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Natural Radioactivity Study in The Coastal Villages of Northern Chennai

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Abstract—**The natural radioactivity in three villages are studied along the north coast of Chennai. The activity of the Primordial radionuclide Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K) are randomly distributed. The activity of Thorium (^{232}Th) is elevated in one of the sampling site, Nettukupam.**

Keywords- Natural radioactivity; Gamma ray spectroscopy; Activity concentration.

I. INTRODUCTION

Soil is one of the most complicated systems, which vary from place to place with a variety of parameters. Natural radioactivity is one among them. Several reports claim that natural radioactivity varies depending on the mineral composition of the soil, parental rock composition, climate etc.[1] The dose caused from natural radioactivity depends mainly on the most important Primordial radionuclides ^{238}U, ^{232}Th and ^{40}K. The study of these radionuclides in soil plays an important role to assess the biological effect of natural radiation in biotic environment. The current study concentrates on the radiation level of the three coastal villages along the north Chennai coast. Further investigations are ongoing.

II. MATERIALS AND METHODS

A. Study area

The coastal stretch of north Chennai is one of the densely populated coastal stretches of India; this coastal stretch has a thriving fisher man population. Many reports suggests the elevated level of natural radioactivity along the southern coast of India especially along the Kerala Malabar coast which is along the south west of India[2]. Even though many reports are available for the Tamil Nadu coast which is in the south-eastern side of the India[3], no report is available for this coastal stretch of 50 km along the north coast of Chennai. Three samples were collected from three sampling sites Pulicat, Nettukuppam and Marina Beach (Chennai). Pulicat is located at $13^0$25’21’’ N; $80^0$19’45’’ E, Nettukuppam at $13^0$14’00’’ N; $80^0$19’52’’ E and Chennai (Marina) at 13˚25’21” N; $80^0$17’22’’ E and this is represented in Figure. 1.

B. Sample collection and preperation

The Approximately 1 – 2 kg of soil samples were collected from each site at a depth of 10-15 cm. Collected samples were then packed in polythene zip-lock bags and labelled. Packed bags were transported to laboratory for analysis. Each sample was dried atmospherically, then placed in a hot air oven and maintained at a temperature of 120^o C for 24 hours to ensure the removal of moisture. Then the samples were homogenized using a sieve with 0.7 mm mesh, and packed in a 250 ml plastic beaker. The filled beakers were labelled, sealed and kept for one month for attaining the secular equilibrium between the primordial radionuclide and their daughter products.

C. Experimental setup

The radiological parameters were analysed using high resolution NaI (Tl) detector (3 in. x 3 in.) gamma ray spectrometry system (7.5% Resolution for 661.65 keV) with 15 cm thick lead shielding, 8k multichannel analyser (TNI PCA II Ortec model) was used. IAEA reference standards with standard 250 ml geometry containers were used for calibrating the instrument. The below detectable limit (BDL*) of the each radionuclide is determined from the background radiation spectrum for the same counting time as for sediment samples and is estimated as 2.3 Bq/kg for ^{238}U, 2.5 Bq/kg for ^{232}Th and 9 Bq/kg for ^{40}K.

III. RESULT AND DISCUSSION

The activity concentration values of the major primary radionuclides ^{238}U, ^{232}Th and ^{40}K for the three locations are tabulated in Table 1. From the table it is evident that the Activity of Uranium (C_U) is comparatively low when compared with the activity of Thorium (C_{Th}) and activity of Potassium (C_K). The values are higher in Nettukuppam than in the other two places may be attributed to the presence of Ennore thermal power plant. A similar report on elevated level of radioactivity was reported near Baqiao coal-fired power plant in China [4]. The activity of Uranium is found to be below the world and Indian average of 33 Bq/kg and 29 Bq/kg respectively. The activity of Thorium exceeds the world and Indian average of 45 Bq/kg and 64 Bq/kg respectively in this area. The activity of Potassium is found to be nearly equal to the world and Indian average of 420 Bq/kg and 400 Bq/kg respectively. The elevated level of Thorium in Nettukuppam is due to the discharge and deposition of the fly ash to the surrounding environment during coal combustion [4].

A. Radium Equivalent (Ra.Eq)

A common index for measuring the hazards created by the radionuclides is Radium equivalent activity and is determined by the following equation [5].

$$\text{Ra.eq (Bq/kg)} = (C_U + 1.43C_{Th} + 0.077C_K)$$

Where, C_U, C_{Th} and C_K are the activity concentrations (Bq/kg) of ^{238}U, ^{232}Th and ^{40}K respectively. The calculated values are given in Table 2. The Radium equivalent values for the three sites are 100.45 Bq/kg, 284.37 Bq/kg and 37.49 Bq/kg respectively. The values are well below the world average of 370 Bq/kg [6].

