210PO CONCENTRATION IN WATERS AND SEDIMENTS OF THE BLACK SEA

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Abstract

The activities of dissolved and particulate ^{210}Po in the water and in the surface sediment samples from the Black Sea were determined. In all the water samples collected from 4-m depth, the dissolved ^{210}Po activities are less than those of the particulate ^{210}Po activities, showing the particle-reactive nature of Po. In a 100-m deep water sample from central part of the western Black Sea, however, the dissolved ^{210}Po activity is 6 times more than that of the particulate ^{210}Po activity. Moreover in this deep-water sample, the dissolved and especially the particulate ^{210}Po activities are several times lower than those in the surface water at the same station, strongly suggesting a redox control on the partitioning of the ^{210}Po between particulate matter and water. This result, together with a high ^{210}Po activity of 1930 Bq/kg DW in the surface sediment in this location, implies that ^{210}Po is being effectively transferred from the water column to the surface sediments under the cyclonic gyres.

Key-words: Black Sea, ^{210}Po activity, Water; Suspended solids; Sediment

The Black Sea is a semi-isolated sea subjected to various types of pollution, including heavy metals, artificial and natural radionuclides, pesticides, fertilisers and other organic pollutants. It has a layered water column, consisting of brackish (~18 ‰), oxic surface waters and anoxic H_2S-rich, more saline deep waters (~22.5 ‰) separated by a 100-150 m deep pycnocline (Fig. 1). Near and at the pycnocline is a few tens of metres-thick suboxic zone, which is the location of important redox and biogeochemical reactions (1). The water circulation in the Black Sea is characterised by a cyclonic boundary (rim) current which encloses two main cells (gyres) over the eastern and western deep basins (2) Natural radionuclides of various sources contributing to the total radioactivity have recently received increasing attention in aquatic environments. ^{210}Po is one of these natural radionuclides which is derived mainly from phosphate fertilizers, The main product of phosphate fertilizer industry is phosphogypsum. This product is produced during the wet phosphoric acid process from the raw material phosphate rock, which is enriched in various trace elements, rare-earth elements and certain naturally occurring radionuclides, including ^{210}Po. The activity of ^{210}Po in the phosphogypsum originates mainly within the ^{238}U and ^{232}Th decay series. Previous work on ^{210}Po in the Black Sea is very limited (3). The present work involves study of ^{210}Po distribution in water and surface sediment samples collected during a IAEA cruise between 21 September-15 October 2000 (Fig. 1). The water samples were collected from 4 m depth, except at Station 37, where a water sample was also recovered from 100 m depth. Water samples were analysed for both dissolved (<0.45 mm) and particulate ^{210}Po (>0.45 mm).

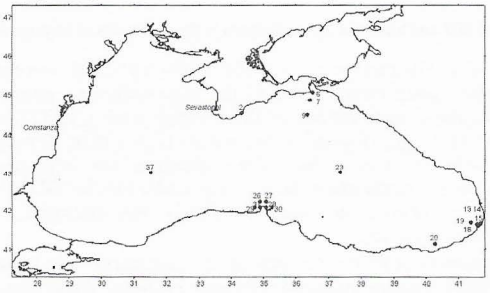

Fig. 1. Map showing the water and sediment sampling stations.

Results and discussion

The activities of dissolved and particulate ^{210}Po in the water samples recovered from the various stations are given in Table 1. In all the water samples collected from the surface euphotic zone, the activities of dissolved ^{210}Po are less than those of the particulate ^{210}Po, showing the particle-reactive nature of Po. In the 100-m deep-water sample from Station 37, however, the activity of the dissolved ^{210}Po is about 6 times that of the suspended solids. Moreover in this deep water sample, the dissolved and particulate ^{210}Po activities are about 2.7- and 24.5 times lower than those in the upper water layers at the same station. This strongly suggests that the deep-water sample is from the suboxic zone which appears to have imposed a redox control on the partitioning of the ^{210}Po between particulate matter and water. (4). It seems that ^{210}Po bound to different types of organic and inorganic suspended particulate matter is mobilised under reducing conditions, and again quickly transferred from this zone to the sediment by adsorption and particle-particle interactions (5,6). The rapid influx of ^{210}Po to the sediment appears to be especially more effective under the eastern gyre, as evidenced by highest level of ^{210}Po activity in the surface sediment sample from this area (Table. 2). This tentative conclusion needs further investigation with more detailed sampling and ^{210}Po analysis of the water column and surface sediments in the central part of the eastern and western Black Sea deep basins.

Table 1: Dissolved and particulate ^{210}Po contents in sea water samples.

Station no	Dissolved (Bq/m3)	(Bq/m3)
2	357±36	370±32
6	224±18	413±34
13	525±43	607±54
14	231±28	-
15	214±53	414±35
20	203±28	426±38
23	157±12	-
26	190±29	299±22
27	176±43	254±23
28	159±26	404±30
31	222±26	231±25
37s	315±37	472±27
37b	118±40	19±20

Table 2: ^{210}Po contents in surface sediments.

Station name	Act. ± 1σ	Depth (m)
2 (0-1 cm)	129±88	33
7 (0-1 cm)	205±1	38
9 (0-1 cm)	748±40	611
14 (0-1 cm)	39±4	12
15 (0-1 cm)	51±7	14,8
18 (0-1 cm)	87±7	71
19 (0.0-0.5)	294±19	860
19 (0.5-1.0)	244±16	860
20 (0.0-0.5)	594±31	1530
20 (0.5-1.0)	262±31	1530
23 (0.0-0.5)	1931±98	2168
23 (0.5-1.0)	1780±299	2168
26 (0-1 cm)	381±29	71
27 (0-1 cm)	237±16	57
29 (0.0-0.5)	301±18	91
29 (0.5-1.0)	195±13	91
30 (0.0-0.5)	137±13	54
30 (0.5-1.0)	164±15	54
31 (0.0-0.5)	242±13	69,5
31 (0.5-1.0)	273±17	69,5

The ^{210}Po activities in the bottom sediments range from 39 to 1930 Bq/kg DW (dry weight), with the highest activity being at Station 23 under the eastern Black Sea gyre. The low values were determined in the samples from Stations BS14, BS15 and BS18 located near mouth of the Çoruh River. The activity levels of these stations are 39.3, 51.3 and 87.1 Bq/kg DW, respectively.

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