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Analysis of Naturally Occurring ^{210}Po in Sediments from Periyakalapattu to Parangipettai Coast of Tamilnadu, India

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Abstract: The natural radionuclide ^{210}Po is widely existing in the terrestrial environments and also presenting in the Earth's crust because of the decay of ^{238}U. The presence of the above mentioned radionuclide in the atmosphere is due to the decay of ^{222}Rn, diffusing from the Earth ground. In the present study, the concentration of natural ^{210}Po in the sediment samples from Periyakalapattu to Parangipettai of East Coast of Tamilnadu, India was measured using Radiation Counting System with an alpha counter of ZnS (Ag) detector. The distribution ranges of ^{210}Po activity in the sediment samples were determined as 2.38±0.33 - 6.62 ± 0.52 Bq kg^{-1} with a mean value of 3.97 ± 0.3 Bq kg^{-1}. The annual committed effective dose of ^{210}Po consumed by the public was estimated. The results obtained from this study were compared with the values of earlier studies carried out in India and other countries and thus the final conclusion was reported.

Keywords: Sediment samples, ^{210}Po, Radioactivity, Public Health.

1 Introduction

Naturally occurring radionuclides, ^{210}Po and ^{210}Pb, are highly radiotoxic members of ^{238}U decay chain.^{210}Pb is a beta emitter with a half-life of 22.3 years whereas ^{210}Po is an alpha emitter with a half-life of 138.4 days. These naturally occurring radionuclides are important because of their contributions to the natural radiation dose and technologically enhanced releases from sources of natural radioactivity. Particularly ^{210}Po dose has focused the attention due to its major contribution regarding background of the natural radiation in the public dietary habit [1].

^{210}Po is ubiquitously distributed in rocks, sea, earth's crust, atmosphere and in natural waters [2]. It has been recently proved from the radiological point of view that public consuming sea foods as dietary habit received doses of natural radionuclides as high as 2 mSv/y from which 75% of doses are attributed to ^{210}Po [3-4]. The concentration of ^{210}Po in edibles of marine organisms is very much higher than that of seawater because of biological re-concentration processes [5].

Naturally the sea foods are consumed widely by the people living in the coastal areas of India, particularly in Tamil Nadu state but the percentage of consumption varies in different places [6]. Generally the peoples in coastal area has limited knowledge regarding the natural radiation persists in their food habits especially in sea foods.

The present work is aimed to measure the activity concentration of ^{210}Po in the sediments from Periyakalapattu to Parangipettai, East Coast of Tamilnadu, India by the radiochemical procedure. The study was used to estimate the intake of ^{210}Po through specific dietary habit of the public and also the annual committed effective dose intake by the local people in the study area.

2 Materials and Methods

2.1 Study Area:

The study area covers from Periyakalpattu (12° 1' 46.6320" N-79° 51' 49.0032" E) to Paringepettai (11° 30' 0.0000" N-79° 46' 0.0012" E) of East coast of Tamil Nadu, India. Fig. 1 shows the location map of the study area. Due

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to the recent development of industries such as offshore oil production, chemical, fertilizer processing plants in this region, the area has more attention to carry out the study of ^{210}Po. Also more than 300 small scale industries are located in this region, have created the interest to do good active research in this industrialized area. The sample location were recorded in terms of Latitudinal and Longitudinal position (degree - minute - second) using handheld Global Positioning System (GPS) (Model: GARMIN GPS- 12) unit. The distance between each location is separated by 10-15 km approximately.

