Radioecological research of the Black Sea: Report from Romania

Marine scientists in Romania are involved in a range of national and international projects for monitoring the marine environment

by Alexandru Bologa

A semi-closed tideless basin bordering six countries, the Black Sea is considered a "unicum hydrobiologicum" because of its physical, chemical, and biological peculiarities. Unlike any other sea, the Black Sea is permanently deficient in oxygen, or anoxic, below a depth of 150-200 meters.

The Sea's radioactivity levels have been the subject of rigorous research in the riparian countries and among organizations participating in various international oceanographical cruises. After the Chernobyl accident in 1986, interest in radioecological research of the Black Sea increased in Romania, as it did in a number of other countries. Studies have included both radioactivity surveys on abiotic and biotic compounds and experiments on the biokinetics of radionuclides in the marine environment.

In Romania, such work has carried particular importance. The need for monitoring radioactivity levels is mainly explained by the continuing existence of fallout, by the Danube river's presence, and by the prospects for nuclear energy's use in electricity generation. The Danube is the main collector of radioactive wastes from seven riparian countries before flowing into the Black Sea; this important river flow (80% of the total input of fresh water to the Sea) could contribute to radiocontamination of the marine ecosystem as well. The utilization of nuclear energy in the future, following the completion of the nuclear power plant at Cernavoda in Romania, will be — despite all assurances — another possible source of radioactive wastes having an impact on the environment.

This article highlights Romanian research of the marine environment in the Black Sea, and the country's participation in related regional and international projects.

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National research activities

Studies of radioactivity in some environmental components in the Romanian sector of the Black Sea have been carried out sporadically in various laboratories since 1962. Beginning in 1978, the Romanian Marine Research Institute (RMRI) initiated the country's systematic study of marine radioactivity using a network of permanent stations located between the Danube mouths, the southern extremity of the Romanian littoral, and occasionally offshore up to 90 nautical miles. Up to 1983, the work was carried out with the Fundeni Hospital/Laboratory of Radiobiology, and then in close co-operation with the Institute of Meteorology and Hydrology/Research Laboratory of Environmental Radioactivity. The monitoring programme has resulted in a fairly extensive database covering more than 10 years.

The monitoring is being done for a number of reasons. One objective is to define the levels of radioactivity in the marine environment as a baseline before the new nuclear power plant starts operation. Another objective is the identification of bioindicators for studying radiocontamination of the marine ecosystem, and experimentally determining possible levels of accumulation of critical radionuclides in marine biota and biological systems having direct or indirect influences on the environment and human health.

The main research tasks include completion of the database on marine radioactivity levels. Data will be used for a systematic study of distribution coefficients for marine sediments and seawater and of concentration factors for the relevant local species. Assessments also are being made of external and internal individual and collective doses from marine radioactivity due to immersion in seawater and/or food consumption.

Samples of sediments, seawater, and biota (macrophytes, mollusks, benthic and pelagic

fish) have been continuously collected, at monthly, quarterly, and semi-annual intervals. For all seawater samples, some physical-chemical parameters such as temperature, salinity, pH, and O_2 concentration were also measured. From this work, researchers were able to determine the gross beta activity, the gamma radioactivity of sediment, seawater, and biota, the distribution coefficients of some radionuclides between seawater and sediment, and the concentration factors in marine biota.

The studies revealed significant radionuclide concentration factors for the uranium-radium and thorium series in some seaweeds. They further found fission product concentrations (originating from earlier atmospheric nuclear tests and post-Chernobyl environmental contamination) in different non-living and living marine components.

Given their importance, special attention was paid to caesium-134 and caesium-137, for which international organizations established maximum permissible limits for food products following the Chernobyl accident in 1986. Romanian studies thus particularly focused on computing the concentration of caesium-137 for sediment and seawater in the pre-Danubian sector of the Sea.

Environmental concentration factors for caesium-137 for different Black Sea biota were also estimated. In the Romanian Black sea sector, the maximum values of caesium-137 in seawater and fish were found in 1987, in macrophytes and mollusks in 1988, and in sediment in 1990 and 1991.

The isotopic ratio values of caesium-137/caesium-134 in sediments and seawater demonstrated that the Chernobyl accident was a source of radioactive contamination along the Romanian shore. Furthermore, the content of artificial gamma radionuclides there continually decreased in all components (sediment, sea water, biota) compared to 1986. This decrease was more gradual during 1990-91 than it was during the previous year. The relatively slow decrease of caesium-137 concentrations in sediment compared to seawater confirmed the ability of sediments to concentrate radionuclides.

The highest caesium-134 and caesium-137 concentration in edible marine biota (fish, mollusks) in this sector ranged below the maximum permissible level allowed for food by the United Nations Food and Agriculture Organization (FAO) in 1987 and the following years.

Analysis of the data that continue to be recorded on gamma radioactivity in the Romanian marine sector suggest the need for further surveys and monitoring of critical radionuclides in the Black Sea. The work will help in understanding the biogeochemical cycling of radionuclides and their radiological significance for human health.

The concentration factors for iron-54, cobalt-60, zinc-65, strontium-85 and strontium-89, iodine-131 and/or caesium-134 were experimentally derived for biota from the Romanian Black Sea littoral ecosystem. These biota proved to be potential bioindicators for marine pollution caused by one or several of these radionuclides: *Enteromorpha linza* for iron-59 and zinc-65, *Cystoseira barbata* for strontium-89 and iodine-131, *Mytilus galloprovincialis* and *Mya arenaria* for iron-59 and zinc-65. Low CFs are typical in the three bivalves for cobalt-60 contamination.

