NATURAL RADIONUCLIDES AND ^{137}CS IN MARINE SEDIMENTS FROM TWO GULFS OF CENTRAL GREECE

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Abstract

Natural radionuclides and ^{137}Cs activity concentrations were measured in marine sediments collected from the most representative areas of Patras and Corinth Gulfs. Their regional distributions depend on geological, geochemical and anthropogenic (mining activities) factors.

Keywords : Radionuclides, Sediments.

Introduction - The total amount of radionuclides and ^{137}Cs in the marine sediments depends on many geological, geochemical, biological and anthropogenic factors and processes such as the geology of the surrounding land, mineral composition, content of organic matter, sedimentation rate, resuspension, texture of the sediment, etc. In this paper the ^{238}U, ^{232}Th, ^{226}Ra, ^{40}K and ^{137}Cs specific activities in the marine sediments of Patras and Corinth Gulfs and their possible relation to the above mentioned factors and processes are presented.

Study area - The Gulfs of Patras and Corinth represent a continuous system of WNW-ESE trending basins in the Central Greece. Sampling stations were chosen to cover the most representative areas of the two gulfs as detailed below: (i) Antikyra Bay (ANT): Located at the northern margin of the Gulf of Corinth. This region has been extensively sampled and investigated in previous years [1], as an aluminum processing plant (ALUMINIO HELLAS) discharges bauxitic red mud tailings into this Bay. The discharged red mud tailings have resulted in the formation of a surface layer which covers the seafloor. It should be noted that the bauxites usually contain significant amounts of uranium and thorium as result of their formation. (ii) Galaxidi (GAL) and Kirra (KIR) coastal areas are located at the Itea Bay at the northern margin of the Gulf of Corinth. (iii) Eratini Bay (ERA) and Ag. Pantes (AGP) coastal areas are also situated at the northern margin of the Gulf of Corinth. ERA 5 and 6 sampling points are located in the vicinity of the submarine fan delta of the Eratini seasonal river. (iv) Basin of the Gulf of Corinth (CORBAS): a reference sampling point for background levels which is located at the central basin of the Gulf at a water depth of 850m. (v) Messolonghi Lagoon (MES) is located in the northern coast of the Patras Gulf and constitutes the southernmost part of the Messolonghi-Aetoliko lagoon complex, which is the most extended lagoon system in Greece. This complex is part of the same water course in the drainage basin of the Acheloos and Evinos rivers. The northern part of the drainage basin was heavily contaminated by the Chernobyl fallout. (vi) The Patras harbour (PATH) is located at (in) the southeastern coast of the Gulf of Patras. The Patras harbour due to its vicinity to Patras city (200.000 citizens), is contaminated with respect to harbour and urban activities. (vii) Basin of the Patras Gulf (PATBAS): a reference sampling point for background levels which is located at the basin of the Gulf in a water depth of 95m.

Materials and Methods - Sediments were sampled using a 50x50x50cm box corer, a 3.0 m long gravity corer and a Day grab. The uppermost 2cm of all cores were subjected to a direct γ-ray spectrometry for specific activity measurements of ^{238}U, ^{232}Th, ^{226}Ra, ^{40}K and ^{137}Cs using a HPGe detector.