B. Absorbed dose rate (D)

The external exposure due to the terrestrial gamma rays caused by the natural occurring radionuclides 1 m above the ground is the air absorbed dose rate. The conversion factors 0.462, 0.604 and 0.0417 are used for the activity concentration of ^{238}U, ^{232}Th and ^{40}K for their conversion to dose rates [6]. By using these factors the equation for calculating the total dose rate (D) is,

$$D \text{ (nGy/h)} = 0.462C_U + 0.604C_{Th} + 0.0417C_K$$

Where, C_U, C_{Th} and C_K are the activity concentrations (Bq/kg) of ^{238}U, ^{232}Th and ^{40}K respectively. The values measured are 46.514 nGy/h, 124.4 nGy/h and 19.17 nGy/h for Pulicat, Nettukuppam and Marina respectively. Except Nettukuppam the remaining two values from the sampling sites Pulicat and Marina are well below the world average of 57 nGy/h. Thus from this estimation it is confirmed that the Nettukuppam village has comparatively higher terrestrial dose rate.

C. Annual effective dose equivalent (AEDE)

Effective dose experienced by a human due to the terrestrial gamma ray is given by the annual effective dose equivalent. For converting absorbed dose rate in nGy/h to annual effective dose equivalent in µSv/yr we use 0.7 Sv/Gy as the conversion factor. A human normally spends around 19 hours indoor and 5 hours outdoor by fractionalising we obtain the occupancy factor values as 0.8 and 0.2 for indoor and outdoor respectively, by using the above relations the annual effective dose equivalent equation follows [7],

$$\text{AEDE - Outdoor } (\mu Sv/h) = \text{(Absorbed dose) nGy x 8760 h x 0.7 Sv/Gy x 0.2x10-3}$$
$$\text{AEDE - Indoor } (\mu Sv/h) = \text{(Absorbed dose) nGy/h x 8760 h x 0.7 Sv/Gy x 0.8 x10-3}$$

The calculated values are tabulated in Table 2. It is evident that the annual effective dose equivalent values for Pulicat and Marina are below the world average of 70 µSv/h and 450 µSv/h [6] for outdoor and indoor respectively. And the AEDE values for Nettukuppam is comparatively higher and thus dwelling there possess health risks.

D. Hazard Index and Excess life time cancer risk

The level of exposture that Human is subjected to the radiation caused by the primordial radionucleides is given by Internal and External Hazard Index and the cancer risk that the radiation possess is given by the Excess lifetime cancer risk. The eqution for calculating the external and internal hazard index (H_{ex} & H_{in}) by Beretka and Mathew, 1985 [8] is given below,

$$H_{ex} = (C_U/370 + C_{Th}/259 + C_K/4810) \leq 1$$
$$H_{in} = (C_U/185 + C_{Th}/259 + C_K\ 4810) < 1$$

Where, C_U, C_{Th} and C_K are the mean activity concentrations of ^{238}U, ^{232}Th and ^{40}K in Bq/kg, respectively. As denoted in the equation the value of H_{ex} and H_{in} must be less than unity to have negligible hazardous effects. The calculated values for all the sites are below the limit. The cancer risks are calculated by equation suggested by Taskin et al [9].

$$ELCR = AEDE \times DL \times RF$$

Where, DL is duration of life (~70 years) and RF is the risk factor (Sv^{-1}) its value recommended by ICRP is 0.05 for public. Only Nettukuppam village possesses the lifetime cancer risk threat the other two sites has the values well below the world average of 0.29 x 10^{-3}.

IV. Conclusion

The radioactive activity concentration values for ^{238}U, ^{232}Th and ^{40}K are studied for the three villages along the coast of northern Chennai. The values show that the Nettukuppam village has elevated level of Radiation than the other two sampling sites Pulicat and Marina. The increase in the concentration of the radioactive nuclide especially Thorium ^{232}Th in Nettukuppam may be attributed to the usage of Coal in Ennore thermal power plant. Since, the Coal combustion may increase the level of fly ash with higher radionuclide in the environment. The other two sites has all the radiological values below the permissible level which suggests that the there is no potential Radioactive thereat in Pulicat and Marina.

