ASSESSMENT OF NATURAL RADIOACTIVITY LEVEL IN SHORE SEDIMENT SAMPLES FROM NASSER LAKE AT ASWAN, EGYPT

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ABSTRACT

Thirty shore sediment samples taken from the side beach of Lake Nasser in south Arab Republic of Egypt to measuring the terrestrial radionuclides radium-226, thorium-232 and potassium-40 and its associated hazard indices. The activity concentration of natural radionuclides ^{226}Ra,^{232}Th and ^{40}k in shore sediments samples under investigation are ranged from 1.92±0.077 to 17.55±0.676 Bqkg^{-1} with average value of 5.02±0.194 Bqkg^{-1}, 5.62±0.281 to 28.77±1.441 Bqkg^{-1} with average value of 13.15±0.641 Bqkg^{-1} and 123.27±10.604 to 277.38±23.861 Bqkg^{-1} with average value of 200.26±17.054 Bqkg^{-1}respectively .The radiation hazard indices which resulting from the presence of natural radionuclides in shore sediment samples were calculated and the obtained results indicate that the values of radium equivalent activity varies from 21.85 to 80.04 Bq/kg with average value of 39.25 Bq/kg, representative level index $I_{\gamma r}$ varies from 0.16 to 0.58 with average value of 0.29.Absorbed dose rate varies from 10.63 to 37.541 nGy.h^{-1} with the average value of 18.83 nGy.h^{-1} . External hazard index Hix varies from 0.059 to 0.216 with average value of 0.105, internal hazard index Hin varies from 0.070 to 0.263 with average value of 0.119, annual outdoor effective dose varied from 0.013 to 0.046 mSvy^{-1} with average values 0.023 mSvy^{-1}andThe indoor effective dose ranged from 0.052 to 0.184 mSvy^{-1}, with average values 0.092 mSvy^{-1}.

KEYWORDS

Activity concentration, NaI (TI), Nasser Lake, Radiation hazards, Shore Sediments

1. INTRODUCTION

There are a lot of sources of radiation in the environment. The activity concentration levels of terrestrial radioactive nuclides which found in air, sediments, water ,building materials and other component of the environment are depending on the properties of the geological, geochemical and geographical of the region under studied and appear at different rates of the world [1, 2, 3,4]. Gamma- ray released from naturally occurring radionuclides, always called terrestrial background radiation, it is responsible for the main external source of exposure to the human body. Human beings are exposed to radiation fundamentally from cosmic radiation and from the gamma ray released in soils, building materials, water, food, and air. Natural radionuclides have basically existed in the environment since the creation of the universe. Nuclides with half-lives equal to the age of the ground or their identical disintegration products like ^{40}K, and the radioactive nuclides which resulting from the decay of the ^{238}U and ^{232}Th series can still be found on earth[5].In our world all people are insecure due to the exposure ofradiation released from natural radioactive materials which found in earth's crust and also from man-made sources [6].Based on that, it is indispensable to survey the levels of terrestrial radionuclides in the various components of the environment to obtain the achievement of comprehensive surveys in any nation. Naturally occurring radionuclides of terrestrial origin are existing in rivers and lakes sediments [7].

Sediment plays a role in piling and transferring contaminants within the geographic region and is considered the environmental host of the waste discharged by natural or man-made processes in our universe. Lakes doing as basin for the materials which pass through the different aquatic chemical and biological circles including radionuclide contaminants. The assessment of natural radioactivity levels in Nasser Lake are gives benefits to continue the program of measuring natural radioactivity in different environmental media in south Egypt started in the Environmental Radioactivity Measurements Laboratory, physics department, Faculty of Science, South Valley University, Qena, Egypt since 1990.[8-12].

1.1. Stay Area

In the 1960's.,a high dam was built on the Nile river at Aswan in Egypt during this time, the water flooded an area in the Nile Valley behind dam estimated at 6,200 m^2 making one of the big man-made lakes in the world (fig. 1) which changed the Egyptian environment[13,14].. This lake was named Lake Nasser and located at the border between Egypt and Sudan between latitudes 21.8 to 24.0°N and Longitudes 31.3 to 33.1°E. The largest surface area and maximum storage capacity of the reservoir are estimated at 600 and 162 km3, respectively [15].Nasser Lake is underlain and surrounded by a wide variety of rocks that include granitoids, gneisses, schists in its southern parts and Nubian sandstones and tertiary and quaternary basalts in the north.

