Distribution of artificial radiocontamination in the Northern and Middle Adriatic Sea (1989-1990)

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Radioactive fallout from the Chernobyl accident offers an opportunity to study physical-chemical and biological processes influencing the transport of surface-introduced contaminants in the marine environment (1). The direct impact of Chernobyl fallout on the Mediterranean Sea has been investigated in the past by several authors (1, 2, 3). All sampling has been conducted during seasonal oceanographic cruises executed within the ASCOP (Adriatic Scientific Cooperative Programme) and NADEX (Northern Adriatic Delta Experiment) programmes on fixed stations bordering both the Italian and Yugoslavian territorial waters. The ASCOP 13, 14, 15, 16 and NADEX cruises have been managed by mixed Italian and Croatian researchers on board the Italian vessels BANNOCK and LO BIANCO, owned by the National Research Council, and on the Croatian ship VILA VELEBITA, owned by the Ruder Boskovic Institute for Marine Research.

The results highlight the distribution of cesium radio-isotopes in different abiotic comparts and at different levels of the trophic web, and allow making a complete assessment of the Chernobyl-derived radiocontamination after four years of intense and extended monitoring of the Adriatic ecosystem.

Methods

Sampling methodologies and radio-analytical techniques are reported in detail in papers published elsewhere (3, 4, 5).

Results and discussion

Ranges of concentrations of Cs-137 and Cs-134 are reported in Table 1. Sea water samples (25, 50 or 100 l) show a progressive decrease of activities over time due mainly to the high dilution capacity of the water mass and its hydrodynamic properties. It is noteworthy that concentrations very similar to pre-Chernobyl values (6) have been detected since August 1989 and those concerning Cs-134 during the same period are lower than the detection limits. A single exception was noted at St. 108 in August 1989 which showed slightly higher activity of Cs-137 (8.44±1.41 Bq/1000 l) at 15-30 meter depth, probably a result of the strong influence of the current approaching from the Po delta rich in contaminated silt and organic particles.

Cs-137 and Cs-134 concentrations measured in mixed plankton samples reflected the same kind of decrease demonstrated for sea water. This is a result of the short life cycle of the planktonic organisms and by their concomitant rapid element times. Nevertheless, it is noteworthy that Cs-137 trends in mixed plankton are correlated with the biomass present, i.e., higher concentrations have been detected in samples collected during periods of high production.

Activities in benthic macrofauna are higher than pre-Chernobyl values in all samples analyzed. Even radiocesium concentrations detected in filter feeders such as *Chlamys* and *Pinna* are higher than those measured in *Mytilus* at the time of the Chernobyl accident. Considering this, a comparison between mussels and *Chlamys* indicates a higher general cesium uptake and bioaccumulation in the clam living in deep, soft, muddy substrates where particle availability is great, rather than in the bivalves living at the surface and in intermediate waters.

Since radionuclides are concentrated by physical mechanisms as well as by biological ones, some fine sediments have been examined at two different levels to determine the radiocesium flux in this abiotic compartment. The relative degree of cesium contamination is a reflection of the clay properties of sediments which maintain high concentrations of this radiocontaminant. For this reason, high concentrations of Cs-137 (18.1±0.91 Bq/Kg dry) have been detected even on the June 1990 cruise at stations facing the Po delta (St. 108 and 201) which is very rich in silt, clay and loam. Furthermore, all surface sediments (0-3 cm) collected during the same cruise (June 1990) seem to be more contaminated by Cs-137 than strata at 12-15 cm and less contaminated than those at 3-6 cm. The Cs-134 radio-isotope was last detected in samples collected during the August 1989 cruise, falling below the detection limits in the subsequent ASCOP oceanographic campaigns. During the August 1989 campaign, Cs-134 was measured with activities around 1.19 Bq/Kg dry in the surface and with concentrations ranging between 0.79 and 1.11 Bq/Kg dry in the 3-6 cm stratum. No Cs-134 was detected in the 6-9 cm level. Therefore, the flux of Chernobyl-derived Cs-137 and Cs-134 in August 1989 apparently reached a depth of 5-6 cm in the sediment core due mainly to percolation and sedimentation of the suspended matter sinking from above.

TABLE 1 Ranges of concentrations of Cs-137 (1st line) and Cs-134 (2nd line).

Sample	ASCOP 13 Aug.89	ASCOP 14 Oct./Nov.89	NADEX May 90	ASCOP 15 June 90	ASCOP 16 Aug.90
Unfiltered Sea water (Bq/1000 l)	3.41-8.44 <1.60	4.29-5.67 <1.48	3.36-4.88 <0.64	3.05-3.44 <0.73	No Samples Available
Mixed plankton Surface trawl (Bq/Kg wet)	0.27-0.93 <0.48	0.27-0.35 <0.52	No Samples Available	No Samples Available	0.07 <0.05
Soft bottom Macrofauna (Bq/Kg wet)	0.74-1.23 <0.38	No Samples Available	No Samples Available	No Samples Available	0.70-1.12 <0.22
Sediments 0-3cm Box corer (Bq/Kg dry)	1.86-8.79 1.19	No Samples	No Samples	1.07-18.1 <0.50	No Samples
Sediments 6-15cm (Bq/Kg dry)	1.35-4.85 0.79-1.11	No Samples	No Samples	0.50-8.54 <1.0	No Samples

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