel and macroalgae species are also investigated under contaminated field conditions after Chernobyl accident (Topcuoglu et al., 1996; Topcuoglu and Van Dowen, 1997). The depuration rates are estimated in terms of biological half-lives.

The biological half-life of cesium-137 in mussels found to be 63 days under field conditions. On the other hand, the biological half-life of cesium-137 in the same organism was found to be 27.1 days in the laboratory experiment. Due to the data obtained on the bioelimination rates of the radionuclide in mussels, it is imposible to compare the results in contaminated field and under laboratory conditions.

The pattern of depuration results represented by a single component for each algae division under field conditions. The biological half-lives of cesium-137 in red (*Phyllophora* nervosa), green (*Chaetomorpha* linum) and brown (*Cystoceira* barbata) algae were found to be 18.5, 21.6 and 29,3 motnhs, respectively.

The bioaccumulation of cesium-137 in macroalgae, polychate, brown shrimp, isopods and fish species was investigated in brackish and sea water conditions. The accumulation rate of cesium-137 in isopods at low salinity regime was increased to be significant. On the other hand, the bioaccumulation rate of the radionuclide of the fish species in the sea water was higher than brackish water (Topcuoglu, in press)

Distribution coefficient (K_D)

The distribution coefficient (K_D) is used to express the exchange of radionuclides between the dissolved and sediment sorbed phases. For this purpose, distribution coefficient and desorption rate of cesium-137 and americium-241 radionuclides were investigated in the Black Sea sediments. The top 4 cm sediment samples were collected near the shore of the stations by using of a Lenz Bottom sampler.

The adsorption rates of the two radionuclides in sediments at the four stations were not found to be significant. For this reason, distribution coefficients were described by one exponencial curves for each radionuclide. The adsorption kinetics of cesium-137 and americium-241 were described by a nonlinear model over the experiment time. K_{Dss} were values calculated to be 500 and 3800 for cesium-137 and americium-241, respectively.

The desorption kinetic for cesium-137 in different Black Sea sediment samples were best described by 3-component exponential models. On the other hand, the desorption rate of americium-241 radionuclide was described by only one component for all sediment samples. The fast components of cesium-137 were characterized by very short desorption half-times and very high flux rates.The long desorption half-time in slow components of the cesium-137 were found identical to be 49.5 d at Sinop and Persembe stations. In contrary, the short desorption rate determined to be 25.7 d in slow component at the Rize sediment. The desorption rate of americium-241 is markedly different from cesium-137 and the desorption amount of americium-241 was 5.17 % at end of 28 d.

REFERENCES

1. **Bulut, M., Topcuoglu, S., Sezginer, N., Sönmez, M.** 1993. Chernobyl radioactivity in sea snail (*Rapana venosa*). Turkish Journal and Nuclear Sciences, **20,** 2, 31-37.
2. **Güngör, N., Tugrul, B., Topcuoglu, S., Güngör, E.** Experimental studies on the biokinetics of ^{134}Cs and ^{241}Am in mussels (*Mitilus galloprovincialis*), (submitted).
3. **Güven, K.C., Plevneli, M. Cevher, E., Topcuoglu, S., Köse, N., Bulut, M., Bayülgen, N.** 1990. The radioactivity level of Black Sea marine algae before and after the Chernobyl accident. Toxicol. Environ. Chem. **27**, 297-302.
4. **Güven, K.C., Topcuoglu, S., Güngör, N.** 1993. Chernobyl radioactivity in algae collected from the Marmara and Black Sea. Turkish Journal and Nuclear Sciences. **20,** 2, 21-31.
5. **Onat, B. and Topcuoglu, S.** 1999. Alaboratory study of Zn and ^{134}Cs depuration by the sea snail (*Rapana venosa*). J. Environ. Radioactivity, **46,** 201-206.
6. **Onat, B., Tugrul, B., Topcuoglu, S.** 1999. The excretion of ^{110m}Ag by a gastropod species (*Natica intricata*). J. Radioanal. Nucl. Chem. **240,** 2, 677-679.
7. **Portakal, S. And Varinlioglu, A.** 1992. Natural and artificial radionuclides in the fluffy layer of the Black Sea surface sediment. Final report of radioactive pollution of the Black Sea 56-57, published by TAEK-ÇNAEM, April 1992.
8. **Topcuoglu, S., Bulut, A.M., Bayülgen, N., Esen, N., Akgün, F., Kut, D., Küçükcezzar, R.** 1988. Radioecological studies in the Black Sea fish after Chernobyl accident. In: I.Urgancioglu (Ed.), First National Medical Physics Meeting, (pp.264-268), Istanbul, 8-9 October, Turkey.
9. **Topcuoglu, S., Kut, D., Esen,N., Güven, K.C., Cevher, E.** 1993. The effect of the Chernobyl on the marine radioactivity level in Akkuyu and Iskenderun Bay of Turkey. Turkish Journal and Nuclear Sciences. **20,** 2, 37-42.

10. **Topcuoglu, S., Kut, D., Esen, N., Küçükcezzar, R.** 1995. Radioactivity and trace element levels in sediments of the Black Sea. Rapport Commision Internationale Mer Méditerranée, **34,** 232.

11. **Topcuoglu, S., Güven, K.C., Küçükcezzar, R., Kut, D., Esen, N.** 1996. The natural depuration rate and concentrations of ^{137}Cs radionuclide in the Black Sea macroalgae. J. Radioanal. Nucl. Chem. **214,** 4, 319-325.

12. **Topcuoglu, S. and Van Dowen, A.M.** 1997. A study on the elimination of ^{137}Cs in mussels under contaminated field and laboratory conditions. Toxicol. Environ. Chem. **58,** 217-222.

13. **Topcuoglu, S., Esen, N., Egilli, E., Güngör, N., Kut, D.** 1998. Trace elements and ^{137}Cs in macroalgae and mussels from the Kilyos in the Black Sea. IAEA-SM/30P, 283-284.

14. **Topcuoglu, S. and Güngör, N.** 1999. Radionuclide concentrations in macroalgae and sediment samples from the Bosphorus. Turkish J. Marine Sciences, **5,** 19-24.

15. Topcuoglu, S. 2000. Bioaccumulation of cesium-137 by biota in different aquatic environment. Chemosphere (in press)

16. Varinlioglu, A., Köse, A., Çevik, U, Kopya, A.I., Altunbas, M., Karal, H. 1995. Levels of natural and artificial radioactivity in sediments in the eastern Black Sea of Turkey. J. Radional. Nucl. Chem. **201,** 1, 31-37.