Figure 1. Nasser Lake

2. Material And Methods

2.1. Sample Collection And Preparation

Thirty shore sediment samples taken from the side beach at depth of about 0.5-1 m of Lake Nasser in south Egypt to measuring the terrestrial radionuclides ^{226}Ra,^{232}Th and ^{40}K. Data from Global Positioning System (GPS) will used for tracking the data record in order to obtain a representative sample (Table 1). The masses of the collected samples varied between 0.75 to 1 kgm.. The samples were then drying at 100^{o}C to ensure that moisture is completely removed. The samples were stored in tight containers for 30 days before starting the counting by using gamma spectrometry in order to ensure that the daughter products of ^{226}Ra up to ^{210}Pb and of ^{228}Th up to ^{208}Pb achieve equilibrium with their respective parent radionuclides [16].

2.2. Experimental Setup

To calculate the average concentration of naturally occurring radioactivity in the present study we measured the concentration of ^{226}Ra, ^{232}Th and ^{40}K in shore sediment samples by using gamma- ray spectrometer consisting of a NaI (TI) setup and multichannel analyzer 8192 channel, with the following conditions: resolution (FWHM) at 1.33 MeV ^{60}Co is 60 keV, relative efficiency at 1.33 MeV ^{60}Co is 7.5 %. In order to maintain the detector and reduce the effect of the background radiation, it must be placed in a middle of wall double chamber. The first wall is made of stainless steel with 10 mm thick and the other wall is made of lead with 30 mm thick. After preparation of the samples it was placed above the detector for at least 10 h. To analyse the spectrum we use computer software program Maestro (EG&G ORTEC). Activity concentration of ^{226}Ra in shore sediment samples was analyzed the counts at gamma energies of 295.22, 351.93 keV and 609.31, 1120, 1764.49 keV, emitted from daughter nuclides ^{214}Pb ^{214}Bi respectively. ^{232}Th activity of the sample was determined from the Girondist nuclides (^{228}Ac), (^{212}Pb) and (^{208}Ti) through the intensity of 209.25, 338.32, 911.2 keV Gamma-lines for (^{228}Ac), (^{212}Pb) emissions at 238.63 keV and (^{208}Ti) emissions at 583.19, 2614 keV Gamma-lines. ^{40}K activity determined from the 1460.7 keV emissions Gamma-lines.

2.3. Radioactivity Measurements

Activity concentrations of natural radionuclides in shore sediment samples were calculated by using the following formula [17,18].

$$AS = \frac{Ca}{\eta\ Pr\ Ms}\ \text{Bq / kg} \qquad (1)$$

Where Ca is the net counting of γ-ray (counts per second), η the detector efficiency of specific γ-ray, Pr the absolute transition probability of γ-decay and Ms the mass of the sample in kg.

3. Radiation Hazard Indices

The best indicator for radiation hazard is called radium equivalent activity Raeq [19,20], which is a weighted sum of activities of the three natural radionuclides based on the estimation that 370 Bq/kg of ^{226}Ra, 259 Bq/kg of ^{232}Th and 4810 Bq/kg of ^{40}K produce the same gamma-ray dose rate[21,22]. Raeq was calculated from the next equation [20].

$$Raeq\ (Bq.Kg^{-1}) = ARa + 1.43ATh + 0.077AK \quad (2)$$

Where ARa, ATh, and AK, are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K respectively. To estimate the level of γ- radiation hazard associated with the natural radionuclides in specific investigated samples, Representative Level Index were used which calculated from the following relation [23,24].

$$I\gamma r = (1/150)\ ARa + (1/100)\ ATh + (1/1500)\ AK \quad (3)$$

Absorbed dose (D) assess the energy which stored in a medium due to the ionizing radiation emitted from natural occurring radionuclides and measured in SI units as joules per kilogram (Gray Gy).It is calculated based on guide lines provided by UNSCEAR 2000. D can be calculated according to [25]:

$$D\ (nGy.h^{-1}) = 0.462ARa + 0.621ATh + 0.0417AK \quad (4)$$

External and internal hazard indices which resulting from exposure to radon and its daughters are calculated from the following equations respectively [20,17]:

$$Hex = (ARa/370 + ATh/259 + AK/4810) \leq 1 \quad (5)$$
$$Hin = (ARa/185 + ATh/259 + AK/4810) \leq 1 \quad (6)$$

