CAESIUM-137 IN MARINE SEDIMENTS OF THE EASTERN MEDITERRANEAN FROM THE PRE-CHERNOBYL AGE TO THE PRESENT

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1. INTRODUCTION

Caesium-137 (half-life 30.2 years) was first introduced into the marine environment as a result of the atmospheric nuclear weapon testing during 1953-1963. The second and largest contamination was the fallout after the Chernobyl accident in April 1986. Since 1986 the radiological status of the Mediterranean has changed. During 1986 the average deposition of 137Cs from the fallout in the Aegean Sea has been estimated to be approximately 4 kBq m⁻², whereas the respective value for the Ionian Sea (the area of 24,300 km² along the coasts) was 2.5 kBq m⁻². The total caesium (137Cs + 134Cs) input from Chernobyl fallout has been estimated to be 2400 Tbg for the Black Sea, 820 Tbg for the Aegean Sea and 600 Tbg in the Ionian Sea (60 Tbg in the zone of 50 km across the coast). Although, the residence time of 137Cs in seawater is long, it has been observed that 137Cs has reached the bottom sediments, as the remaining period is long enough if compared to the estimated sinking time for the Mediterranean environment.

2. THE GREEK MARINE ENVIRONMENT

The Mediterranean Sea is a semi-enclosed marine area, exchanging water, salt, heat and other physicochemical properties through the strait of Gibraltar with the Atlantic Ocean. The basin is characterized by low precipitation and high evaporation, which causes accumulation of contaminants in seawater and sediment. Taking into account the topography, one could note the importance of the eastern part of the Mediterranean, since it comprises a continuous source of interregional input (Black Sea). However, the motive of determining 137Cs in the Greek marine territory was basic research (pre-Chernobyl age) and monitoring reasons (after Chernobyl accident). Several Greek marine systems have been examined throughout these years (FIG. 1) and the results are evaluated in the present study.

3. EXPERIMENTAL

During the period 1984-2007, sediment samples were collected using several corers in oceanographic vessels, fish-boats and/or diving (coastal). Stones, shells and algae were removed from the samples and weight of the remaining sediment was recorded. Then the sample was homogenized and dried overnight at 105 °C until constant weight. After that, the sample was sieved through a 2 mm sieve and the weight of dry sample was recorded. Then the material was homogenized and subsample was taken to obtain the optimal counting geometry.

The measurements of over 70000 sec for each sample were carried out in a high-resolution gamma - spectrometry system, with an HPGe detector of 20 % relative efficiency and computerized multi-channel analyzer of 4000 channel in a total spectrum area of 2000 keV and a resolution of 2.0 keV (at 1.33 MeV photospeak of 137Cs). ORTEC software was used for the analyses of the obtained spectra. The relative statistical error (1σ) did not exceed 18%.

4. RESULTS AND DISCUSSION

4.1 Chernobyl impact in Aegean and Ionian Seas

Time series data obtained before and just after Chernobyl accident are illustrated in FIG. 2. The data of Chernobyl accident in 1986 (FIG. 3) shows the accident is in the deepest layers, while the data of Chernobyl accident in 1999 and 2007 (FIG. 4) shows the impact is in the shallowest layers. The data of Chernobyl accident in 1986 (FIG. 3) shows the accident is in the deeper layers, while the data of Chernobyl accident in 1999 and 2007 (FIG. 4) shows the impact is in the shallowest layers.

4.2 Chernobyl impact in Saroikis Gulf and Cyclades Plateau

Saronikos Gulf is an area not affected by intense washout processes, as it accepts low rainfall supplies and inputs from small rivers and ephemeral streams. For that reason the impact after the accident was limited (FIG. 3). Comparable values were observed in Cyclades Plateau, although there were no previous measurements of 137Cs in the area (FIG. 3).


The data in Thermokais Gulf shows that activity concentrations of 137Cs tend to decrease with time, although some extreme values appeared (increased up to 20 times) (FIG. 4). The data are considered to be 2 times higher than those observed before the accident, even though more than 20 years interceded. 137Cs ranged from below detection limit (LD = 0.05 Bq kg⁻¹) to 6.9 ± 0.6 Bq kg⁻¹ in the Gulf of Patras (FIG. 4), demonstrating that 137Cs tends to background levels. On the other hand, in Nisyros Isl. located in Southeastern Aegean 137Cs seems to be negligible, as all values were below 1.0 Bq kg⁻¹ (FIG. 5). The results were corrected for decay to 25 September 2007.

4.4 Recent measurements in Amvrakikos Gulf

Two campaigns were carried out in Amvrakikos Gulf at 1999 and 2007, respectively; the latter was organized by the IAEA in the frame of the TC Program RER003. All data were corrected for decay to 25 September 2007. 137Cs decreased up to 50 % in surface sediments of Amvrakikos Gulf (FIG. 5). In fact, this is prospective, as earlier studies in the area have shown that Amvrakikos Gulf is characterized by intense sedimentation.

Moreover, two core samples were collected in the entry (A3A) of Amvrakikos Gulf, as well as in the center (13B) and the profiles are shown in FIG. 6. The impact of Chernobyl and nuclear weapon testing processes is apparent at least in one station (13A). Using 137Cs technique, the sedimentation rate in station 13A was estimated to be 0.54 cm y⁻¹. This rate was certified using the 210Pb method estimating 0.95 ± 0.02 cm y⁻¹, indicating the application of 137Cs in sedimentation estimations.

The impact from Chernobyl accident in surface sediments of the Greek territory was more apparent in 1987 in the coastal sediments, as the particulate fraction submerged to the depth. The impact was more intense in enclosed marine systems rather than the open sea. This is an evidence of processes, such as erosion and washout, as well as internal current movements that result in accumulation of pollutants for long time period inside the gulf. Recently, 137Cs concentrations tend to the pre-Chernobyl levels in the open sea. The high concentrations in some enclosed systems are attributed to local phenomena such as the complicated topography and/or enhanced drainage of freshwater systems, rapid sedimentation etc.

Finally, the wide applications of 137Cs as a tracer of marine processes should be noted since it comprises a powerful indicator of current movement, sedimentation etc.