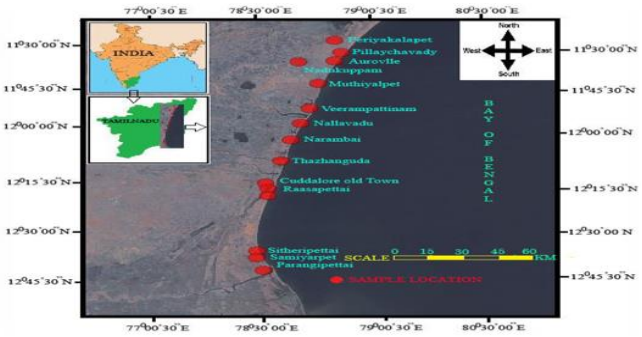

Figure 1. Location map of the study area

2.2 Sample collection

Sediment samples for studying ^{210}Po activity were collected using Peterson grab sampler. The grab sampler collects 10 cm thick bottom sediment layer from the seabed along the 15 different locations from periyakalpattu to parangipettai of East coast of Tamilnadu, India during low tide and pre-monsoon season (Figure. 1). During the pre-monsoon, clear sediment texture and ecological conditions prevailed and also the original activities are predominant only when the sediments were not transported from the river and estuary towards the beach and marine the study area is highly productive rich in marine fauna [7]. Table 1 lists the geographical latitude and longitudinal values of collected samples in the study area. The sediment samples were collected in each location with uniform quantity to ensure the sample collections. The top layer of sediments collected was scooped with plastic spatula which was washed by acid. The purified sediment samples were packed with plastic bags and stored in refrigerator at -4ºC and used as study samples for further analysis [8].

2.3 Sample preparation

The samples were dried for 12 hours in an oven at 105ºC to constant mass. Dry sediment samples were sieved using a stainless steel mesh with the size of <63µm in order to get uniform grain size. This fine fraction of sediment sample was used to carry out the study of natural radionuclide analysis [6].

2.4 Analysis of ^{210}Po

For analyzing the activity of ^{210}Po, the samples were repeatedly digested with concentrated HNO_3 and H_2O_2 until the digestion is complete. The concentrated HCl was added in the specimen to form chloride medium by heating. The digested sample was taken up with 0.5N HCl, filtered through Watman-40 filter paper. This filtrate was subjected to electrochemical deposition on a silver planchette of 2.5 cm diameter, by adding ascorbic acid with constant stirring for 6 hours [9-11]. The Ascorbic acid reduces the ferric ions to ferrous ions thereby ^{210}Po was spontaneously auto-deposited on the rotating silver disc without any interferences. Fig.2 shows the Radiochemical procedure for the determination of ^{210}Po in sediment samples.

Table 1. Characteristics and Geographic coordinates of the sampling sites and Activity concentration of ^{210}Po in sediments

S. No	Name of the Location	Location ID	Latitude	Longitude	Activity concentration (Bq kg^{-1} of Dry Wt.)
1	Periyakalapet	PKP	12° 1' 46.6320" N	79° 51' 49.0032" E	5.03 ± 0.45
2	Auroville	ARV	11°59'2.8422"N	79°50'55.5334"E	5.36 ± 0.49
3	Nadukuppam	NDK	11°58'1.7401"N	79°38'35.5103"E	2.43 ± 0.35
4	Muthialpet	MTP	11° 57' 18.2556" N	79° 50' 4.1712" E	3.64 ± 0.40
5	Nallavadu	NVD	11° 51' 27.6014" N	79°34'27.46"E	5.4 ± 0.46
6	Narambai	NRB	11° 49' 3.2520" N	79° 48' 0.9216" E	2.38 ± 0.33
7	Thazhankuda	TZK	11°46'14.2020"N	79°47'40.5605"E	2.78 ± 0.36
8	Cuddalore OT	COT	11° 45' 0.0000" N	79° 45' 0.0000" E	3.1 ± 0.35
9	Raasapettai	RSP	11° 40' 56.2692" N	79° 46' 17.5008" E	6.62 ± 0.52
10	Betlodai	BLD	11° 21' 45.2300" N	79° 32' 21.8544" E	3.45 ± 0.40
11	Samiyarpettai	SYP	11° 32' 57.2100" N	79° 45' 31.8744" E	3.42 ± 0.38
12	Parangaipettai	PGP	11° 30' 0.0000" N	79° 46' 0.0012" E	4.06 ± 0.42

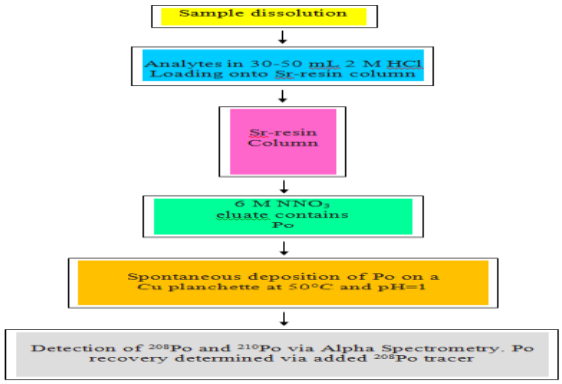

Figure 2. Radiochemical procedure for the determination of ^{210}Po in sediment samples

