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A Correlation Study between Radium Content and Radon Exhalation Rates in Soil Samples along the Coastal Regions of Perumathura and Vizhinjam, Trivandrum District, Kerala

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Abstract:The natural radioactivity due to uranium, Thorium and potassium in soil contributes to the radiation dose received by human beings significantly. There are quite a few identified monazite sand-bearing placer deposits causing environmental high back ground radiation area along its long coastline of Kerala and Tamil Nadu in India. The extent and effects of the radioactivity in the regions like Chavara and Neendakara in Kollam, Kerala is well known. Other coastal regions are assumed to have normal environmental radiation levels. Following a pilot study along the southern west coast of Kerala state, India we found certain regions with higher levels of natural radioactivity and hence made a detailed investigations of activity concentration of ^{226}Ra, radon exhalation rates and radon emanating factor of those locations namely Perumathura and Vizhinjam. The results indicates that most of the soil sample shows higher specific activity of ^{226}Ra and there is a linear relation to ^{222}Rn mass exhalation rate .But radon emanation factor is not so linear to the specific activity of Radium in sample analyzed.
***Keywords**:Natural radioactivity, High back ground radiation, Radiation dose, Radon exhalation rates, Radon emanating factor*

I. INTRODUCTION

Contribution of indoor radon (^{222}Rn) and its decay products to the population dose from natural sources is estimated to be nearly 50% of the total dose received and is well documented [1]. ^{222}Rn entry into indoor environment occurs mainly due to exhalation of ^{222}Rn from the soil and building materials. Exhalation of^{222}Rnfrom materials depends primarily on^{222}Rn emanation rate from the grains and the microstructure of the material. To give a quantitative explanation of ^{222}Rn emanation rate, a parameter called^{222}Rnemanation factor (f) is introduced, which is defined as the ratio of ^{222}Rnatoms that reach out of grain into pore volume to that of the total^{222}Rn atoms that are produced in the sample matrix. ^{222}Rnemanation factor can be determined by the radium content of the material and mass exhalation rate of^{222}Rn from the sample of fine grain powder form.[2]Reported ^{222}Rn emanation factor from several countries had shown that in soil, it varied from 1% to 50%; while that in building materials it varied from 0.2% to 30% [3], [4].The ionizing radiation exposure of human beings from natural sources is a continuing and inescapable feature of life on earth [1].There are two main contributors to natural radiation exposures: high energy cosmic ray particles incident on the earth's atmosphere and radioactive nuclides that originated in the earth's crust. Radon is produced due to the radioactive decay of radium in earth crust. It's concentration in the ground depends on the radium content of the soil and the emanation power of soils and rocks [5], [6]. Radium is a decay product of uranium in the naturally occurring uranium series. When radium decays in soil, the resulting atoms of radon isotopes first escape from the mineral to air-filled pores. The rate at which radon escapes from soil into the surrounding air is known as radon exhalation rate of the soil. This may be measured by either per unit area or per unit mass of the soil. About 20% of the natural radiation dose is due to external radiation from terrestrial radioactivity.[7],[8].When radon gas is inhaled, densely ionizing alpha particles emitted by deposited short- lived decay products of radon ^{218}Po and ^{214}Po can interact with biological tissue in the lungs leading to damage and causes lung cancer[9]. Due to the hazardous effect of radon exhalation on human health, it has great significance to conduct measurements of radium content in the soil. Higher values of ^{226}Ra in soil have greater contribution in the enhancement of environmental radon[10]. In the present study investigations have been carried out to measure the radium content and radon mass exhalation rates in soil samples collected from some areas of Perumathura and Vizhinjam in Kerala, India using smart radon monitor. The importance of this work, is that, it represent the first study on measuring radon mass exhalation rates and radium content in Perumathura and Vizhinjam in Kerala. Incidentally these two locations are famous tourist destinations with thick population. Perumathura is a small hamlet located 26 km towards North from District headquarters Thiruvananthapuram. Vizhinjam is a natural port located close to international shipping routes in Thiruvananthapuram city in the Indian state of Kerala. In additions to the floating population (tourists) average population in these regions are about 60,000 each.

