J. Mar. Biol. Ass. India, 48 (2) : 229 - 232, July - December 2006

Note

A radiological survey in the ecosystem of Athangarai Estuary in the Palk Strait

R.Krishnamoorthy[1], A.Sadiq Bukhari[2], M,M Shahul Hameed[2], H.E.Syed Mohamed[2] and P.Shahul Hameed[3]

[1]*Department of Biotechnology, Pavendar Bharathidasan College of Arts and Science, Mathur, Tiruchirapalli – 622 515 Tamilnadu, India. E-mail: drrk_bt@rediffmail.com*

[2]*Post Graduate Department of Zoology, Jamal Mohamed College, Tiruchirapalli. Tamilnadu, India*

[3]*Environmental Research Center, J.J. College of Engg. and Tech. Tiruchirapalli Tamilnadu, India*

Abstract

Measurements of Terrestrial Gamma Radiation, Primordial Radionuclides and Gross Alpha were made in sediment sample collected from Athangarai Estuary (9°20'41.99''N – 78°59'55.92''E) in Palk Strait. Water, sediment and selected biota were subjected to ^{210}Po determination. The Terrestrial Gamma radiation level in the estuary was 9.4± 3.0mR/h. The Primordial radionuclides levels in the estuarine sediment are ^{238}U (0.9 Bq/kg), ^{232}Th (8.45 Bq/kg), ^{40}K (289 Bq/kg). The Gross Alpha level in Athangarai Estuary was 6.4 mBq.g^{-1}. In water, dissolved concentration of ^{210}Po was found to be 1.2 mBq/l and in sediment (6.3 Bq/kg). Sediment samples of six different sizes grain ranging from 50 μm to 900 μm were subjected to analysis. Particles of 900 μm registered activity between 6.9 Bq/kg and 186 Bq/kg. The highest activity of ^{210}Po 6.3 Bq/kg was in the upper layer sediment (0-5cm) and 5.3 Bq/kg at 5-10 cm and 3.8 Bq/kg at 10-15 cm. The ^{210}Po activity in the biota was within the range of 12.3 and 345.8 Bq/kg. The bivalve mollusc *Meretrix casta* of the estuary was identified to concentrate higher level of ^{210}Po in their soft tissues, suggesting that it could be used as a sentinel organism for ^{210}Po in an estuarine system. The significance of the results are discussed.

Ecologists are concerned with the increasing radiation load reaching the environment both from the natural and artificial sources. Ionising radiation has been considered as an environmental hazard since the beginning of life on earth. The major contribution (97.7%) to the radiation exposure for mankind comes from natural sources. These include external sources such as cosmic rays and radiation from primordial radionuclides (^{238}U and ^{232}Th) and their decay products in the environment. In the recent years, there has been an upsurge of interest on the magnitude and variation of exposure of populations to radiation origin.

Polonium-210 is an alpha emitter belonging to natural Uranium-238 series with a half-life of about 138.4 days. The main source of ^{210}Po entering into the environment is the exhalation of ^{222}Rn from the earth crust and its subsequent decay in the atmosphere resulting in ^{210}Po deposition on the earth surface by rainout or fallout (Abe and Abe, 1980). The estuary plays a dominant role in the transport of heavy metals, pesticides and radioactive substances from land to sea through the river. Most investigations on the distribution of natural radionuclides are limited to marine ecosystem and similar work on estuarine system is scanty. The present paper discusses the results of a study on bioaccumulation of ^{210}Po in the abiotic and biotic components of an estuary.

Materials and methods

Athangarai Estuary (9°20'41.99''N – 78°59'55.92''E) is situated in Palk Strait 16 km east of Ramanathapuram (Tamilnadu) in the east coast of India and Vaigai River confluences with Palk Bay through this estuary.

Samples of water, sediment, plants, seaweeds, crustaceans, gastropods, bivalves and fishes were collected from the sampling sites of this estuary. The biological samples were washed thoroughly with distilled water to free them from attached sand/silt. The soft tissue and muscle were separated from the specimens collected. The wet weights of the samples were recorded and then dried in an oven at 110°C overnight to obtain the dry weights.

Primordial radionuclides and terrestrial gamma radiation were measured by Hyper Pure Germanium detector (HPGe) and terrestrial gamma level measurement by Scintillometer respectively.

