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A Study on the Level of Terrestrial Gamma and Gross Alpha Activity in Sirumalai, Dindigul District, Tamil Nadu

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ABSTRACT: This study presents the results of outdoor ambient gamma and gross alpha activity of Sirumalai, Dindigul district, Tamil Nadu, and these measurements were carried out by using environmental radiation Scintillation Counter (UR-705). Results showed that the terrestrial Gamma radiation levels of the Sirumalai was ranged from 4.33±0.47µR/h to 12.67±0.47µR/h. The Gross alpha radioactivity levels of the Sirumalai ranged between 8.25Bq/kg and 26.56 Bq/kg. The calculated ambient gamma and gross alpha activity were found to be lesser than the world average. Gamma absorbed dose rates in air outdoors were calculated to be in the range between 37.671nGy/h and 110.23nGy/h. This value is slightly higher than the population weighted world-averaged of 60 nGy/h. Inhabitants of Sirumalai are subjected to external gamma Annual dose exposure ranging between 0.0462mGy/y and 0.1352mGy/y. The result reveals the non-uniform distribution of Gamma radiation and an irregular distribution of radiation profile was observed during the survey period. The values of the external hazard index determined from the soil radioactivity of the study area are less than the recommended safe levels.

Keywords: Sirumalai hills, Gross alpha, terrestrial gamma radiation.

INTRODUCTION

Radioactivity is a part of our earth - it has existed all along. Naturally occurring radioactive materials are present in its crust, the floors and walls of our homes, schools, or offices and in the food we eat and drink. There are radioactive gases in the air we breathe. Our own bodies - muscles, bones, and tissue - contain naturally occurring radioactive elements. Man has always been exposed to natural radiation arising from the earth as well as from outside the earth. The radiation we receive from outer space is called cosmic radiation or cosmic rays (Skwarzec, 1988). We also receive exposure from man-made radiation, such as X-rays, radiation used to diagnose diseases and for cancer therapy. Fallout from nuclear explosives testing, and small quantities of radioactive materials released to the environment from coal and nuclear power plants, are also sources of radiation exposure to man. The radionuclides decay at a characteristic rate that remains constant regardless of external influences, such as temperature or pressure. The time that it takes for half the radionuclides to disintegrate or decay is called half-life. This differs for each radioelement, ranging from fractions of a second to billions of years. For example, the half-life of Iodine 131 is eight days, but for Uranium 238, which is present in varying amounts all over the world, it is 4.5 billion years. Potassium 40, the main source of radioactivity in our bodies, has a half-life of 1.42 billion years (Odum, 1971).

On average, our radiation exposure due to all natural sources amounts to about 2.4 mSv a year - though this figure can vary, depending on the geographical location by several hundred percent. In homes and buildings, there are radioactive elements in the air. These radioactive elements are radon (Radon 222), thoron (Radon 220) and by products formed by the decay of radium (Radium 226) and thorium present in many sorts of rocks, other building materials and in the soil. By far the largest source of natural radiation exposure comes from varying amounts of uranium and thorium in the soil around the world. The radiation exposure due to cosmic rays is very dependent on altitude, and slightly on latitude: people who travel by air, thereby, increase their exposure to radiation (Cherry & Shannon 1974; Cherry and Shannon 1974). The environment normally has some amount of natural radioactivity resulting from cosmic rays, and ionizing radiations from naturally occurring radioactive substances in soil, air, water and biota. These radiations provide the 'background radiation' to which all living beings are exposed. Studies on natural radioactivity in India are largely made on marine ecosystem (Basith and Krishnamoorthy 2021; Bukhari, 2004; Iyengar, 1983; Shahul Hameed *et al.,* 2002; Krishnamoorthy, 2021; Musthafa and Krishnamoorthy 2011; 2012; Somasundaeam, 1998; Tholkappian *et al.,* 2018). Present study was designed with following objectives to study the distribution and the effects of natural radioactivity in the Sirumalai hills, Dindigul, Tamil Nadu.

MATERIALS AND METHODS

Study Area. In the Present study 10 sampling station were fixed in the Sirumalai hills, Dindigul, Tamil Nadu (Fig. 1), stations are namely Thenmalai (S1), Agasthiyar Malai (S2), Palaiyur (S3), Puthur (S4), H.P.B. - 13 (S5), H.P.B. - 08 (S6), H.P.B. - 03 (S7), Check Post (S8), Natham main Road (S9), Dindigul Junction (S10). Sirumalai is a region of 60,000 acres (200 km^2) situated 25 km (16 mi) from Dindigul, 90 km (56 mi) from Madurai, and 125 km from Trichy, Tamil Nadu, India. There are many high hills in the area Sirumalai range is the last mountain range of the Eastern Ghats. The nearest Eastern Ghats hills to Sirumalai Hills are the Narthamalai Hills. Sirumalai is a dense forest region with a moderate climate throughout the year. With an altitude of 1600 metres above sea level, it contains diversified flora and fauna. The hill has 18 hairpin bends.