The annual indoor and outdoor effective dose rate in mSv/yr is given by the following formulas respectively. [25]

$$\text{Indoor effective dose rate } (m\ Svy^{-1}) = D(nGy\ h^{-1}) \times 8760\ h \times 0.8 \times 0.7\ SvGy^{-1} \times 10^{-6} \quad (7)$$
$$\text{Outdoor Effective dose rate } (m\ Svy^{-1}) = D(nGy\ h^{-1}) \times 8760\ h \times 0.2 \times 0.7\ SvGy\text{-}1 \times 10^{-6} \quad (8)$$

4. RESULTS AND DISCUSSIONS

The activity concentration in (Bq/kg) of ^{226}Ra,^{232}Th and ^{40}K for shore sediment samples collected from Nasser Lake are listed in (Table1) and shown in figure (2).From the results, activity concentration varies from 1.92±0.077 to 17.55±0.676 with average value of 5.02±0.194, from 5.62±0.281 to 28.77±1.441 with average value of 13.15±0.641 and from 123.27±10.604 to 277.38±23.861 in with average value of 200.26±17.054 in (Bq/kg) for ^{226}Ra, ^{232}Th and ^{40}K respectively .The averages values of activity concentration are smaller than the universal average given by UNSCEAR (2000), which due to Most of sediments in Nasser Lake are silts and sands derived from basic intermediate volcanic rocks that are representative of the provenances of Ethiopia and Sudan with minor contribution from the underlying and surrounding rocks [26]. Table 2and figure 3 indicates that the obtained results in this study are lower than the results in similar studies when compared to each other. The obtained values of the radiation hazard indices of shore sediment samples are listed in table 3 and shown in (figures 4,5and 6). Results indicate that, radium equivalent activities Raeq ranged from 21.85 to 80.04 Bq/kg with average value of 39.25 Bq/kg; this value is less than the internationally accepted value 370 Bq/Kg [27].Representative level index Iγr ranging from 0.17 to 0.59 with an average value of 0.30.The (Iγ) values of all samples are within the world standard value [27].. Absorbed dose rate D($nGyh^{-1}$) ranged from 10.63 to 37.54 ($nGyh^{-1}$) with an average value of 18.38 $nGyh^{-1}$ and less than the estimate of average global terrestrial radiation of 55 ($nGyh^{-1}$) [27]. Indoor and outdoor annual effective dose rate from these samples are ranged from 0.052 to 0.184 $mSvy^{-1}$with an average value of 0.092 $mSvy^{-1}$ and from 0.013 to 0.046 $mSvy^{-1}$ with an average value of 0.023 $mSvy^{-1}$

respectively and all values are less than the recommended limit of 1mSv/y, UNSCEAR, 2000 while The external and internal hazard indices are varies from 0.059 to 0.216 with average value of 0.106 and from 0.071 to 0.264 with average value of 0.120 respectively. The average estimated values of Hex and Hin which calculated in this work were minimum than unity [28], which are appropriate with the universal values

5. CONCLUSIONS

The activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in the studied samples are found to be normal and below the average global values .The average values of radium equivalent activity Raeq, gamma dose rate D, Indoor and outdoor annual effective dose rate, External hazard index and internal hazard index Hex and Hi and representative level index Iγr were all found to be lower than the worldwide average values. By reference to the values of radiation hazard indices for all shore sediments samples collected from Lake Nasser, shore sediment can be used safely in agriculture, construction and also do not be a radioactive danger to the people which live beside the lake.