TABLE I. ACTIVITY CONCENTRATION OF THE PRIMORDIAL RADIONUCLEIDES

Site Name	**Activity Concentration (Bq/kg)**		
	^{238}U	***^{232}Th***	***^{40}K***
Pulicat	BDL*	52.48±5.92	329.82±27.27
Nettukuppam	18.19±7.86	165.18±8.24	389.27±32.35
Marina	BDL*	BDL*	398.09±25.72

TABLE II. SUMMARY OF THE PRESENT STUDY

Site Name	Ra. Eq. (Bq/kg)	Dose rate (nGy/h)	AEDE-O (μSv/yr)	AEDE-I (μSv/yr)	Hex ≤ 1	Hin <1	ELCR x 10^{-3}
Pulicat	100.45	46.514	57.045	228.179	0.277	0.284	0.199
Nettukuppam	284.37	124.405	152.57	610.28	0.768	0.817	0.53
Marina	37.49	19.173	23.514	94.055	0.097	0.104	0.082

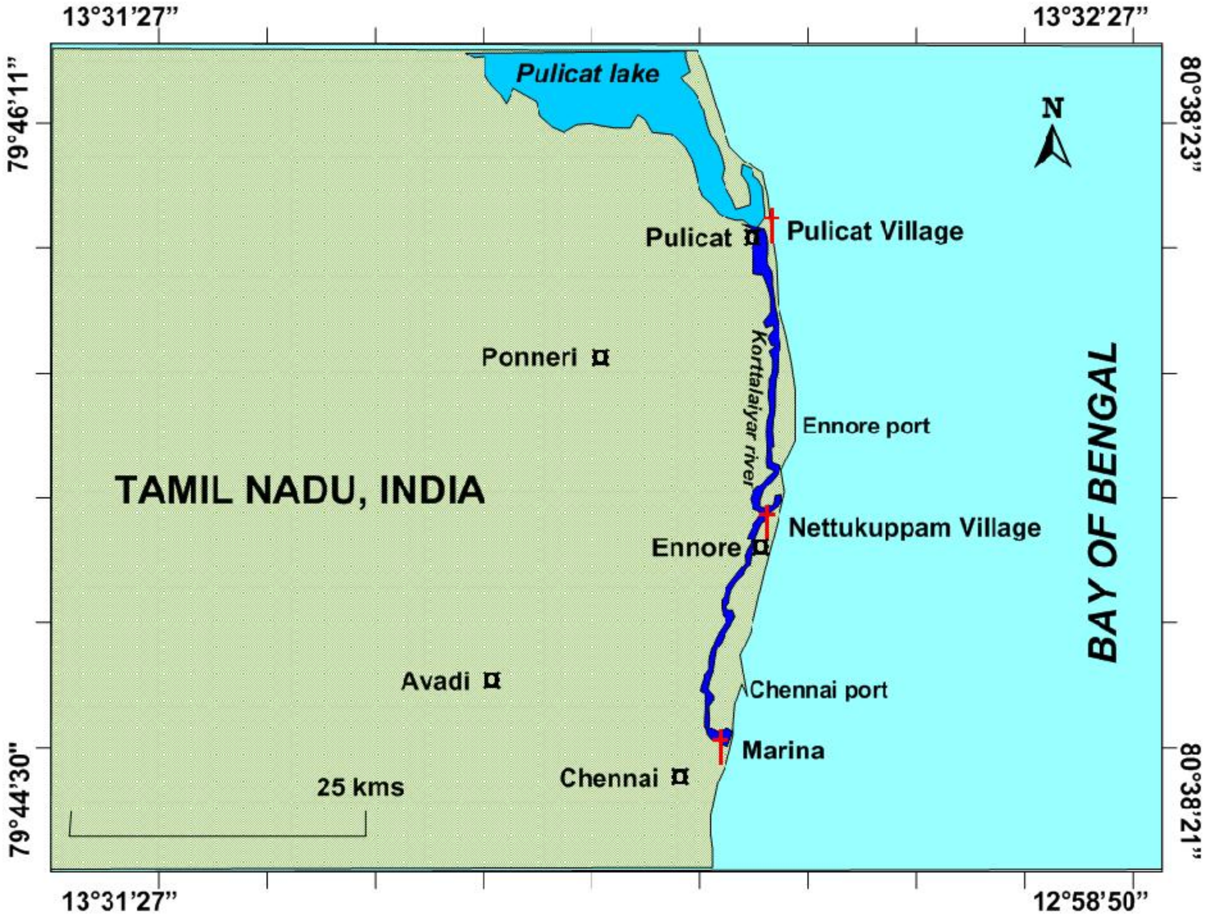

Figure 1. Location of the sampling sites

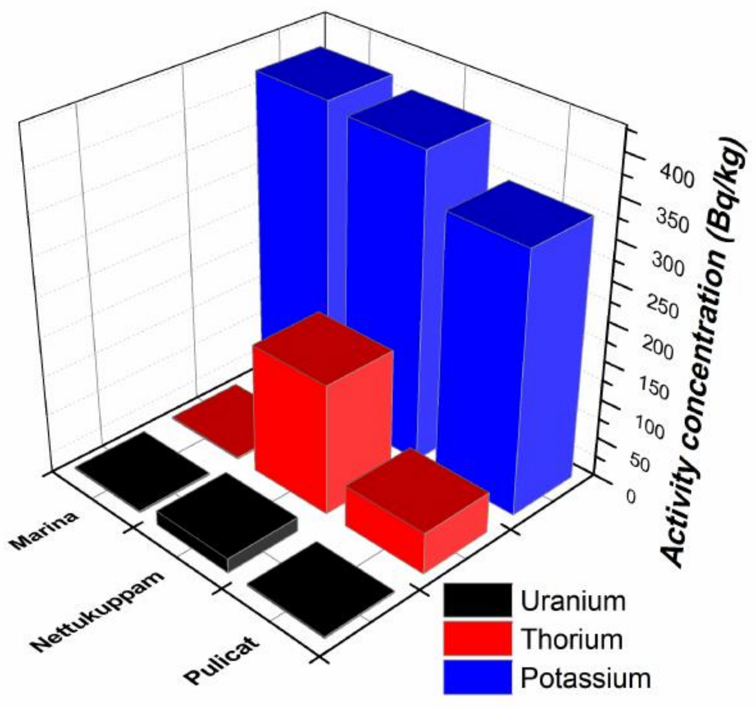

Figure 2. Activity concentration of ^{238}U, ^{232}Th and ^{40}K

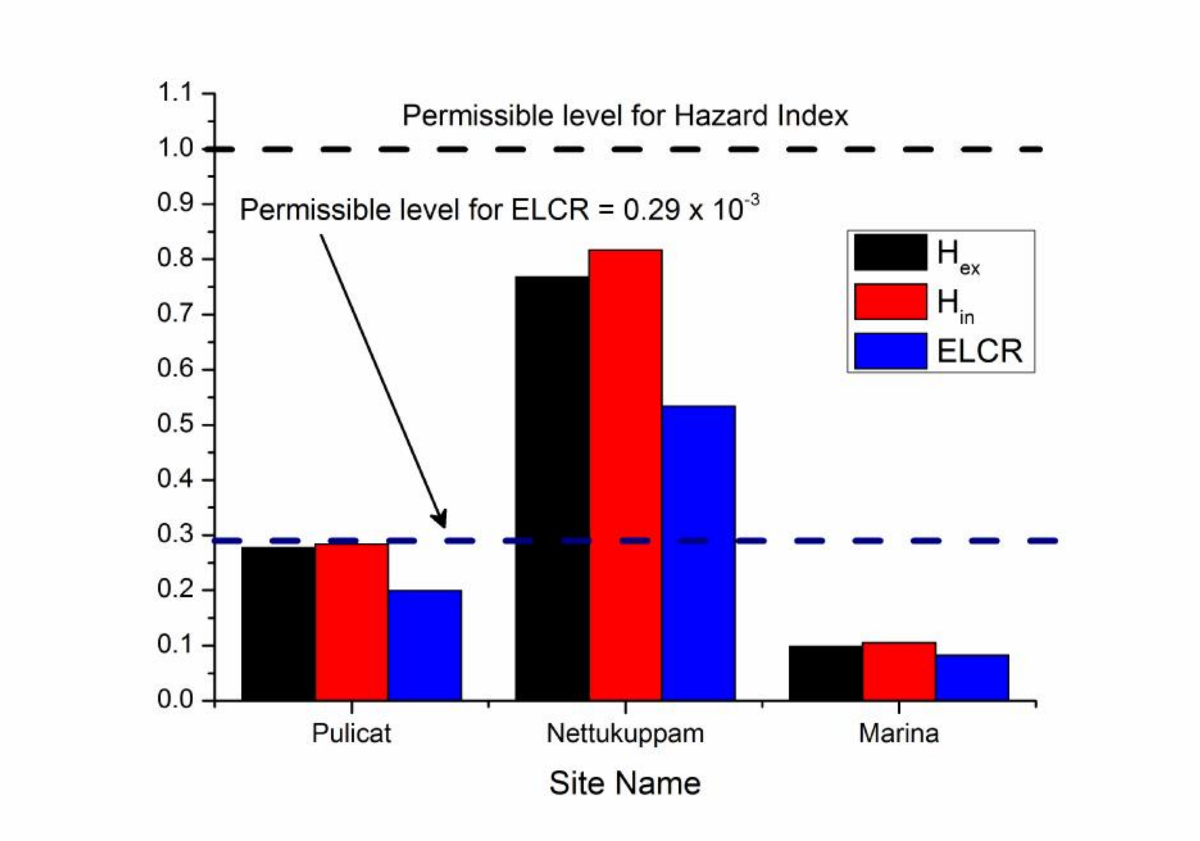

Figure 3. Hazard index and Excess lifetime cancer risk distribution along the villages

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