Collection of Samples. Sediment samples were collected directly from the 10 sampling stations of Sirumalai hills, Dindigul. Samplings were done in surface soil; approximately 1 kg of sediment was collected using an improvised hand-held dredger. Sample collections were done during 2020-2022. The sediment samples were collected by Polythene Cover (Zip lock cover) of two kg capacity and brought to the laboratory for analysis of Radioactivity.

Preparation of Samples. The collected sediment samples were contain the extraneous materials like plant parts, pebbles and benthic fauna were strained out and the sediment samples were dried in sun light for a day and an oven at 100°C for 24 hrs to remove the water content and the weight was measured. The dried samples were crushed to fine powder and then the sediment samples were sieved through a 0.5 mm mesh screen. The one gram of sediment samples was subjected to analysis of Radioactivity.

Determination of Ambient Gamma Radioactivity. Environmental radioactivity measurements are necessary for determining the background radiation level due to natural radioactive sources of terrestrial and cosmic origins (Shashikumar, 2011). Radionuclide activity concentration in soil is one of the main determinants of the natural background radiation. The present study is focused to survey the ambient gamma radiation was measured by Scintillometer (UR-705). It is a rugged, light weight and Portable Scintillometer designed for radiometric, geophysical and environmental reconnaissance survey.

Determination Gross Alpha Activity in samples. The gross alpha indicates the levels of radioactivity from all alpha emitting radionuclides irrespective of individual contribution in the particular matrix. Measurements of gross alpha activity in various environmental matrices are considered important because these offers quick information on the radioactivity profile of any environment concerned. Such procedures are important preliminary steps in the radioactivity inventory of any ecosystem. For the measurement of gross alpha activity in the biota and soil from sampling stations were collected and dried in an oven at 105°C to 110°C for 24 h. About 0.5-1.0 gm (for alpha) of the powdered dry sample was uniformly spread over a clean background counted, Aluminiumplanchette (3 cm diameter) using a micro sieve and the radioactivity was measured in alpha and beta counter (Kannan, 1983; Ganapathy, 1984).

Derivation of the absorbed dose rates and effective dose rates. If natural radioactive nuclides are uniformly distributed in the ground, dose rates at 1 m above the ground surface are calculated by the following formula (Kohshi *et al.*, 2001):

Dose rate (nGy h^{-1}) = Radiological concentration (Bq kg^{-1}) × Conversion factor (nGy h^{-1} per Bq kg^{-1})

Nuclear Instruments Used. For the present investigation an Scintillation Counter manufactured by Nucleonix Systems (UR-705) and Alpha Counter System (Nucleonex- RC 605A, 33% Efficiency) were used for the estimation of Ambient Gamma and Gross Alpha activates of samples and this instrument is available in the Environmental Research Laboratory, P.G. and Research Department of Zoology, Jamal Mohamed College, Tiruchirappalli.

RESULTS AND DISCUSSION

The absorbed dose rate of gamma radiation was calculated from ambient gamma levels in the selected station of Sirumalai hills, Dindigul, Tamil Nadu (Table 1). The terrestrial Gamma radiation levels of the Sirumalai hills ranged from 4.33±0.47µR/h (H.P.B. - 13 (S5) and H.P.B. - 08 (S6)) to 12.67±0.47µR/hin Natham main road (S9). The result reveals the non-uniform distribution of Gamma radiation in the study area. During the survey period an irregular distribution of radiation profile was observed. Chinnaduari and Krishnamoorthy (2021) reported that the ambient gamma radiation level in the Calicut district ranged from 8 -16 µR/h. The terrestrial Gamma radiation levels of the Pulicat Lagoon ranged from 3.0 to 8.0 µR/h in the lake region, 3.0 to 8.0 µR/h in the mouth bar region and 5.0 to 16.0 µR/h in the canal region (Krishnamoorthy, 2021). Shahul Hameed (2002) reported that the activity of Gamma radiation in the Palk Strait sediments ranged from 5 to 25µR/h. Meeramoideen (2012) reported that the terrestrial Gamma radiation activity in the Pondicherry costal sediments ranged from 3.03 to 5.04µR/h. Somasundaram (1998) reported that the activity of terrestrial Gamma radiation in the Gulf of Mannar ranged from10 -450 µR/h and the world range was 28 – 120 µR/h for normal background areas (UNSCEAR, 2008).