II. MATERIALS AND METHODS

Each sample was taken maintaining a distance of about 200m from each other. About 0.75 - 1.00 kg of sample was collected from each location. These samples were first weighed, and then dried at 110°C in a dry air oven for 24 hours. The homogenized and sieved samples were transferred to cylindrical plastic container of 7 cm height and 5.5 cm in diameter. All the sample containers were sealed hermetically and were stored for eight weeks to ensure the secular equilibrium between ^{226}Ra (of the ^{238}U) with their radioactive progenies.

The gamma spectrometer is a 5"x4" NaI(Tl) detector. Samples were analysed for ^{238}U (^{226}Ra) by gamma spectroscopy. The counting period for samples and background was set for 10,000 s. The activity of ^{238}U was evaluated from 1764 keV gamma of ^{214}Bi.

Preliminary observations of the parameters like background efficiency and MDL for the Gamma ray spectrometer were done periodically. The sample kept for attaining secular equilibrium were analysed using the Gamma ray spectrometer. The samples in the standard bottle were placed into the detector for counting and left for recording spectrum for 10,000s.By selecting the respective peaks for the isotopes ,the region of interest (ROI) are noted and the corresponding gross counts are calculated. The net activity was determined by deducting background radiation from the gross count.

Radon monitor-Smart RnDuo

The SMART RnDuo is a portable continuous activity monitor for radon (^{222}Rn), thoron (^{220}Rn) and gross alpha in the sampled air. The detection principle is based on detection of alpha particles, emitted from sampled radon/thoron and its decay products formed inside the detector volume, by scintillation with ZnS: Ag. The counts obtained for each interval are converted to radon/thoron/alpha activity concentration using a smart algorithm implemented in the micro-controller. The advanced algorithm has been developed by Bhabha Atomic Research Centre, Mumbai based on radioactive decay and growth laws. This algorithm accounts for the counts obtained from the decay products formed during the previous intervals.

The radon emission potential from soil sample is governed by radon mass exhalation rate (Jm). Jm can be estimated by performing measurements using smart radon monitor- SMART Rn Duo of the sample in a closed accumulation chamber (also called mass exhalation chamber) and monitoring the build-up of radon concentration in the chamber at regular time intervals. Typically about 350 – 500 g of soil or any power sample may be enclosed in a leak tight metallic chamber coupled to the SMART Rn Duo. Measurement cycle should be 1 hour. Sampling should be done preferably by diffusion mode. Hence Detector probe should be connected to the mass exhalation chamber directly. The radon concentration C(t) at time t since closing the chamber builds up according to the formula.

$C(t)=\frac{JmM}{V\lambda e}[1-e^{-\lambda t}]+C0\ e^{-\lambda t}$….(1)

Where C0 is the ^{222}Rn concentration (Bq m-3) present in the chamber volume at t= 0

M is the total mass of the dry sample (kg)

V is the effective volume (residual air volume of exhalation chamber r+ Porous Volume of Sample + internal volume of SMART RnDuo (m3))λ_e is the effective decay constant for ^{222}Rn, which is sum of the leak rate (if existing) and the radioactive decay constant of ^{222}Rn (h-1) is the measurement time (h)$C(t)=\frac{JmM\ t}{V}+C$……(2)Upon least square fitting of the data to the above equation one may obtain Jm from the fitted slope value with the information of the mass M of the sample and residual air volume, V of the set up. Emanation facto become free to migrate through the bulk medium.

Emanation factor $f=\frac{Jm}{CRa\ \lambda}C_{Ra}$ - Radium concentration in Bq/kg

III. RESULTS AND DISCUSSION

Activity concentrations of and ^{226}Ra, Mass exhalation rate of ^{222}Rn and emanation factor in the soil samples from Kovalam are shown in Table 1. The values of activity concentration of radium are given in Bq /kg of dry weight. Below Detectable Value (BDL) of ^{226}Ra is 4.7Bq/kg.