Table.1: Activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in shore sediment samples

Sample code	Coordinates		Activity concentration (Bq/Kg)		
	Latitude(N)	Longitude (E)	Ra-226	Th-232	K-40
S1	23° 58′ 152″	32° 51′ 950″	4.14±0.160	10.58±0.527	186.71±16.062
S2	23° 58′ 45″	32° 51′ 866″	4.24±0.164	14.76±0.733	255.59±21.986
S3	23° 57′ 837″	32° 51′ 832″	5.00±0.196	23.47±1.170	247.812±21.317
S4	23° 56′ 400″	32° 51′ 296″	10.99±0.424	23.94±1.911	257.01±22.109
S5	23° 56′ 52″	32° 50′ 775″	17.55±0.676	28.77±1.441	277.38±23.861
S6	23° 56′ 212″	32° 50′ 491″	7.57±0.283	16.77±0.835	215.87±18.570
S7	23° 56′ 85″	32° 50′ 181″	4.83±0.186	9.76±0.494	240.1±17.479
S8	23° 55′ 982″	32° 50′ 464″	6.89±0.267	12.26±0.613	209.95±18.061
S9	23° 54′ 982″	32° 52′ 608″	4.45±0.172	17.67±0.907	243.4±20.938
S10	23° 54′ 596″	32° 52′ 675″	7.02±0.272	11.83±0.592	268.41±23.089
S11	23° 54′ 685″	32° 52′ 950″	5.04±0.197	9.70±0.487	245.59±21.126
S12	23° 54′ 790″	32° 52′ 732″	6.14±0.241	12.93±0.648	178.39±15.346
S13	23° 55′ 554″	32° 52′ 977″	4.28±0.167	17.4±0.868	197.4±16.981
S14	23° 58′ 107″	32° 51′ 895″	2.61±0.102	15.88±0.795	161.15±13.862
S15	22° 20′ 653″	31° 36′ 841″	2.46±0.095	14.59±0.736	194.53±16.734
S16	22° 20′ 653″	31° 36′ 792″	2.49±0.097	9.99±0.499	167.65±14.422
S17	22° 20′ 543″	31° 36′ 714″	2.45±0.095	10.71±0.556	131.73±11.332
S18	22° 20′ 442″	31° 36′ 686″	4.33±0.168	5.62±0.281	123.27±10.606
S19	22° 20′ 399″	31° 36′ 698″	4.42±0.175	6.34±0.317	185.09±15.922
S20	22° 20′ 166″	31° 36′ 856″	4.82±0.191	9.79±0.494	218.29±18.778
S21	22° 19′ 935″	31° 37′ 326″	1.92±0.077	8.23±0.411	184.03±15.831
S22	22° 19′ 891″	31° 37′ 408″	3.59±0.143	12.5±0.627	199.42±17.155
S23	22° 20′ 103″	31° 36′ 855″	4.09±0.160	17.53±0.873	195.05±16.779
S24	22° 20′ 113″	31° 36′ 829″	4.58±0.183	10.37±0.535	193.39±16.636
S25	22° 20′ 133″	31° 36′ 797″	4.14±0.165	8.94±0.454	184.5±15.871
S26	22° 20′ 141″	31° 36′ 779″	4.45±0.153	11.62±0.489	153.59±11.182
S27	22° 20′ 145″	31° 36′ 727″	2.43±0.095	7.49±0.372	148.61±12.784
S28	22° 20′ 112″	31° 36′ 796″	5.45±0.212	14.21±0.724	174.9±15.045

S29	22° 20′ 115″	31° 36′ 687″	4.28±0.165	8.57±0.440	178.27±15.335
S30	22° 20′ 507″	31° 36′ 589″	3.95±0.156	12.44±0.659	190.93±16.424
Minimum			1.92±0.077	5.62±0.281	123.27±10.604
Maximum			17.55±0.676	28.77±1.441	277.38±23.861
Average			5.02±0.194	13.15±0.641	200.26±17.054

Table 2: Comparison of Radiological parameters of present work with other studies

Location	^{226}Ra	^{232}Th	^{40}K	References
present (work)	5.02±0.194	13.15± 0.641	200.26± 17.054	Present work
Buruls Lake)	14.3	20	312	[29]
Mariout Lake	12.65±1.53	7.24±0.76	518.75±46.24	[30]
Suez Canal	10.69±0.25	13.71 ±0.28	194.58 ± 0.81	[31]
Qarun Lake	23.5 ±9.7	14.1±6.2	933±384	[32]
Idku Lake	20.37	26.05	329.18	[33]
Worldwide	32	45	420	[25]