The average absorbed dose rates from outdoor terrestrial γ radiation at all the designated locations from Nandaprayag to Allahabad. The values were found in the range of 81.33±2.34nSv/h to 144±5.77nSv/h with an average of 100.83nSv/h. Terrestrial gamma radiation dose measurement and health hazard along river Alaknanda and Ganges in India (Prema *et al.*, 2004). The geology of the local area plays an important role in distribution of these radioactive elements. Environmental terrestrial gamma radiation dose rates were measured around the eastern coastal area of Odisha with the objective of establishing baseline data on the background radiation level. The values of the terrestrial gamma radiation dose rate vary significantly at different locations in the study area. The values of the terrestrial gamma dose rate ranging from 77 to 1651 nGy/h, with an average of 230 nGy/h (Gusain *et al.,* 2012).

The Gross alpha radioactivity levels of the Gulf of Mannar ranged from 8.25Bq/kg (H.P.B. -8 (S6)) to 26.56 Bq/kg in H.P.B. -3 (S7). The result reveals the non-uniform distribution of Gross alpha radioactivity in the study area. During the survey period an irregular distribution of radiation profile was observed (Fig. 2). Basith and Krishnamoorthy (2021) reported that the gross alpha activity in Pulicat lagoon sediment were ranges from 1.38 – 10.08 mBq/g in the lake region, 2.38 to 5.26 mBq/g in the mouth bar region and 2.29 to 16.64 mBq/g in the canal region. Bukhari (2004) reported that the gross alpha activity in the Palk Strait sediments mean value ranged from 5.0 to 11.0Bq/kg. The activity concentration of gross alpha in the Pondicherry costal sediments ranged from 2.89 to 4.20Bq/kg and in Caddulore costal sediments ranged from 10.1 to 14.80Bq/kg (Meeramoideen, 2012). Krishnamoorthy *et al.* (2009) reported that the gross alpha activity in the Punnaikayal estuarine sediments 73.2Bq/kg. The Gross Alpha activity in the Gulf of Mannar sediment samples 86mBq/g (Somasundaram, 1998).

Biswas *et al.* (2015) reported that the Gross alpha and gross beta radioactivity in thirty environmental samples of soil, water and vegetable were randomly collected from the different locations of Bheramara and Ishwardinear the proposed Rooppur, Kushtia and Pabna nuclear power plant area, Bangladesh. The Gross Alpha activity under investigation ranges from 1.13 to 5.66 Bq/kg with an average of 2.78±0.16 Bq/kg for soil sample. This study will help to prepare baseline data for gross alpha radioactivity in environmental sample which will be used as finger print for the comparison of radioactivity level. Determination of the gross-alpha radioactivity of river soil and sediment samples was collected from Bendimahi River which originates near the Tendürek Mountain (Van, Turkey), its tributaries and Van Lake (Turkey). The gross-alpha activity concentrations in soil samples ranged from 0.800 to 4.277 Bq/g in May and 0.686 to 4.713 Bq/g in August, respectively. Concentrations ranging from 0.782 to 4.596 Bq/g in May and from 0.580 to 5.824 Bq/g in August for gross-alpha radioactivity were observed in sediments, respectively (Özlem *et al.,* 2009).

An understanding of natural radioactivity will allow us to control or limit the toxicity and thus the risk to individuals and society of those exposed. The gross alpha radioactivity concentration in soil varies between 0.25 and 1.20 mBq/g (Periyasamy *et al.,* 2016). The concentrations of gross alpha radioactivity were analyzed in Holocene sediments of the Gulf of Izmir (Eastern Aegean Sea). Sediments were collected from four different sites affected by industrial activities, overcrowding and shipping in İzmir Bay. The obtained results show that natural gross alpha activity concentrations in the drilling cores range from 537 ± 77 to 1800 ± 207Bq/kg. These results were compared with previous studies throughout the world, and the study could be a reference data for the future researches related to radiological mapping or environmental monitoring in the area (ErolKam *et al.,* 2017). The present study indicates that the radiation dose received by to population of Sirumalai hills through environment was less compared to those at Mumbai and Kalpakkam.

The absorbed dose rate of gamma radiation was calculated from ambient gamma levels in the selected station of Sirumalai hills, Dindigul, Tamil Nadu (Table 1). The result showed that the sampling station 9Natham main road recorded the highest absorption rate of 110.23nGy/h, whereas station 5 (H.P.B. -13) and 6 (H.P.B. - 8) registered the lowest absorption rate of 37.671nGy/h. Outdoors Gamma absorbed dose rates were calculated ranged between 32 nGy/h and 59.1 nGy/h with an arithmetic mean of 43.3 ±9 nGy/h (Senthilkumar *et al.,* 2010). The highest Annual dose in Sirumalai was 0.135mGy/h in Natham main road (S9) and lowest value 0.0462mGy/h in H.P.B. -13(S5) and H.P.B. – 8(S6). External annual effective dose ranged from 0.17 to 0.60 mSv/y with the mean value of 0.33 ± 0.05 mSv/y (Louis *et al.,* 2018). The ambient gamma radiation in various regions of the world largely depends on geological and geographical condition of the soil in the particular region of the world (UNSCEAR, 2008).