2.5 Measurement of ^{210}Po concentration

After the spontaneous auto deposition of ^{210}Po on the silver planet, α-activity of ^{210}Po was measured on deposits of silver planchette, using an alpha counter. The silver planchette was counted in PNC-Alpha counter (Electronic Enterprises (India) Pvt. Ltd, Mumbai, India) of ZnS(Ag) detector having an efficiency of 31%. After applying the decay corrections, ^{210}Po concentration in the sediment samples were measured and expressed in Bqkg^{-1}.

2.6 Dietary survey

The dietary habit of the people who are living in the study area was surveyed based on the questionnaire type. The contribution of different dietary sources was calculated from the survey report of the respondents. The results of data would also be used to assess the role of ^{210}Po concentration in the seafood like mussel, fish, prawn, crab and hence the annual committed effective dose was estimated.

2.7 Dose calculation

The annual committed effective dose was estimated based on the dose coefficients as reported in the ICRP publication 72 [12]. For adults the annual committed effective dose of radio nuclides intakes through ingestion and inhalation was calculated by the following method.

Annual effective dose (Sv/year) = A × B × C ----- (1)

Where A is Food consumption (kg/year), B is ^{210}Po concentration (Bqkg^{-1}), C is Annual committed effective dose conversion factor (1.2 × 10^{-6} Sv/Bq) [12].

3 Results and discussion

3.1 ^{210}Po Activity concentration

Table -1 lists the activity concentration of ^{210}Po in the sediments of the study area. The concentration of ^{210}Po is varied from 2.38±0.33 (Narambai) to 6.62±0.52 Bqkg^{-1} (Rosapettai). It is observed that the sediment in the Rosapettai location has higher ^{210}Po concentration. This may be due to the anthropogenic inputs and marine environment from their physical, chemical and geo-chemical properties for enhancement [13-14]. The mean concentration of ^{210}Po was calculated in the present study (3.97 Bqkg^{-1}) and compared with coastal areas of Kanyakumari (2.20 ± 0.3 Bqkg^{-1}) and Nagapattinam (1.9± 0.3Bqkg^{-1}) [6, 15-18]. Fig.3 shows the ^{210}Po activity in the various locations of study area. Table 2 shows the mean concentration of ^{210}Po in edibles and total annual committed effective dose for inhabitants in the study area. The ^{210}Po concentration in the sediment samples of different regions in the world are compared with the present study is reported in Table-3.

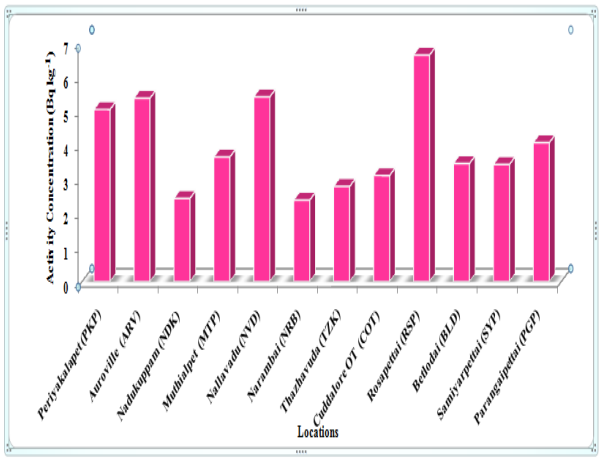

Figure. 3 Location versus Activity concentration of ^{210}Po in sediments.

3.2 Dietary survey and dose calculations

The dietary studies of the local population may reveal the consumption of various edibles which in turn helped to assess the annual committed effective dose. From the dietary survey, it is observed that the seafood especially fish, mussel, prawn and crab comprise a major portion in daily dietary intake and the edibles of plant origin play a minor contributor in the diet of the local people. Among the sea food samples, although the mussel species be available only for a short period (3-4 months in a year), the per capita consumption of mussel by each adult has been found to be about 4.5 kg/year.

The annual committed effective dose was estimated using the equation (1) with edibles and total committed effective dose be 1.90 mSvy^{-1} in the study area. The annual committed effective dose in this study is compared with the value of Kanyakumari coast, Tamilnadu, India showed that it is lower [6]. This study clearly indicating that contribution of ^{210}Po is primarily due to the intake of mussel from sea food.

