Environmental radioactivity in Sonadia Island of the Bay of Bengal of Bangladesh

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INTRODUCTION

Sonadia island is a marine resource rich island of Bangladesh, lies about 5 km. off from the main land of Bangladesh towards south. It is situated between $91^{o}55^{/}$E – $21^{o}30^{/}$N in the north-eastern part of the Bay of Bengal. The Sonadia island is an important area of Bangladesh in view of its contribution to the national economy. Sonadia island has been found to be a wealthy source of seaweed's. Fishing in the area is the main economic activities. A considerable number of people for their survival depend on fishing and drying fishes. The present work initiate a environmental radioactivity assessment program for Sonadia island of the Bay of Bengal, with the aim of establishing a baseline map of radioactivity background levels in the island environment. The island presents a variety of physiographic features - sandy beach, sand dunes, a lagoon, marshes, a tumble. Spatial grading of particles as sand, silt and clay was observed. Contents of organic carbon, organic matter and pH in sediments were closely studied in relation to hydrographical changes and attempts were made to describe the textural distribution on the above basis. The northern and southern parts of the upper island were mainly composed of sand particles. The lower regions of island indicated seasonal abundance of sand during monsoons pointing out to bed load movement otherwise this area was predominantly covered by rock fraction.

MATERIALS AND METHODS

Soil and sediment samples were collected from the twelve stations of the island at a depth of 15 cm from the surface by a soil sampler from the island. The collected samples were weighed individually just after collection, placed in plastic sample bags and transported to the laboratory. The soil samples were air-dried then powdered and passed through a 2mm mesh sieve separately and dried in an oven at 105 - 120^{0}C for 48 hours. Samples were weighed, then packed in plastic containers, sealed and kept stand for four weeks to reach secular equilibrium between the ^{226}Ra and ^{232}Th series and most of their respective progeny (Schotzing and Debertin, 1983). Immediately after collection water samples were acidified by adding concentrated hydrochloric acid to prevent adsorption of radionuclides at the container walls (IAEA, 1970). The collected samples were dried at the laboratory to reduce their volume for gamma-spectrometric measurement. The detection and measurement of the radionuclides were carried out by γ-ray spectrometry using 110cm^3 intrinsic p-type coaxial HPGe detector with a relative efficiency of 20% and a resolution of 1.8 keV (FWHM) for the peak of 1332 keV of ^{60}Co. The γ-ray energies of ^{212}Pb (238.63 keV), ^{212}Bi (727.17 keV) and ^{208}Tl (583.2 keV) was used to determine the activity of ^{228}Th and ^{228}Ac (338.4, 911 and 969 keV) was used to determine the activity of ^{228}Ra. The γ-transitions of ^{214}Bi (609.3, 1120.3 and 1764.5 keV) and ^{214}Pb (295.2 and 351.9 keV) were used to determine the activity of ^{226}Ra. The ^{40}K and ^{137}Cs radionuclides were measured from their respective γ-ray energies 1460 and

661.66 keV, respectively (IAEA, 1989; ICRP, 1983). The geometry of the counting samples was the same as that of the standard samples and the counting time for all the samples were 50 ksecs.

RESULTS AND CONCLUSION

The physico-chemical parameters in soil, sediment and water of the Sonadia island are shown in Table-1. The activity concentrations of ^{228}Th, ^{226}Ra, ^{228}Ra and ^{40}K in soil, sediment and water of the island are shown in Table-2 and the outdoor and indoor absorbed dose rate and annual effective dose derived from the activity concentrations of the natural radionuclides are shown in the Table-3. The activity of ^{228}Ra in soil ranged from 26.0 ± 5.2 to 64.4 ± 8.0 Bq.kg^{-1} with a mean activity of 49.8 ± 15.0 Bq.kg^{-1}, ^{228}Th is ranged from 25.0 ± 5.0 to 61.4 ± 7.8 Bq.kg^{-1} with a mean activity of 46.6 ± 14.0 Bq.kg^{-1}, ^{226}Ra is ranged from 24.7 ± 5.0 to 45.3 ± 6.7 Bq.kg^{-1} with a mean activity of 33.4 ± 6.7 Bq.kg^{-1} and ^{40}K is ranged from 625.0 ± 25.0 to 1069 ± 33 Bq.kg^{-1} with a mean activity of 831 ± 140 Bq.kg^{-1}. Anthropogenic ^{137}Cs was not observed in any of the samples. The calculated outdoor absorbed dose rate in air due to natural radionuclides at one meter above the ground surface was observed in the range of 65.04 – 98.91 nGy.y^{-1} and the mean outdoor dose rate of the area was 84.67 ± 9.59 nGy h^{-1}. Considering the indoor contribution is 1.2 times higher than the outdoor dose the indoor dose rate, the calculated range of indoor dose was 78.05 – 118.69 nGy.y^{-1} and the mean outdoor dose rate of the area was 101.60 ± 11.51 nGy h^{-1}, and the total dose from outdoor and indoor was found to be 143 – 217.6 nGy.y^{-1} with a mean dose rate of the area was 186.27 ± 21.10 nGy h^{-1}.