Polonium-210 was estimated by the standard technique of acid digestion, spontaneous deposition of ^{210}Po from an acid solution on to both sides of a polished silver

disc, and counting in an alpha counting system (Flynn, 1968). Deposition efficiency of ^{210}Po on sea water and biological samples varied from 95 to 100 % with an average efficiency of 98 ± 2%.

Results and discussion

The investigation on the gamma radiation level in Athangarai Estuary was 9.4± 3.0 μR/h. The ^{210}Po concentration in estuary sediment was 6.3 Bq/kg. On reaching water the radioisotopes of biologically essential elements spread rapidly to the sediment and biota. The ^{210}Po rich sediment therefore serves as a vital link in the transfer of ^{210}Po from water to the living systems. The higher ^{210}Po activity in the sediment samples may be attributed to the accumulation of organic debris and particulates which in general are enriched sources of ^{210}Po. The distribution co-efficient (Kd factor) evaluated for sediment was 5.2 x 10^3. This is indicative of high affinity of ^{210}Po to organic and mineral fractions of the sediment as also reported by other investigators (Cherry and Shannon, 1974; Skwarzec, 1988). Attempt was made to study ^{210}Po concentrations in relation to different sediment size and depth (Tables 1 & 2). Sediment samples of six different grain sizes ranging from 50 μm to 900 μm were subjected to analysis. It was observed that each particles of 900 to 200 μm registered activity between 6.9 and 26.2Bq/kg. Higher activity of 186 Bq/kg was in the smallest particle size of 50μm.

The maximum activity was observed in the depth range of 0 to 5 cm and the activity decreased with increasing depth (Table 2). The highest activity of ^{210}Po (6.7 Bq/kg) was in the in the upper layer of the sediment (0-5cm). At Kaiga also the activities of ^{210}Po and ^{210}Pb were higher in the surface soil and decreased with increasing soil depth and remained constant below 20 cm depth (Karunakara *et al.*, 2000)

Table 1. *^{210}Po concentration in different grain size of Athangarai estuarine sediment (n=3)*

Grain Size (μm)	Activity (Bq / kg)
900	6.9 ± 2.9
450	9.5 ± 5.1
300	13.81 ± 5.8
200	26.2 ± 10.3
100	95.1 ± 23.1
50	186 ± 19.1

Table 2. *Depthwise activity of ^{210}Po (Bq/kg) in Athangarai estuarine sediment (n=3)*

	0 – 5 (cm)	5 – 10 (cm)	10 – 15 (cm)
	6.7 ± 2.4	6.1 ± 1.8	4.1 ± 1.3
	6.3 ± 2.1	5.8 ± 1.2	3.9 ± 0.75
	5.9 ± 1.4	4.7 ± 0.95	3.6 ± 0.69
Range	(5.9 – 6.7)	(4.7 – 6.1)	(3.6 – 4.1)
Mean	6.3 ± 1.6	5.3 ± 1.3	3.8 ± 0.91

^{210}Po concentrations in the Athangarai estuarine water was 1.2 mBq/l. (Table 3). The dissolved radionuclide concentrations in the water are similar to those reported by Hameed *et al.* (1995) for the Kaveri river water (1.02 mBq/l). The seaweed *Padina parvulla* (brown algae), *Ulva reticulata, Enteromorpha intestinalis*, (green algae) and *Cymadocea serrulata* (sea grass) registered 12.3 Bq/kg, 18.0 Bq/kg, 15.1 Bq/kg, 15.4 Bq/kg respectively in Athangarai estuary. Among the sea weeds *U. reticulata* (18.0 Bq/kg) showed higher activity than the Athangarai Estuary.

