# BLACK SEA ECOLOGY

## POLLUTION RESEARCH IN TURKEY OF THE MARINE ENVIRONMENT

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Scientific research is leading to answers that can help protect the Black Sea marine environment. Through projects supported by the IAEA and other cooperative channels, countries in the Black Sea region are applying their expertise and capabilities to expand scientific knowledge of chemical and radioactive pollution.

Turkey stands among the countries engaged in studies of the Black Sea, for a number of reasons related to environmental, economic, and health issues. The Black Sea coast length is more than 4000 kilometers, of which 1400 kilometers belongs to Turkey. The country's fish production from the Black Sea is about 454 to 500 thousand tones annually. More than 80% of the fish caught is anchovy, with the remainder mostly horse mackerel, whiting, bonito, blue fish, and other species. The production of sea snails and mussels is about 20 thousand tonnes annually.

Throughout the Black Sea region, the annual fish consumption per adult is approximately 20 kilograms. The protection of human health thus is the first priority in scientific research of pollution in fish and other edible marine organisms. The process of scientific investigation is no straightforward matter, as environmental pollution and any associated health-related impacts are dependent on a variety of mechanisms. To illustrate this fact, some results of tests in Turkey on marine organisms have indicated low levels of a given pollutant. This result does not mean, however, that the organism is environmentally safe, nor is it possible to say that it is a safe product for human consumption without further detailed analysis to determine each type of pollutant.

Our scientific knowledge of pollution problems in the marine environment promises to expand in years ahead. Advances in the integration of biokinetic, ecotoxicology and risk analysis with environmental monitoring studies could make it possible to eventually determine the sensitivity to pollutants of human populations and marine organisms. Such integrated studies are being conducted by the Radioecology Laboratory of Çekmece Nuclear Research and Training Center (ÇNAEM) in Turkey. The Laboratory has gained considerable experience over the years, including through its collaboration since 1970 with the IAEA's Marine Environment Laboratory (MEL) in Monaco. Agency technical cooperation projects and research programmes additionally have benefited the laboratory. This article highlights selected Turkish studies of the Black Sea related to both radioactive and chemical pollution.

Radioactive Pollution. Following the Chernobyl accident in 1986, the fallout radionuclides in Black Sea fish samples were determined weekly and monthly for three years. The fish samples were selected from both the pelagic and benthic species that can become products for human consumption. High levels of total gamma activity (iodine-131, ruthenium-106, caesium-134 and caesium-137) in fish samples were found in the range of 37 to 65 Bq/kg during May 1986. The total radioactivity levels in the fish samples gradually decreased during the first three months. Thereafter, except for caesium-137, radionuclides attributed to the Chernobyl accident were not detected.

The Chernobyl radionuclides were also investigated in mussel, sea snail and macro-algae species after the accident. The highest activities found for caesium-134 and caesium-137 were 142Bq/kg and 289 Bq/kg dry weight in soft tissues of mussels during May and June 1986, respectively. The silver-110m

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radionuclide was detected at low levels in sea snails during 1986 and 1987. Strontium-90 activity was found to be below 0.1 Bq/kg dry weight in all samples. The results showed that the western part of the Black Sea's Turkish region was less contaminated than its eastern part.

Of late, the study of natural radionuclides in the marine environment has received increasing attention. This is due to the finding of enhanced levels of some natural radionuclides from the fossil fuel industry, phosphate industry, oil industry, and the use of fertilizers. CNAEM is engaged in an IAEA research project in this area. Turkish specialists have been working on the determination of anthropogenic radionuclides -- namely, polonium-210, lead-210, uranium-238, thorium-232 and potassium-40 -- in biota and sediment samples from seven stations in the Black Sea since 1997. Studies of anthropogenic caesium-137 also have been conducted.

The preliminary results showed that the uranium-238 and polonium-210 concentrations in anchovy were within the ranges of 38 to 101Bq/kg and 94 to 112 Bq/kg dry weight, respectively. These results confirm that the dominant contribution to radioactive contamination in fish comes from natural radionuclides, and the contribution of anthropogenic caesium-137 (from atmospheric nuclear-weapons testing and the Chernobyl accident) is negligible. *(See table, this page.)*

Biokinetics of americium-241, silver-110m and caesium-137 were also investigated in mussel, limpet, sea snail and macro-algae species in the Black Sea water under laboratory conditions. In addition, caesium-137 in mussel and macro-algae species was investigated under contaminated Black Sea conditions after the Chernobyl accident. The biological half-lives of the caesium-137 in mussel and macro-algae were found to be 63 days and 19 to 29 months, respectively.

These findings follow results of an IAEA coordinated research programme from 1993-96 on the application of tracer techniques in studies of processes and pollution in the Black Sea. The programme showed that concentrations of anthropogenic radionuclides in the Black Sea environment, although considerably higher than in other parts of the world ocean, are such that no significant radiological consequences can be expected for the public.*

Turkey also has been actively engaged in regional and national IAEA Technical Co-operation Projects. One regional project, initiated in 1995 and entitled "Marine Environmental Assessment in the Black Sea Region", involves laboratories in Turkey and five other countries in the region. It assists countries that border the Black Sea to develop regionally coordinated monitoring and emergency response programmes for radionuclides in the marine