Table 4 reports the annual committed effective does due to ^{210}Po from different parts of the world. From the analysis, the dose calculations studies are essential for evaluating the dose to humans by the consumption of seafood and providing an additional knowledge about the behavior of radio nuclides. Thus the present study reflects the role of ^{210}Po activity consumed through the intake of mussel and also to estimate the annual committed effective dose.

Table 2. Mean concentration of ^{210}Po in edibles, and total annual committed effective does for inhabitants in the study area.

S. No	Edibles	Intake (kg y^{-1})	^{210}Po Activity (Bq kg^{-1})	Annual committed effective doss rate (mSv y^{-1})
1	Banana	35	0.035 ± 0.01	1.47
2	Guava	3	0.053 ± 0.02	0.1908
3	Curry leaves	7	0.995 ± 0.02	8.358
4	Bitter gourd	1	0.071 ± 0.02	0.0852
5	Bottle gourd	2.3	0.055 ± 0.02	0.1518
6	Tomato	16.5	0.058 ± 0.02	1.1484
7	Papaya	11.25	0.04 ± 0.01	0.54
8	Cassava	25	0.05 ± 0.03	1.5
9	Green Chilli	1	0.13 ± 0.06	0.156
10	Drumstick	8.3	0.041 ± 0.02	0.40836
11	Rice	180.5	0.205 ± 0.04	44.403
12	Coconut	16.5	0.040 ± 0.01	0.792
13	Fish (Lethrinus lentjan)	103.55	1.18 ± 0.10	146.6268
14	Mussel (Perna perna)	3.9	312.00 ± 16.1	1460.16
15	Prawn (Fenneropenaeus indicus)	2.3	51.81 ± 3.1	142.9956
16	Crab (Portinus sanguinolentus)	2.21	36.11 ± 4.3	95.76372
17	Total Annual Committed effective dose			1.904

Table 3.^{210}Po concentration in sediment samples in different regions of the world

S. No	Location	Activity of ^{210}Po (Bq kg^{-1})	Reference
1	Sudan Red Sea Coast (Surface Marine Sediment)	1.6 - 12.5	[19]
2	Ghazaouet Bay Algeria (Surface Marine Sediment)	52 - 118	[20]
3	Surface sediment, Kalluvilai area, Kanyakumari coast, Tamilnadu, South India	2.30 - 0.3	[6]
4	Latakia	17.6	[15]

	Syrian Coast (Surface Marine Sediment)		
5	Mayanur Kaveri River System Tamilnadu India	14.44	[16]
6	IAEA-368 (Pacific Ocean Sediment)	20	[17]
7	Coastal area of Nagapattinam	1.9 ± 0.3	[18]
8	Atlantic Ocean (Africa)	35	[12]
9	Atlantic Ocean (South America)	0.8	
10	Indian Ocean, India	11	
11	Kudankulam Tamilnadu India	78.09	[6]
12	**Present Study**	**2.38-6.62 (3.97)**	-

Table 4. Committed effective does due to ^{210}Po from different locations of the world

S. No	**Location**	**Does (mSv y^{-1})**	**Reference**
1	Kalpakkam, India	0.74 ± 0.153	[10]
2	Kudankulam coast	0.01 - 0.51	[21]
3	Meghalaya, India	0.34	[22]
4	Sudan, Red Sea	0.003 - 0.004	[23]
5	France	0.04 - 0.01	[24]
6	Baltic Sea	0.70	[25]
7	Kanyakumari Coast	2.24	[6]
8	Periyakalapet To Parangipettai	**1.904**	**Present Study**

4 Conclusions

The activity concentration of natural ^{210}Po was measured in the sediment samples from Periyakalapattu to Parangipettai of East coast of Tamilnadu by using Radiation Counting System with an alpha spectrometer. The average activity of ^{210}Po in the sediments of study area is found to be lower than the world average value. The annual committed effective dose was estimated from different sea foods available in the study area, among these spices, it is revealed that especially the mussel has higher contribution of ^{210}Po. Thus this present work in studying the natural radionuclide of ^{210}Po will be used as a baseline for doing further research in many other regions in near future.

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