The concentration of ^{210}Po in the muscles and exoskeleton of the shrimp *Fenneropenaeus indicus*, crabs *Scylla serrata* and *Portunus pelagicus*, gastropod

Table 3. *^{210}Po activity and Concentration factor in abiota and aquatic weeds of Athangarai Estuary (n=3)*

Sample	Athangarai Estuary	
	^{210}Po Activity (Bq/kg)	Concentration factor
Water (mBq/l)	1.2 ± 0.5	——
Sediment	6.3 ± 0.6	——
Seaweeds		
Brown algae		
Padina parvulla	12.3 ± 0.3	1.0 x 10^4
Green algae		
Ulva reticulata	18.0 ± 1.5	1.5 x 10^4
Enteromorpha intestinalis	15.1 ± 1.6	1.2 x 10^4
Sea-grass		
Cymadocea serrulata	15.4 ± 0.5	1.2 x 10^4

Potamides palustris (whole), soft tissue and shell of *Strombus canarium* and bivalve *Meretrix casta* of Athangarai Estuary were found to be 112.5 Bq/kg, 90.7 Bq/kg, 40.5 Bq/kg, 18.7 Bq/kg, 72.6 Bq/kg, 10.4 Bq/kg, 279.6 Bq/kg, 51.0 Bq/kg, 13.7 Bq/kg, 345.8 Bq/kg, 45.2 Bq/kg respectively (Table 4).

Among the aquatic organisms the general pattern of accumulation was that ^{210}Po concentrated in soft tissues and muscle to a higher degree (20.8 - 345.8 Bq/kg) than in shells and bones (10.4 - 102.2Bq /kg) in the estuaries. It is well known that benthic fauna show unique characteristic of accumulating radionuclide in their internal compartments by tens of thousand times than those in water through various physiological process (Bernhard and Zattera, 1974). Among the benthic organisms, molluscs in general and mussels and oysters in particular, have been identified as sentinel organisms. The soft tissue of the bivalve mollusc *Meretrix casta* of both the estuaries concentrated higher level of ^{210}Po than the soft tissue of gastropods. The selected gastropods feed chiefly on vegetation whereas bivalves feed on organic particulates which are enriched with ^{210}Po. Based on the accumulation pattern of ^{210}Po in various invertebrates Skwarzec and Falkowski (1988) concluded that accumulation is higher in the soft parts. The results of the present study also confirm this conclusion. The study also provides evidence to suggest that the bivalve *M. casta* could be used as a sentinel organism for ^{210}Po in the estuaries.

The ^{210}Po contents in the muscle and bone of fish of the Athangarai Estuary are presented in Table 5. The concentration of ^{210}Po in fish muscle was in the range from 20.8 Bq/kg to 181.3 Bq/kg and in bone from 12.6 to 102.2 Bq/kg.

Table 4. *^{210}Po activity and concentration factor in crustaceans and molluscs of Athangarai Estuary*

Sample	Athangarai Estuary	
	^{210}Po Activity (Bq/kg)	Concentration factor
Crustaceans		
Shrimp		
Fenneropenaeus indicus		
Muscle	112.5 ± 3.2	9.4 x 10^4
Exoskeleton	90.7 ± 4.5	7.5 x 10^4
Crab		
Scylla serrata		
Muscle	40.5 ± 2.12	3.4 x 10^4
Exoskeleton	18.7 ± 1.5	1.5 x 10^4
Portunus pelagicus		
Muscle	72.6 ± 2.8	6.0 x 10^4
Exoskeleton	10.4 ± 1.1	8.7 x 10^3
Molluscs		
Gastropods		
Potamides palustris		
Whole	279.6 ± 6.4	2.3 x 10^5
Strombus canarium		
Soft tissue	51.0 ± 2.4	4.2 x 10^4
Shell	13.7 ± 1.3	1.1 x 10^4
Bivalves		
Meretrix casta		
Soft tissue	345.8 ± 5.2	2.9 x 10^5
Shell	41.2 ± 2.7	3.4 x 10^4

Table 5. *^{210}Po activity and concentration factor in fishes of Athangarai Estuary (n=3)*