Fig. 1. Map showing the sampling station in Sirumalai hills.

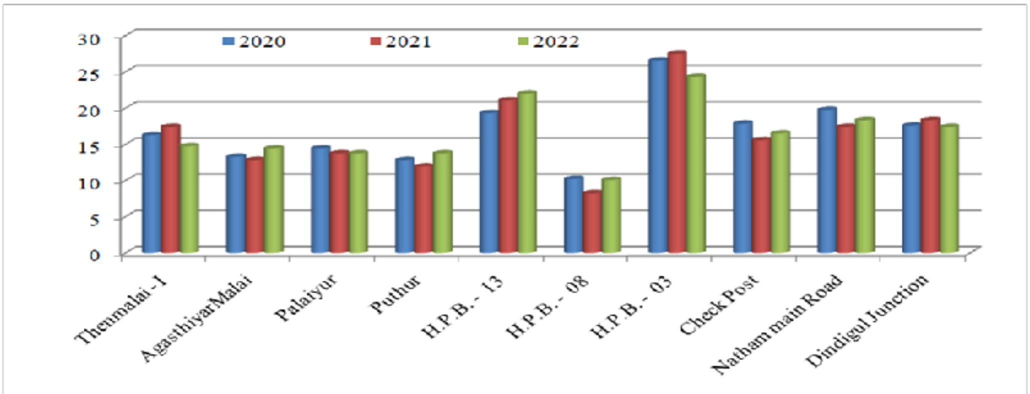

Fig. 2. Gross Alpha radioactivity (Bq/kg) in sediment samples of Sirumalai, Tamilnadu.

Table 1: Terrestrial Gamma levels in the different sampling stations of Sirumalai, Tamilnadu.

Sr. No.	Station name	Terrestrial Gamma Level			Mean±SD (μR/h)	Absorbed Dose (nGy/h)	Annual effective Dose (mGy/y)	Excess Lifetime Cancer Risk (10^{-3})
1.	Thenmalai (S1)	7	9	7	7.67±0.94	66.729	0.0818	0.33
2.	Agasthiyar Malai (S2)	5	6	5	5.33±0.47	46.371	0.0569	0.23
3.	Palaiyur (S3)	6	5	6	5.67±0.47	49.329	0.0605	0.24
4.	Puthur (S4)	5	4	5	4.67±0.47	40.629	0.0498	0.20
5.	H.P.B. - 13 (S5)	5	4	4	4.33±0.47	37.671	0.0462	0.18
6.	H.P.B. - 08 (S6)	4	5	4	4.33±0.47	37.671	0.0462	0.18
7.	H.P.B. - 03 (S7)	5	4	5	4.67±0.47	40.629	0.0498	0.20
8.	Check Post (S8)	6	6	6	6.00±0.00	52.2	0.0640	0.26
9.	Natham main Road (S9)	12	13	13	12.67±0.47	110.229	0.1352	0.54
10.	Dindigul Junction (S10)	11	12	12	11.67±0.47	101.529	0.1245	0.50

CONCLUSION

The present study investigates on the ambient gamma survey of Sirumalai sediment samples and the resulting radiation dose from ambient gamma radionuclides. In addition to that, the estimation of the absorbed gamma dose rate, and the annual effective dose rate were also studied. The data presented in this study will serve as a baseline survey for naturally occurring radionuclides concentration and radiation exposure in Sirumalai. The ambient gamma values ranged from 4.33±0.47 to 12.67±0.47μR/h, ambient gamma absorbed dose rate (37.67-110.23Gy/h) and ambient gamma annual effective dose rate (0.046-0.135mSv/y) in the Panrimalai area measured from radiation survey meter was found to be lower when compared to the worldwide average value of 0.42 mSv/y. From the present study, it was concluded that the non-uniform distribution of ambient gamma, absorbed dose rate, and annual effective dose rate in the soil samples of Sirumalai was found to be less than that of the recommended safe levels.

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Conflict of Interest. None.

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UNSCEAR (2008). United Nations Scientific Committee on the Effect of Atomic Radiation Report to the general assembly. Annex B Exposure of the public and workers from various sources of radiation.

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