The annual effective dose D_{eff} from outdoor terrestrial gamma-radiation is (UNSCEAR, 1988):

$$D_{eff(O)} = \text{Outdoor dose (nGy.h}^{-1}) \times 0.7 \text{ (Sv.Gy}^{-1}) \times 8{,}760 \text{ (h.y}^{-1}) \times 0.2 \text{ nSv.y}^{-1} \quad ...(3)$$

where 0.2 is the outdoor occupancy factor and 0.7 Sv.Gy^{-1} is the quotient of effective dose rate to absorbed dose rate in air. For indoor exposure, using an occupancy factor of 0.8, the annual effective dose is:

$$D_{eff(I)} = \text{Indoor dose (nGy.h}^{-1}) \times 0.7 \text{ (Sv.Gy}^{-1}) \times 8{,}760 \text{ (h.y}^{-1}) \times 0.8 \text{ nSv.y}^{-1} \quad .....(4)$$

The results of outdoor and indoor dose rates and annual effective doses are shown in Table 3. The outdoor and indoor annual effective doses from terrestrial radiation in the island was found to be in the range of 0.08 – 0.121 mSv and 0.383 – 0.582 mSv respectively with mean of 0.104 and 0.498 mSv. The total (outdoor plus indoor) annual effective dose was found to be 0.602 mSv, the corresponding world average values is 0.41 mSv of which 0.34 mSv from indoor and 0.07 mSv from outdoor (UNSCEAR, 1988). The adjacent areas of the Sonadia island was investigated (Alam *et al.,* 1999; Alam *et al.,* 1997; Alam *et al.,* 1997a), the average activity of ^{40}K in soil of Cox's Bazar area beach was observed 458.23± 30.22 Bq.kg^{-1}, in salt pans soil of Cox's Bazar, Moheshkhali and Chakaria ^{40}K was in the range of 383 ± 35 to 652 ± 66 Bq kg^{-1}, and in sediments of the Karnaphuli estuary varied from 118 ± 20 to 608 ± 76 Bq.kg^{-1}. The activity of ^{226}Ra in sediments of the Karnaphuli river estuary of Bangladesh was observed in the range of 5.87 ± 1.21 - 27.85 ± 1.71 Bq.kg^{-1}, and in Cox's Bazar beach soil was in the range of 10.85 ± 1.64 - 27.33 ± 2.61 Bq.kg^{-1} with an average of 18.89 ± 2.16 Bq.kg^{-1}.

Saint Martin's is the nearest island of Sonadia island, the average dose rate in soil of St. Martin's Island of Bangladesh was observed 6.10 mGy.y^{-1} at one meter above the ground surface (Chowdhury *et al.,* 2004). In soil of St. Martin's Island, the average activity of ^{40}K

was 480 ± 88 Bq.kg^{-1} and the average activity of ^{226}Ra was 23.15 ± 17.8 Bq.kg^{-1}. The activity of ^{228}Ra, ^{228}Th and ^{226}Ra in water of the Sonadia island ranged from 0.90 ± 0.25 - 1.60 ± 1.21, 1.45 ± 1.20 – 1.60 ± 1.20 and 1.80 ± 1.32 – 2.10 ± 1.40 Bq.l^{-1} with mean of 1.25 ± 0.49, 1.53 ± 0.11 and 1.95 ± 0.21 Bq.l^{-1} respectively. The activity of ^{40}K ranged from 5.20 ± 2.20 - 5.70 ± 2.30 Bq.l^{-1} with a mean of 5.45 ± 0.40 Bq.l^{-1}.

