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Short communication

Assessment of ^{210}Po and ^{210}Pb in marine biota of the Mallipattinam ecosystem of Tamil Nadu, India

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ABSTRACT

To provide baseline data on background radiation levels for the future assessment of the impact of nuclear and thermal power stations, a systematic study was carried out in the Mallipattinam ecosystem of Tamil Nadu, India. Mallipattinam is located between the Kudankulam and Kalpakkam nuclear power plants and near to Tuticorin thermal power plant. Water, sediments, seaweeds, crustaceans, molluscs, and fish were collected to measure the concentrations of ^{210}Po and ^{210}Pb. The concentrations of ^{210}Po and ^{210}Pb in most samples are comparable to values reported worldwide. In fish, the concentrations of ^{210}Po and ^{210}Pb are in the range 16–190 Bq kg^{-1} and 8–153 Bq kg^{-1}, respectively. The concentration factors of ^{210}Po and ^{210}Pb for the biotic components ranges from 10^3 to 10^6.

1. Introduction

Numerous sources of radiation (both natural and man made) can lead to internal and external human exposures. According to Clayton and Bradley (1995), about 18% of the average internal dose to humans is caused by the ingestion of ^{210}Po, along with its precursor ^{210}Pb. Lead-210 forms naturally in sediments and rocks that contain ^{238}U, as well as in the atmosphere as a by-product of radon gas. Within 10 days of its creation from radon, ^{210}Pb falls out of the atmosphere (Pietrzak-Flis and Skowronska-Smolak, 1995; Karali et al., 1996). It accumulates on the surface of the Earth, where it is stored. In general, the concentrations of ^{210}Po and ^{210}Pb are relatively low in meat and milk products, intermediate in vegetables and cereals, and much higher in most marine organisms.

The best known high background radiation area in India is the southwest coast, i.e., Kerala. The southeast coast also has some sparse distribution of high levels of radiation. On the east coast, two nuclear power plants are situated: one is functioning at Kalpakkam, and the other is under construction at Kudankulam. Therefore, a systematic study was undertaken to measure the activity of ^{210}Po and ^{210}Pb in abiotic and biotic components on the east coast. As a continuation of our previous work (Suriyanarayanan et al., 2008), we are now reporting the results from the Mallipattinam ecosystem. The study area, Mallipattinam, is situated in the Palk Strait, about 350 km south of Chennai (Madras). It is a muddy shore that serves as a protective shelter for many invertebrates. Radioactivity studies remain fragmentary at this station, and hence the present investigation was launched to determine the activity of ^{210}Po and ^{210}Pb.

2. Materials and methods

Samples of water, sediment, seaweeds, crustaceans, molluscs and fish were collected and washed thoroughly with distilled water to free them from attached sand/silt. The soft tissues and muscles were separated from the shells, exoskeletons or bones of animals. The wet weights of the samples were recorded, and the samples were then dried in an oven at 110 °C overnight to obtain the dry weights.

2.1. Water

2.1.1. ^{210}Po analysis

Approximately 50 l of water was filtered through Whatman 42 filter paper and acidified with concentrated HCl to pH 1. A Fe^{3+} carrier (500 mg) was added and ^{210}Po was collected on $Fe(OH)_3$ by slow addition of concentrated ammonium hydroxide with rapid stirring until reaching pH 9. Two repeated precipitations were carried out to completely capture ^{210}Po. The precipitate was dissolved in 0.5 N HCl, and ^{210}Po was deposited on both sides of a polished silver planchette by electrochemical deposition. Alpha counting was carried out according to the procedure of Flynn (1968) and Iyengar (1983).

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2.1.2. ^{210}Pb analysis

Water (~100 l) was filtered through Whatman 40 filter paper and passed through $Fe(OH)_3^-$ impregnated acrylic fiber (25 g) packed in a glass column at a flow rate of 50–60 ml/min (Krishnaswamy et al., 1972). After complete passage of the water, the column was rinsed with distilled water and the fiber transferred to a 500 ml beaker containing hot 8 N HCl. The fiber was kept immersed until it was bleached white. The leachate was evaporated to dryness on a hot plate, and the residue was dissolved in 2 M HNO_3 and made up to 50 ml. This solution was then used for the determination of ^{210}Pb via its beta-emitting daughter (Iyengar, 1983; Kamath et al., 1964).

2.2. Sediment and biological materials

Five to twenty grams of dry weight sediment and the biological materials were homogenized and transferred to a 400 ml beaker and repeatedly digested with concentrated HNO_3:H_2O_2 (1:1) oxidizing mixture until a white ash was obtained.