Results and Discussion - The activities of ^{238}U, ^{232}Th, ^{226}Ra, ^{40}K and ^{137}Cs are shown in Table 1. The ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K obtain low activities in the sediments of the basin of the two gulfs (CORBAS, PATBAS) ranging from 19.7 to 22.5, 21.0 to 34.4, 20.4 to 25.8 and 356 to 698 Bq kg^{-1}, respectively. These activities are comparable to those of the world average as reported by UNSCEAR [2]; (Table 1). In the Gulf of Corinth, the highest measured ^{238}U, ^{232}Th and ^{226}Ra content was detected in the red mud samples and was found to be in the range of 113 - 400, 113 - 412 and 66 - 185 Bq kg^{-1}, respectively (Table 1). On the contrary, the lowest ^{40}K activity was observed in the natural sediments. The high values of ^{238}U, ^{232}Th and ^{226}Ra are out of the range of those cited in literature. Moreover, the observed values of ^{238}U-^{232}Th-^{226}Ra group in the red mud samples represent the maxima of the reported range of values (29-110, 4-106 and 7-159 Bq kg^{-1}, respectively) for the Aegean and Ionian seas [3]. The ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K activities in the sediments of the KIR, GAL, AGP and ERA coastal areas of the Gulf of Corinth ranging from 9.3 to 30.3, 3.7 to 14.8, 4.5 to 12.3 and 23.9 to 306 Bq kg^{-1},respectively (Table 1). These activities are comparable to those of the world average as reported by UNSCEAR [2] (Table 1). The slightly elevated activities observed in the ERA sampling points may be related to the fine texture of the sediments. The ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K activities in the sediments of the Patras Gulf are comparable to those of the world average and are slightly higher than those of the Gulf of Corinth (Table 1). This may be represents the granulometric and mineralogical influence on the element activities. The sediments collected from the Patras Gulf (muds) are finer than those of the Gulf of Corinth (sand to sandy mud). In addition, the sedimentation at the northern margin of the Gulf of Corinth is dominated by the weathering of the limestones, while the sedimentation of the Patras Gulf is controlled by the erosion of Plio-Quaternary sediments. Regarding the anthropogenic radionuclide ^{137}Cs and considering that in the surveyed area there are neither nuclear power plants nor other direct sources, its concentration is only due to the fallout of the reactor accident at the Chernobyl NPP. In the surface layers of the sediments (0-2cm) of the Gulf of Corinth, the ^{137}Cs concentrations varied from between 0.2 to 4.3 Bq kg^{-1} which are comparable to those found in other Greek coastal areas. The activity concentrations of ^{137}Cs in the sediments of Patras Gulf are significant higher (1.8 to 52.0 Bq kg^{-1}) than those of the Gulf of Corinth, due to increased runoff from the drainage areas of the northern margin of the Patras Gulf, which are heavily contaminated by ^{137}Cs [4]. Moreover, the high content of the clay minerals and organic matter found in the sediments of the Patras harbour and the Messolonghi Lagoon play very important role in the high level of ^{137}Cs.

Tab. 1. Specific activities (Bq kg^{-1}dw $\pm$ 1s_{tot}) of^{238}U,^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in marine sediments from Patras and Corinth Gulfs (for abbreviations see text). s_{tot} : the 1 sigma combined uncertainty, *n : number of samples,**UDL: under detection limit.

Sampling Area	n*	Depth	Range	^{238}U	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
PATBAS	1	95 m	-	22.5 ± 5.0	20.4 ± 1.7	34.4 ± 1.5	698 ± 44	16.0 ± 1.3
CORBAS	1	850 m	-	19.7 ± 5.5	25.8 ± 0.6	21.0 ± 0.6	356 ± 14	3.0 ± 0.4
KIR	1	2 m	-	19.1 ± 6.3	11.4 ± 0.9	5.5 ± 0.8	85 ± 7	0.9 ± 0.4
GAL	1	2 m	-	9.3 ± 4.0	4.5 ± 0.7	3.7 ± 0.5	24 ± 5	0.2 ± 0.1
AGP	2	2 m	min max	14.8 ± 5.3 16.8 ± 6.0	6.9 ± 0.7 8.2 ± 1.0	5.3 ± 1.0 6.2 ± 1.0	70± 6 108 ± 8.0	0.7 ± 2.0 0.9 ± 0.4
ERA	2	2 – 3 m	min max	14.8 ± 5.7 30.3 ± 8.9	12.0 ± 0.8 12.3 ± 0.9	14.0 ± 0.9 14.8 ± 1.0	295 ± 7.0 306 ± 10	1.1 ± 0.4 1.6 ± 0.6
MES	6	0.5 – 3 m	min max mean	31.0 ± 6.0 53.0 ± 4.0 (41.2)	UDL** 17.8 ± 0.7 (9.1)	6.4 ± 0.8 26.0 ± 1.0 (19.4)	208 ± 20 608 ± 41 (434)	3.5 ± 0.3 52.0 ± 0.3 (21.1)
PATH	6	7 – 9 m	min max mean	16.1 ± 1.2 33.3 ± 3.7	14.9 ± 0.8 21.8 ± 1.0 (17.5)	15.4 ± 1.5 26.8 ± 2.7 (21.2)	327 ± 16 516 ± 23 (423.6)	1.8 ± 0.3 11.1 ± 1.2 (4.3)
ANT	5	30 – 60 m	min max mean	36.6 ± 7.8 400 ± 28 (127.5)	16.2 ± 0.4 185 ± 9 (60.3)	4.4 ± 0.9 412 ± 5 (112.5)	71.5± 15 406 ± 22 (206.2)	1.5 ± 0.3 4.3 ± 0.5 (2.9)
UNSCEAR	-	-	-	10 - 50	-	7 - 50	100 - 700	-

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