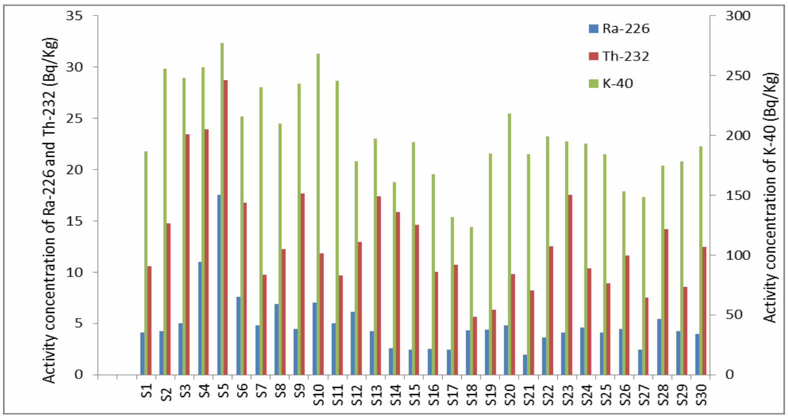

Figure 2. ^{226}Ra, ^{232}Th and ^{40}K activity concentrations in shore sediment samples

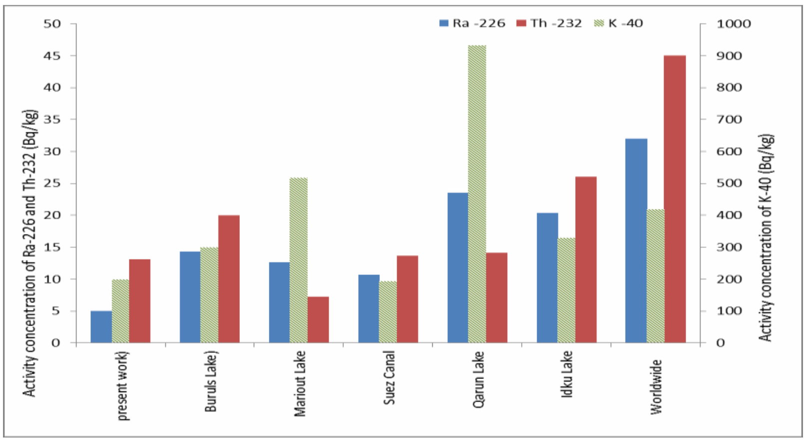

Figure 3. Comparison of ^{226}Ra, ^{232}Th and ^{40}K activity concentrations in samples of present work with other studies

Table 3. radiation hazard indices of shore sediment samples.

Sample	Raeq (Bq.Kg^{-1})	$I_{\gamma r}$	D (nGyh^{-1})	Indoor effective dose (msvy^{-1})	Outdoor effective dose (msvy^{-1})	Hin	Hex
S1	33.65	0.26	16.27	0.080	0.020	0.102	0.091
S2	45.03	0.35	21.78	0.107	0.027	0.133	0.122
S3	57.64	0.43	27.22	0.134	0.033	0.169	0.156
S4	65.01	0.48	30.66	0.150	0.038	0.205	0.176
S5	80.05	0.59	37.54	0.184	0.046	0.264	0.216
S6	48.17	0.36	22.91	0.112	0.028	0.151	0.130
S7	37.27	0.29	18.30	0.090	0.022	0.114	0.101
S8	40.59	0.31	19.55	0.096	0.024	0.128	0.110
S9	48.46	0.37	23.18	0.114	0.028	0.143	0.131
S10	44.60	0.34	21.78	0.107	0.027	0.139	0.120
S11	37.82	0.29	18.59	0.091	0.023	0.116	0.102
S12	38.37	0.29	18.31	0.090	0.022	0.120	0.104
S13	44.36	0.33	21.01	0.103	0.026	0.131	0.120
S14	37.73	0.28	17.79	0.087	0.022	0.109	0.102
S15	38.30	0.29	18.31	0.090	0.022	0.110	0.103
S16	29.68	0.23	14.35	0.070	0.018	0.087	0.080
S17	27.91	0.21	13.28	0.065	0.016	0.082	0.075
S18	21.86	0.17	10.63	0.052	0.013	0.071	0.059
S19	27.74	0.22	13.70	0.067	0.017	0.087	0.075
S20	35.63	0.28	17.41	0.085	0.021	0.109	0.096
S21	27.86	0.22	13.67	0.067	0.017	0.080	0.075
S22	36.82	0.28	17.74	0.087	0.022	0.109	0.099
S23	44.18	0.33	20.91	0.103	0.026	0.130	0.119
S24	34.30	0.26	16.62	0.082	0.020	0.105	0.093
S25	31.13	0.24	15.16	0.074	0.019	0.095	0.084
S26	32.89	0.25	15.68	0.077	0.019	0.101	0.089
S27	24.58	0.19	11.97	0.059	0.015	0.073	0.066
S28	39.24	0.30	18.64	0.091	0.023	0.121	0.106
S29	30.26	0.23	14.73	0.072	0.018	0.093	0.082
S30	36.44	0.28	17.51	0.086	0.021	0.109	0.098
Min.	21.85	0.17	10.63	0.052	0.013	0.071	0.059
Max.	80.04	0.59	37.54	0.184	0.046	0.264	0.216
Average	39.25	0.30	18.38	0.092	0.023	0.120	0.106