2.2.1. ^{210}Po analysis

The ash was evaporated repeatedly with concentrated HCl to convert the ash into chloride medium. Then the ash was dissolved in 0.5 N HCl, and the ^{210}Po electrochemically deposited on a silver planchette (Suriyanarayanan et al., 2008). The deposition efficiency of ^{210}Po using this method varied from 95 to 100%, with an average efficiency of 98 ± 2%. A Radiation Counting System (ECIL-RCS 4027-A) was used with a ZnS(Ag) detector (ECIL-SP 647-A) having a background of 0.1–0.2 cpm and a counting efficiency of 25–28% for a ^{239}Pu standard source.

2.2.2. ^{210}Pb analysis

One to three grams of ash was leached with 2 N HNO_3, then filtered and made up to 50 ml. Lead-210 determination used the method of Suriyanarayanan et al. (2008). The counting system comprised a gas flow-type GM counter with argon as the counting gas and isopropyl alcohol vapor as the quenching agent. A coincidence–anticoincidence technique was used to reduce the background (Mishra and Kerala Varma, 1963). A 15 cm thick lead shield substantially reduced background. The background was 1.5–2.0 cpm, with a counting efficiency of 40% for ^{40}K β-energy. The sample purity was checked by ^{210}Bi decay over a 120 h period, and the final activity was calculated by applying the necessary corrections for decay, chemical recovery (80 ± 4%), date of sampling, etc. Spiked experimental recoveries on water and biological samples using this method yielded an overall efficiency of 90%.

3. Results and discussion

Table 1 presents the activity concentrations of ^{210}Po and ^{210}Pb in water, sediments, seaweeds, sea grass, crustaceans and molluscs of the Mallipattinam ecosystem. All the ^{210}Po and ^{210}Pb results are expressed in Bq kg^{-1} (Fresh weight) and the compared results are also in same fresh/wet weight basis. In water, our values are lower than the reported values from the nearby coastal water of Mandapam (Somasundaram, 1998), Kalpakkam (Iyengar, 1983), and Point Calimere (Suriyanarayanan et al., 2008). Saito et al. (2003) reported that the ^{210}Pb and ^{210}Po levels in the Cananeia–Iguape Estuary of Brazil vary from 2.1 to 6.2 MBq l^{-1} and from 1.6 to 4.1 MBq l^{-1}, respectively, and attributed this high activity to the presence of phosphatic rocks in that region. Taken together, it is clear that Mallipattinam coastal water does not possess high activity of ^{210}Po and ^{210}Pb.

Table 1
The ^{210}Po and ^{210}Pb activities and concentration factors of biota from the Mallipattinam ecosystem.

Name of samples	Number of samples	Activity (Bq kg^{-1} F W)		Concentration factor[a]	
		^{210}Po	^{210}Pb	^{210}Po	^{210}Pb
Water	12	0.4	0.6	–	–
Sediments	8	4	1	–	–
Seaweeds					
Sargassum wightii	8	26 ± 2	2 ± 1	7×10^4	3×10^3
Grateloupia filicina	8	10 ± 1	2 ± 1	3×10^4	3×10^3
Sea grass					
Cymadocea serrulata	8	11 ± 1	2 ± 1	3×10^4	3×10^3
Crustaceans					
Prawn					
Penaeus indicus	8				
Muscle		119 ± 6	6 ± 1	3×10^5	10×10^3
Exoskeleton		77 ± 4	13 ± 2	2×10^5	2×10^4
Crabs					
Portunus pelagicus	4				
Muscle		265 ± 9	5 ± 1	7×10^5	8×10^3
Exoskeleton		55 ± 2	3 ± 1	1×10^5	8×10^3
Portunus sanguinolentus	4				
Muscle		300 ± 4	3 ± 1	7×10^5	6×10^3
Exoskeleton		96 ± 2	10 ± 2	2×10^5	2×10^5
Ocypoda	4				
Muscle		324 ± 12	3 ± 1	8×10^5	6×10^3
Exoskeleton		90 ± 1	5 ± 1	2×10^4	8×10^3
Molluscs					
Gastropods					
Strombus canarium	8				
Soft tissue		11 ± 2	2 ± 1	3×10^4	3×10^3
Shell		3 ± 1	3 ± 1	8×10^3	6×10^3
Tonna dolium	8				
Soft tissue		132 ± 16	2 ± 1	3×10^5	3×10^3
Shell		4 ± 1	4 ± 1	10×10^3	7×10^3
Cephalopod					
Sepia elliptica	8				
Soft tissue		45 ± 2	27 ± 2	1×10^5	5×10^4
Shell		31 ± 2	31 ± 2	8×10^4	5×10^4
Scapharca inaequivalvis	8				
Soft tissue		225 ± 12	9 ± 3	6×10^5	2×10^4
Shell		4 ± 1	10 ± 1	10×10^3	2×10^4
Gafrarium dispar	8				
Soft tissue		415 ± 23	12 ± 6	1×10^6	2×10^4
Shell		3 ± 1	16 ± 1	7×10^3	3×10^4

[a] Concentration factor = ^{210}Pb activity in biota (Bq kg^{-1} F W)/^{210}Pb activity in water (Bq l^{-1}).