Table 1. Physicochemical characteristics of water, soil and sediment of the island.

Parameters	Range	Parameters	Range
Particle characteristics of sediment		Water temp. ^{o}C	21.5 – 22.0
% of sand	96.26 – 99.99	Salinity, ppt	31.52 – 35.49
% of silt	0.004 – 1.765	DO, ml/l	5.51 – 7.14
% of clay	0.004 – 2.039	PO_4, µg/l	0.0127 – 0.038
% of organic carbon	0.054 – 0.586	NO_2, µg/l	0.144 – 0..2496
% of organic matter	0.092 – 1.007	SiO3, µg/l	0.0486 – 0.1946
pH	5.4 – 7.0		

Table 2. Activity concentration of radionuclides in soil and sediment of different location of Sonadia Island of the Bay of Bengal.

Location and sample	^{228}Ra		^{228}Th		^{226}Ra		^{40}K	
	Bq.kg^{-1}							
1. East beach soil	31.0	± 5.6	31.4	± 5.6	30.3	± 5.5	731	± 27
2. Northeast beach soil	26.8	± 5.2	25.0	± 5.0	30.8	± 5.5	1069	± 33
3. Northeast beach soil	63.0	± 7.9	58.0	± 7.6	37.6	± 6.1	924	± 30
4. Middle of mainland soil	64.4	± 8.0	55.0	± 7.4	45.3	± 6.7	855	± 29
5. North midland soil	40.6	± 6.4	34.0	± 5.8	28.5	± 5.3	906	± 30
6. Western side soil	62.0	± 7.9	55.7	± 7.5	31.0	± 5.6	625	± 25
7. Southern midland soil	58.3	± 7.6	52.7	± 7.3	24.7	± 5.0	821	± 29
8. Western side soil	52.8	± 7.3	61.4	± 7.8	38.9	± 6.2	716	± 27
Mean	49.8	±15.0	46.6	±14.0	33.4	±6.7	831	±140
9. West side bay sediment	56.0	± 7.5	52.0	± 7.2	38.0	± 6.2	871	± 30
10. Southern bay sediment	52.0	± 7.2	42.0	± 6.5	36.4	± 6.0	937	± 31
11. North side bay sediment	54.0	± 7.3	62.5	± 7.9	42.0	± 6.5	851	± 29
12. West-north bay sediment	35.2	± 5.9	38.6	± 6.2	35.2	± 5.9	940	± 31
Mean	49.3	±9.54	48.8	±10.8	37.9	±2.96	899	±46
	Bq.l^{-1}							
13. Southeast beach water	0.90	±0.25	1.60	±1.20	1.80	±1.32	5.20	±2.2
14. Northeast beach water	1.60	±1.21	1.45	±1.20	2.10	±1.40	5.70	±2.3
Mean	1.25	±0.49	1.53	±0.11	1.95	±0.21	5.45	±0.4

Table-3. The derived absorbed dose rates and annual effective dose from outdoor and indoor radiation.

Sl.	Absorbed outdoor dose rate	Absorbed indoor dose rate	Total (outdoor + indoor)	Annual effective dose, $D_{eff(Out)}$ from outdoor	Annual effective dose, $D_{eff(in)}$ from indoor	Total Annual effective dose, $D_{eff\ (out+in)}$ from outdoor and indoor
	$nGy.h^{-1}$			mSv		
1	65.04	78.05	143.09	0.080	0.383	0.463
2	77.07	92.49	169.56	0.095	0.454	0.548
3	97.68	117.21	214.89	0.120	0.575	0.695
4	90.45	108.53	198.98	0.111	0.532	0.643
5	90.93	109.11	200.04	0.112	0.535	0.647
6	98.91	118.69	217.61	0.121	0.582	0.704
7	78.19	93.82	172.01	0.096	0.460	0.556
8	90.45	108.53	198.98	0.111	0.532	0.643
9	81.28	97.54	178.82	0.100	0.478	0.578
10	84.61	101.53	186.14	0.104	0.498	0.602
11	82.50	98.99	181.49	0.101	0.486	0.587
12	78.94	94.73	173.67	0.097	0.465	0.562
Mean:	84.67	101.60	186.27	0.104	0.498	0.602
SD:	9.59	11.51	21.10	0.012	0.056	0.068

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