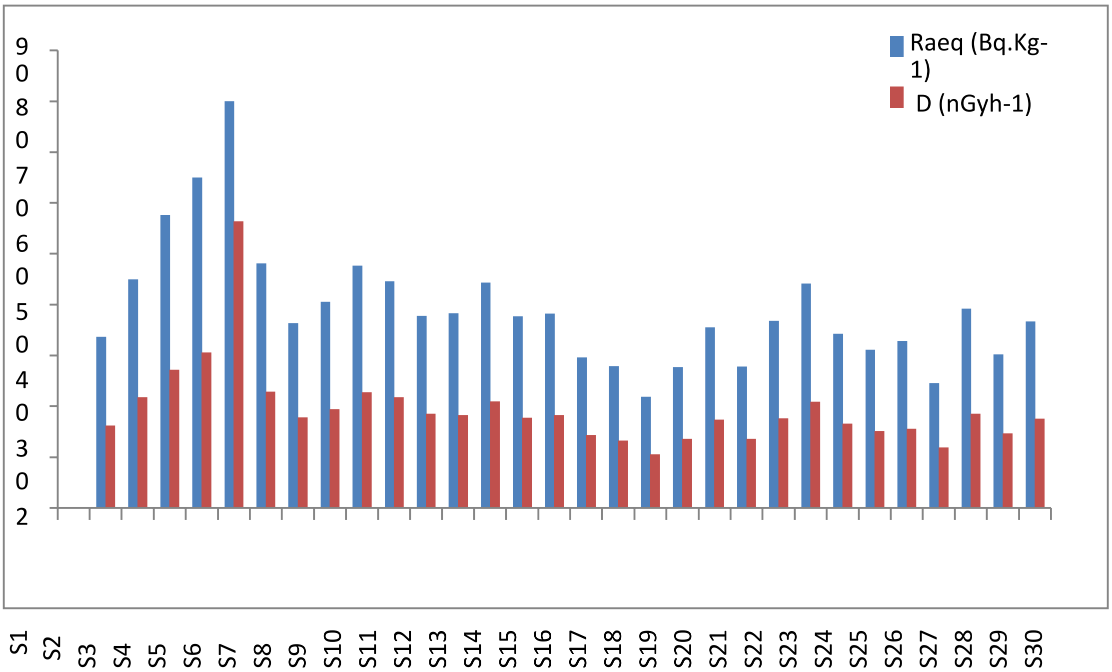

Figure.4: Radium equivalent and absorbed dose rate for all samples under investigation