Table i

Values of radium concentration, radon mass exhalation rates and emanation factor of soil samples from perumathura.

Location	C Ra Bq/kg	Exhalation rate (mBq/kg/h)	Emanation factor
Perumathura			
PMA1	191.0±6.9	5.06	3.53
PMA2	200.3±6.2	5.57	3.71
PMA3	104.3±6.7	3.17	4.05
PMA4	142.3±4.7	3.23	3.03
PMA5	197.3±7.5	5.41	3.66
PMA6	192.0±7.6	5.09	3.53
PMA7	58.5±4	2.52	5.73
PMA8	312.0±6.4	6.50	2.78
PMA9	264.0±8.3	5.71	2.89
PMA10	287.1±12.5	6.76	3.14
PMA11	102.8±5.2	3.09	4.00
PMA12	112.5±5.1	3.55	4.21
PMA13	20.5±.7	1.91	12.43
PMA14	274.1±10.4	6.31	3.07
PMA15	148.0±5.6	5.15	4.64
Mean	173.76	4.60	4.29
Max	312	6.50	12.43
Min	20.5	1.91	2.78
STDDEV	86.22	1.55	2.38

In Perumathura the range and mean values (in brackets) of the activities for ^{226}Ra are 20.5 –312(173.76) Bq/kg, Mass exhalation rate varies 6.5-1.91(4.60) (mBq/kg/h), Emanation factor ranged between 2.78-12.43 (2.78) respectively.

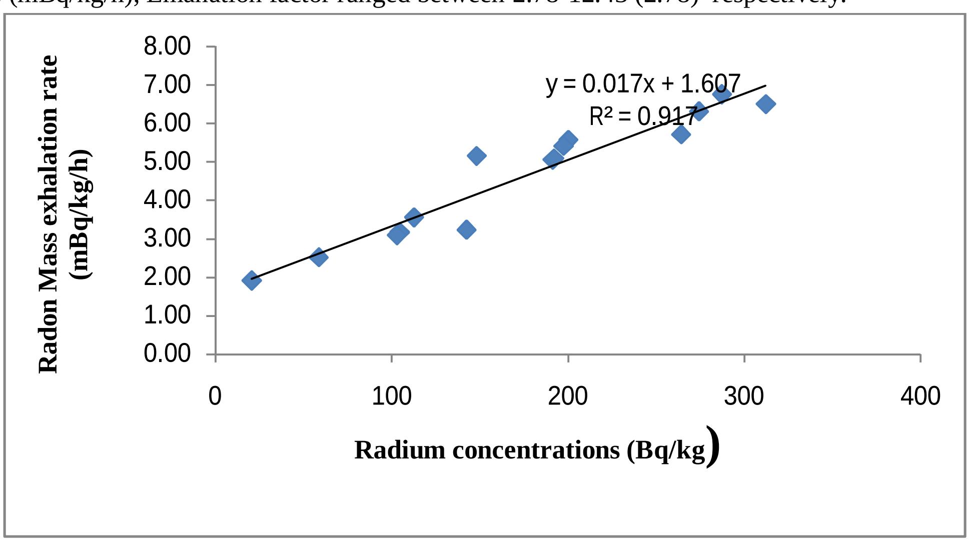

Figure 1: Mass exhalation rate Vs. Radium concentration of soil samples from Perumathura

Figure 1 represent the radium concentration values are found to be linearly dependent with radon mass exhalation rates.

Table II
Values of radium concentration, radon mass exhalation rates and emanation factor of soil samples from vizhinjam.