**METAL CONCENTRATIONS IN BIOTA AND SEDIMENT SAMPLES FROM THE BLACK SEA, 1997-98**

| Metal | Macro-algae | Mussel | Sea snail | Anchovy fish | Other fish | Sediment |
|---|---|---|---|---|---|---|
| Cadmium | 0.5-2.7 | 1.8-6.4 | 0.4-2.2 | 0.1-0.2 | 0.1-0.2 | 0.6-0.9 |
| Cobalt | <0.05-6.5 | 1.8-2.9 | 0.2-0.3 | 0.2-0.3 | 0.2-0.4 | 5.2-17.2 |
| Chromium | <0.05 | 2.2-7.6 | 0.5-0.6 | 0.3-0.8 | 0.2-0.3 | 22-122 |
| Nickel | 2.3-83.8 | 4.0-4.1 | <0.01 | <0.01 | <0.01 | 2.2-69.1 |
| Zinc | 59-96 | 256-512 | 41-45 | 30-40 | 26-30 | 57-127 |
| Iron | 106-1095 | 355-597 | 27-98 | 37-44 | 30-32 | 2.6-4.9 |
| Manganese | 23-296 | 10.1-22.8 | 1.9-3.5 | 1.8-2.5 | 0.5-0.7 | 354-902 |
| Lead | <0.1-10.8 | 0.3-2.6 | <0.01 | <0.01 | 0.3-1.4 | 11-30 |
| Copper | 3.5-16.5 | 7.3-8.0 | 17-35 | 2.2-2.8 | 1.0-1.3 | 23-75 |

Notes: Concentrations are expressed in microgram per gram of dry weight. The macro-algae samples were collected during 1994-95.

**RADIONUCLIDE CONCENTRATIONS IN BIOTA AND SEDIMENT SAMPLES FROM THE TURKISH SECTOR OF THE BLACK SEA, 1997-98**
**(IN BECQUEREL PER KILOGRAM OF DRY WEIGHT)**

| | Polonium-210 | Uranium-238 | Thorium-232 | Caesium-137 |
|---|---|---|---|---|
| Macroalgae | 9-55 | <13-744 | <7-305 | <3-25 |
| Mussel (soft part) | 100-162 | 140-240 | <7 | <3-20 |
| Sea snail (soft part) | 76-141 | 31-179 | <7 | <3-22 |
| Anchovy fish | 94-112 | 38-101 | <7 | <3-10 |
| Other fish species | 2-7 | <13-198 | <7 | <3-25 |
| Sediment | 5-216 | <13-63 | 12-36 | <3-138 |

**See "A Sea of Changing Fortunes, Sustaining Development in the Black Sea Region", IAEA Bulletin, Vol. 40, No. 3 (1998).*

environment, and to assess key processes controlling the fate of contaminants in the Black Sea by using radioactive tracers.

A national technical cooperation project in Turkey approved in 1997 is directed at the application of nuclear techniques for lake and marine pollution studies. Studies investigated pollution of the Küçükçekmece lake region. Scientists are studying the sedimentation rate in the brackish lake environment. Plans are to apply the sediment trap study for radioactivity analysis in sedimentation material in the Turkish Black Sea coastal environment.

Chemical Pollution. Metals are introduced via rivers or direct discharge of industrial wastes into the Black Sea. In addition, levels of heavy metals in the Black Sea are increased by oil pollution and airborne contaminants. Moreover, the western Black Sea has been polluted by chemical wastes in barrels dumped irresponsibly in the past by foreign ships.

In one study, the concentrations of many elements in airborne particles were found to be a factor of two higher in the western part of the Black Sea compared to corresponding concentrations in the eastern part. This study also showed that Europe is the dominant source of anthropogenic metals in the Black Sea atmosphere.

Despite rising concerns over the Black Sea's pollution with metals, no systematic data are available in the region for evaluation or forming a database. To overcome this deficiency, ÇNAEM and the Marine Science Institute of Istanbul University have started a collaborative study on the metal levels of the Black Sea marine environment since 1988.The aim of the project is to determine systematically the concentration of metals in macro-algae and sediment samples, and to consider seasonal and sampling site variability.

At the same time, studies have determined metal concentrations in various fish species from the Black Sea during the period of 1987-89. The results showed that the metal concentrations in macro-algae have gradually increased in Turkish coastal waters of the Black Sea during the years investigated. On the other hand, the metal levels in Black Sea fish have not changed during the past ten years. In the aquatic environment, many metals are generally bound to particulate materials and the rates of deposition are relatively rapid. For this reason, analyses of sediment have considerable value as indicators of contamination levels. *(See table, page 13.)*

The most important contaminants in the Turkish Black Sea marine environment are petroleum hydrocarbons. Oil pollution was the main cause of the ecological degradation observed during the period of 1970 and 1995 in the western Black Sea. Oil fractions or crude oils entered the Black Sea from spills and discharges related to marine transportation, municipal releases, river run-off and tanker ballast. As a result, many sea gulls and other bird species died.

At the same time, it is well known that petroleum hydrocarbons can adversely affect marine organisms. Specifically, oil products at low concentration can inhibit growth and cell division of phytoplankton algae. At high concentrations they can cause a decrease of cell division, the photosynthetic rate and death of the algae. For these reasons, a food chain (phytoplankton-zooplankton-anchovy fish) in the Black Sea was severely degraded by 1995. However, this food chain has gradually recovered after preventive measures were enforced by the Turkish Coast Guard for discharging ballast and bilge waters from ships.

Concentrations of pesticides are generally higher in the eastern Black Sea region than the western Black Sea. This is attributed to pesticide applications in widely diverse habitats, including agricultural croplands and tea and hazelnut plantations. In one study, the pesticide residues were determined in various Black Sea fish during the period 1974-75. Pesticides analyses now will be carried out in fish, sea snails and mussel species collected from different stations in the Black Sea during the period 1997-99.

The concentrations of ammonia nitrogen, ortho-phosphate and anionic detergent were determined in different stations of the Black Sea in 1997 and 1998. The results generally indicate that the Turkish Black Sea coast is not eutrophic. On the other hand, the rate of eutrophication is gradually increasing at industrial hot spots near sewage discharges. Studies further show that microbial pollution is related to discharges of urban waste waters. ❐