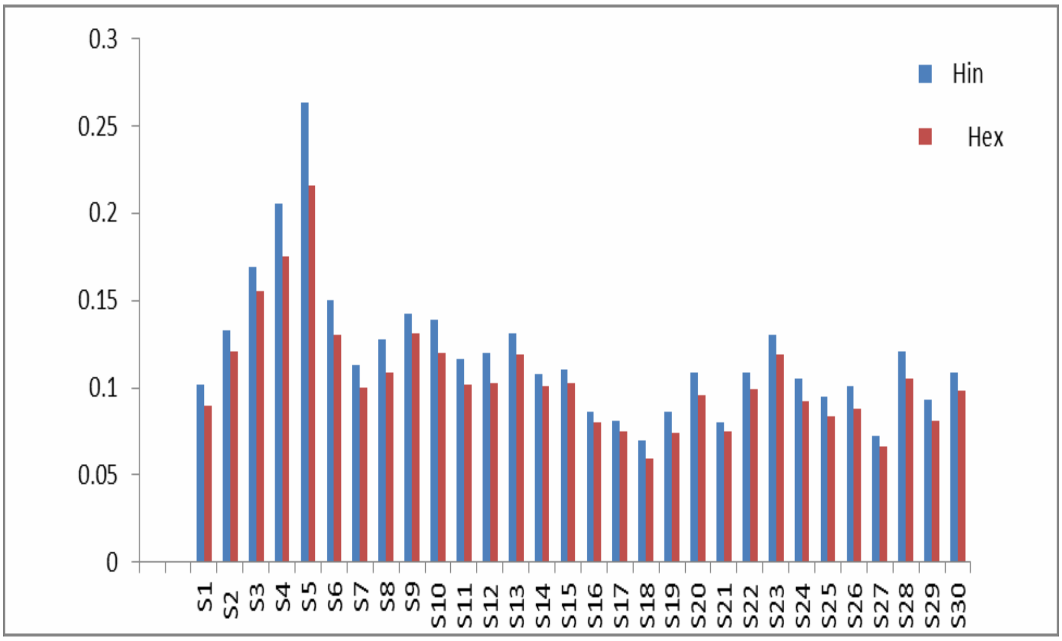

Figure.5: Representative level index, indoor and outdoor effective dose rate of shore sediment samples

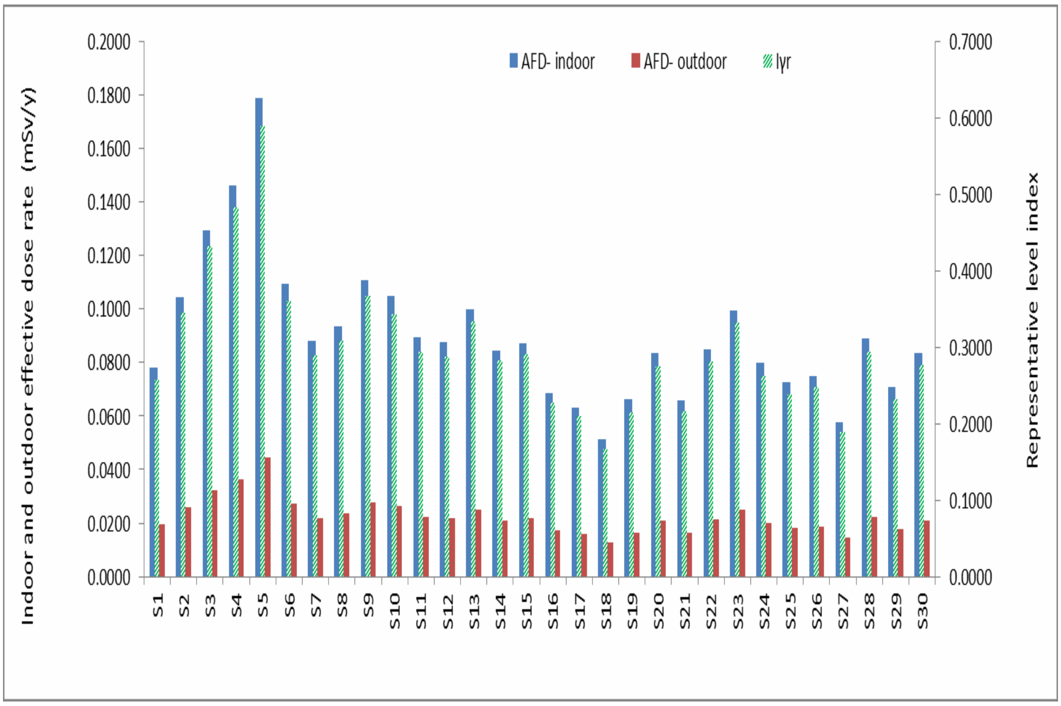

Figure. 6: Internal (H_{in}) and external (H_{ex}) hazard indices of shore sediment samples

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