Location	C Ra Bq/kg	Exhalation rate (mBq/kg/h)	Emanation factor
Vizhinjam			
viz1	278.99±13.95	6.12	2.92
viz2	178.88±8.94	5.42	4.04
viz3	140.31±7.02	4.31	4.09
viz4	126.28±6.3	4.27	4.51
viz5	144.68±7.23	4.87	4.49
viz6	34.34±1.72	3.37	13.10
viz7	143.52±7.18	4.42	4.11
viz8	118.89±5.94	4.13	4.63
viz9	168.85±8.44	5.06	4.00
viz10	106.53±5.33	3.48	4.36
viz11	118.24±5.91	4.11	4.63
viz12	142.71±7.14	4.37	4.08
viz13	136.54±6.82	4.30	4.20
viz14	123.91±6.20	4.27	4.59
viz15	112.52±5.62	4.03	4.78
Mean	138.35	4.43	4.83
Max	278.99	6.12	13.10
Min	34.34	3.37	2.92
STDDEV	50.77	0.80	2.33

Table 2 shows in Vizhinjam, the range and mean values (in brackets) of the activities for ^{226}Ra are 34.34–278.99(138.35)Bq/kg, Mass exhalation rate varies 3.37-6.12(4.43) (mBq/kg/h),Emanation factor ranged between 2.92-13.10 (4.83) respectively.

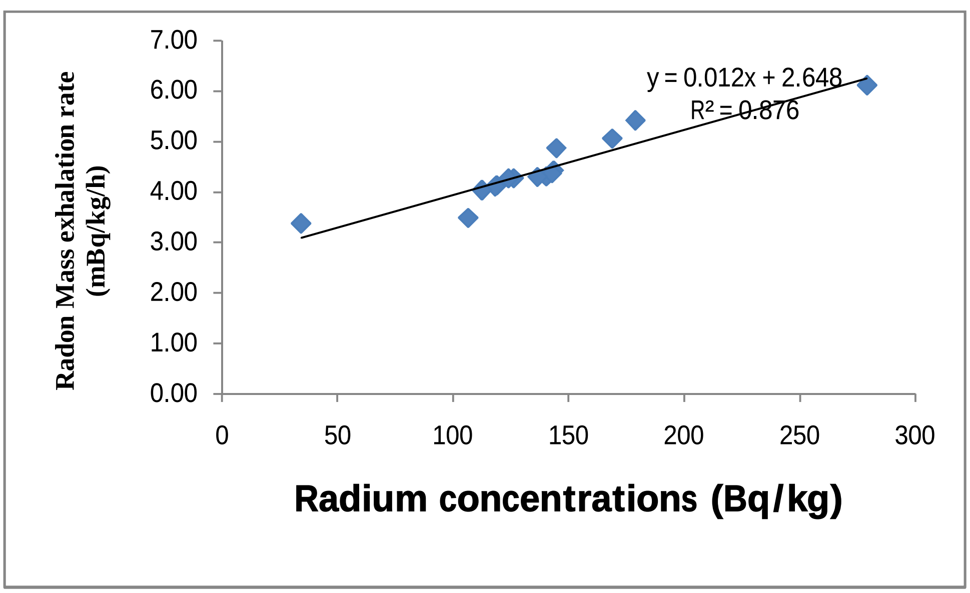

Figure 2: Mass exhalation rate Vs Radium concentration of soil samples from Vizhinjam

Figure 2 reflects the radium concentration values and radon mass exhalation rates of Varkala are found to be linear.

The uneven distribution of radioactivity concentration for different locations has been observed. The variation among radio nuclides in beach soil may be due to the continuous wave action, results in the deposition of heavy minerals along the sea shore[11]. The emanation factor of soil grains is variable because soil is generally composed of many kinds of mineral grains of different rock origins.

IV. CONCLUSION

The two regions under investigation Perumathura and Vizhinjam have higher specific activities for ^{226}Ra. The activity concentration of radium is non uniformly distributed across the study area. The results indicate that the measured values of radon exhalation rates strongly correlated with activity concentration of radium. Results reflects that proper precautions are necessary for masking the ^{222}Rn emission inside a dwelling when soil is used for construction of houses.

V. ACKNOWLEDGMENT

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