Sample	*^{210}Po Activity (Bq/kg)*	*Concentration factor*
Plankton feeders		
Sardinella longiceps		
Muscle	*181.3 ± 4.2*	*1.5 x 10^5*
Bone	*102.2 ± 2.4*	*8.5 x 10^4*
Chanda lala		
Muscle	*108 ± 4.1*	*9.0 x 10^4*
Bone	*29.1 ± 1.5*	*2.4 x 10^4*
Thryssa malabarica		
Muscle	*88.9 ± 4.4*	*7.3 x 10^4*
Bone	*51.7 ± 1.5*	*4.3 x 10^4*
Carnivores		
Sphyraena barracuda		
Muscle	*83.9 ± 4.3*	*7.0 x 10^4*
Bone	*37.0 ± 2.9*	*3.0 x 10^4*
Tachysurus jella		
Muscle	*20.8 ± 1.1*	*1.7 x 10^4*
Bone	*12.6 ± 0.8*	*1.0 x 10^4*
Muraenesox bagio		
Muscle	*76.5 ± 3.2*	*6.3 x 10^4*
Bone	*32.0 ± 2.3*	*2.7 x 10^4*
Omnivores		
Liza vaigiensis		
Muscle	*44.5 ± 3.2*	*3.7 x 10^4*
Bone	*33.6 ± 2.8*	*2.8 x 10^4*
Scolopsis vosmeri		
Muscle	*30.7 ± 2.5*	*2.5 x 10^4*
Bone	*22.9 ± 2.4*	*1.9 x 10^4*
Rhynchobatus djiddensis		
Muscle	*30.5 ± 2.7*	*2.5 x 10^4*
Bone	*27.8 ± 2.5*	*2.3 x 10^4*

No. of Analyses (n) = 3

Among fish, *S. longiceps* (plankton feeder) showed higher activity in Athangarai. Plankton being minute in size have a greater surface area and hence exhibit higher bioaccumulation of ^{210}Po. Fishes are potentially a significant pathway for transfer of radionuclides to humans. Lower concentration of ^{210}Po in muscle is important in humans who consume mostly the muscle of fish.

The concentration factors (CFs) of ^{210}Po in the biotic components of the estuary were in the following range: seaweeds: 10^3 - 10^4; crustaceans : 10^3 – 10^4 ; molluscs: 10^4 - 10^5 and fish: 10^4 - 10^5

The range of concentration factors were between 10^3 to 10^5. Higher CFs are seen for the soft tissues of molluscs as compared with crustaceans and fish. The order of CFs reported here for the biota agrees with the observations by several authors as indicated by Krishnamoorthy *et al.* (2004). This study provides a database on ^{210}Po concentration in estuarine. ecosystem and in the soft tissues of the animals.

Acknowledgements

The authors thank Dr.M.Sheik Mohamed, Principal, Jamal Mohamed College, Tiruchirappalli for institutional support and Head, Environmental Survey Lab, Kalpakkam for technical support.

References

Abe, M. and S. Abe. 1980. Trends in the chemical state of Polonium-210 in the atmosphere. Natural Radiation Environment III, Vol.1, *Proceedings of an International Symposium,* Houstan, Texas, USA, CONF-7804222, p. 430-438.

Bernhard,M. and A. Zattera. 1974. Major pollutants in the marine environment. *Proceedings of the Second International Congress on Marine Pollution and Marine Waste Disposal,* San Remo, p.195-3000.

Cherry,R.D. and M. Heyraud. 1982. *Science,* 218: 54-56.

Cherry,R.D. and L.V.Shannon. 1974. *Atom. Energy Rev.,* 12, 1 - 45.

Flynn,W.W. 1968. *Anal. Chim. Acta.*, 43 : 221-227.

Hameed, P.S., S.S.N. Somasundaram, K. Shaheed and B. Amanullah. 1995. A Study on Polonium-210 Distribution in Abiotic and Biotic Components of Gulf of Mannar, India. *Proceedings of Fourth National Symposium on Environment,* Madras, India, p. 214-218.

Karunakara, N., D.N.Avadhani, H.M.Mahesh, H.M. Somashekarappa, Y. Narayana and K. Siddappa. 2000. *J. Environ. Radioactivity*, 51: 349-362

Krishnamoorthy, R., H.E.Syed Mohamed, P. Raja, M.M. Shahul Hameed and P. Shahul Hameed. 2004. A study on Polonium-210 distribution in the Koraiyar River Ecosystem, Tiruchirappalli-India *Proc. of 13th National Symp. on Environment,* Shillong, India. p.266-271.

Skwarzec, B. 1988. *J.Environ. Radioactivity*, 8: 1111-118

---------, B. and L. Falkowski. 1988. *ibid.*, 8: 99-109.

Received: 18 November 2006
Accepted: 30 December 2006