International involvement

In spite of extremely unfavourable conditions in Romania for maintaining international contacts especially during the last decade, the RMRI has kept close relationships with the IAEA in areas of marine science. Between 1987-92, the RMRI carried out work under an IAEA research contract on the monitoring of marine water, sediment, and biota radioactivity in samples from the Romanian sector of the Black Sea by means of gamma spectrometry. This contract enabled the international distribution of results on the concentration of some natural and artificial radionuclides in abiotic (sediment, seawater) and biotic (seaweeds, mollusks, fish) components from the western Black Sea.

In all samples that were collected, caesium-137 and, in most of them, caesium-134 persisted from 1987 until 1992. Thus, for example, it was possible to track the temporal changes in concentrations of caesium-137. *(See table.)*

Certain results from this work also contributed to Romania's participation in a co-ordinated research programme of the IAEA's Marine Environment Laboratory (IAEA-MEL)

Concentrations of caesium-137 in environmental samples from the Romanian sector of the Black Sea

	1987	1988	1989	1990	1991	1992
Emerged sediment	18.9	11.5	15.5	13.3	21.5	10.7
Submerged sediment	247 0	25.2	—	55.0	24.2	—
Seawater	0.13	0.10	0.09	0.07	0.08	0.06
Macrophytes	4.6	7.1	5.2	3.4	1.9	1.4
Mollusks	3.2	3.3	2.8	1.3	1.5	1.2
Fish	11.0	4.3	5.1	4 0	3.9	3 5

Notes: Values for sediment are expressed in becquerel per kilogram, dry; values for seawater are in becquerel per litre, and values for macrophytes, mollusks, and fish are expressed in becquerel per kilogram of fresh weight.

in Monaco. This programme focused on sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity. Data from Romania's monitoring of the annual concentrations of gamma emitting radionuclides in seawater and edible marine biota were used in this programme for external and internal individual and collective dose assessment arising from immersion in seawater and/or fish consumption in the Black Sea. Total external doses of no more than 2.5 micro-sievert per year (whole body) and 93.6 micro-sievert per year (skin) were received by seawater immersion (for 100 hours) in 1986. In 1987 and 1988, the corresponding values were one order of magnitude lower. Internal doses were estimated by direct and indirect methods; all internal doses were below IAEA recommended dose limits.

Romania also is involved with a number of regional and international programmes. They include the Global Inventory on Radioactivity in the Mediterranean Sea (GIRMED) of the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEM). It was launched in 1988 and includes research on the Black Sea. Additionally, Romania is working with the Co-operative Marine Science Programme for the Black Sea (CoMSBlack), which was formed in 1991 as a non-governmental organization. Since all Black Sea riparian countries have a national programme of some magnitude, one major goal of CoMSBlack is to co-ordinate, where needed, these projects in order to stretch limited resources and to create common standards for such research. From this regional perspective, CoMSBlack will be able to design more effective monitoring arrays, with participation from all Black Sea countries without concern for maritime boundary restrictions.

Within the framework of this programme, Romanian marine scientists from RMRI participated in a research cruise in August 1992 aboard the R/V *Professor Vodyanitsky*. The cruise in the northwestern Black Sea was organized by the Institute of Biology of Southern Seas in Sevastopol, Ukraine; the Woods Hole Oceanographic Institution in the United States; and the US Environmental Protection Agency. The main objective was to conduct oceanographic and radioecological studies in the northwest Black Sea off the Dnieper and the Danube mouths. Researchers investigated the runoff of these rivers, the vertical migration of radionuclides, and the accumulation of long-lived radionuclides (mainly strontium-90 and caesium-137) in sediments and biota. Special attention was paid to intercalibration exercises between participating laboratories concerning the measurement of these radionuclides in sediment and water samples. Technical assistance and training were also provided.

Tracer techniques in Black Sea studies

The RMRI further is working with IAEA-MEL under a research programme addressing the application of tracer techniques in the study of processes and pollution in the Black Sea. The programme's scientific scope is to improve the general understanding of circulation in the Black Sea and of the various physical, chemical, and biological processes which influence the transport and fate of contaminants. It will also investigate how the measurement of environmental isotopes can be used to assess the sources, trends, and impacts of marine pollution in the Black Sea environment.

Nuclear techniques offer a unique method for studying physical circulation of water masses, for providing information on transport dynamics, and for monitoring environmental change. A range of radioactive tracers having different half-lives, chemical reactivities, and source functions are being incorporated in the work. Several different types of chemical tracers will be measured according to the availability of suitable instrumentation/expertise. Typical examples of chemical tracers that could be used in the Black Sea might include Chernobyl-derived radionuclides, naturally occurring uranium and thorium decay-series radionuclides, stable isotopes of carbon, hydrogen, and oxygen, chemical analogues of transuranic elements (e.g. rare earth elements), and other novel chemical tracers. The resultant data will provide a timeframe for assessing, modelling, and predicting the impact of marine pollution in the Black Sea. It will therefore form a basis for improving regional environmental management.

Such results could also be used within the framework of the planned international programme on Environmental Management and Protection of the Black Sea. The programme is under the auspices of the Global Environment Facility initiated by the United Nations Environment Programme, United Nations Development Programme, and the World Bank during a symposium held in Constantza, Romania, in 1992. It is intended to support analyses and activities within the framework of the integral management of the coastal zone, making direct reference to nature conservation, protection of human health, agriculture, fishing, and tourism.

For Romania, and other riparian countries of the region, the project will add an important element to marine research of the Black Sea. ❐