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Estimation of Radiation Dose Due to Air ,Water and Sand Along South West Coast of Kanyakumari District, Tamil Nadu

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Abstract :- The south west coastal region of Kanyakumari district is witnessed as a Naturally High Background Radiation Area. The outdoor Gamma radiation level and concentration of radon, thoron and their progeny level were measured using Environmental Radiation Dosimeter and Solid State Nuclear Track Detector(SSNTD) method. For assessing the environmental radiological impact to public it is essential to evaluate the activity levels of these daughter products of Uranium.. The gross alpha and gross beta activities of drinking water collected from bore wells were estimated for radiological assessment. Results of the Gamma ray spectrometric measurements carried out for natural radioactivity levels due to ^{226}Ra, ^{232}Th and^{40}K in the beach sand samples. The total dose rate was also calculated and the results are reported in this paper. This study provides a baseline data of radioactivity background levels in the coastal regions of Kanyakumari district from Colachel to Midalam and will be useful to assess any changes in the radioactive background levels.

Key words*: Radon, Thoron , Radiation level, dose*

I. INTRODUCTION

Exposure to ionizing radiation from natural sources is a continuous and unavoidable feature of life on earth[1]. There are few regions in the world known to be high background radiation areas due to local geology and geo chemical effects that cause enhanced levels of terrestrial radiation [1]. In the high background areas of the country such as Austria, Brazil, China, France, India and Iran the radiation levels were found to be high varying over an order of magnitude depending upon the site-specific terrestrial radioactivity[2]. In India there are quite a few monazite sand bearing placer deposits causing high background radiation along its long coastal line. Ullal in Karnataka [3], Kalppakkam in Tamil Nadu, coastal parts of Tamil Nadu and Kerala state and south western coast of India are known to be high back ground radiation areas [4]. One of the areas south west coast where high radiation level has been reported was from coastal regions of Kanyakumari district, in TamilNadu. Beach sand in these areas contains heavy minerals like ilmenite, rutile, zircon, monazite and sillimanite. ^{232}Th and ^{238}U are reported from these regions, caused mainly due to the monazite bearing black sands. The radionuclides concentration in underground water depends on the kinds of minerals surrounded, the chemical composition of the water, the water flow rate and the ions retention[5]. Radioactivity present in surface water is mainly due to the presence of radioactive elements in the earth's crust [6]. Surface water and especially ground water plays an important role in the migration and distribution of these radionuclides in the earth's crust.

The pre dominant isotopes in ground water are ^{226}Ra, an Alpha emitter with a half life of 1600 years and ^{228}Ra, a Beta emitter with a half life of 5.8 years [8] .In the NHBRAs, effective dose received by a person is contributed mainly by two factors. They are (1) External dose and (2) Internal dose. External dose comes from radioactive sources located outside the human body and internal dose is contributed by radionuclides deposited inside the human system. The main factors of internal dose are inhalation, ingestion and injection. Among these, inhalation accounts for more than 50% of the total exposure. Some of the contributions to the total exposure to natural background radiation are quite constant in air. Inhalation is mainly the air breathe in, by which radionuclides present in the air are transferred into the human body. Initially they are deposited in the lungs. Depending upon their solubility, size, chemical composition, attachment to other inert or active aerosol etc., from the lungs, their activity will be subsequently transferred to other organs such as bones and blood cells and can cause disease like cancer. Exposure of persons to high concentration of radiations and its short lived progeny for a long period leads to health risk. The most important radioactive element present in the air is Radon. Radon is a radioactive colorless, odorless, noble gas, occurring naturally as an indirect decay product of Uranium or Thorium. Radon has two important isotopes. They are radon-220 and radon-222. Radon-220 is called as Thoron and Radon-222 is often called as Radon. Both radon and thoron are radioactive and radon 222 is formed from the decay of Uranium-238 and radon-220 from Thorium-232. The

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radiological hazard from radon-220 (Thoron) is usually smaller than that from radon 222 because the half life of radon 220 is only 55 seconds while radon 222 has a life of 3.8 days.

Radon is often the single largest contributor to an individual's background radiation dose. More than 52% of the total background radiation dose is considered to be due to inhalation of indoor ^{222}Rn progeny[3]. Despite its short lifetime, some radon gas from natural sources can accumulate to form higher than normal concentrations in buildings. A number of studies reported the indoor radiation level in dwellings in different parts of the world[4,5,6]. In the Naturally High Background Radiation Areas of the world large scale residential radon surveys were carried out on population exposed to ionizing radiation[7,8,9]. About 52% of the total dose received by the population in India is reported to be due to inhalation of indoor radon progeny[6]. Measurement of radon activity inside domestic premises has become prominent after the correlations between exposures to high concentrations.^{222}Rn in uranium mines and the incidence of lung cancer among the miners have been established[10]. Elevated levels of radon in houses are thought to lead to increased malignancy, in particular lung cancer[11,12]. Radon enters buildings mainly from the ground by soil convection or soil diffusion through the underlying soils. Exposure ^{222}Rn and ^{220}Rn and their decay products may be extremely variable depending upon the construction of houses, radioactivity concentrations of the building materials used, ventilation rate and local geography and geology of the region[13,14]. If the ventilation in the houses is inadequate, the concentration of Radon may by hundred or even thousand times higher than the outside environment. The epidemiological studies have suggested that exposure to radon might be a cause of several forms of cancer including certain childhood cancers[15,16]. Hence the retention of the radionuclides inside the human system should be minimized. Assessment of radioactivity in air helps us to evaluate the impact of radioactivity on man[17]. Therefore the radiation exposure and effective dose received by the residents of the study area belonging to the NHBRA in Kanyakumari District of Tamil Nadu have been assessed and reported in this paper.

II. METHODOLOGY

A. Materials And Methods: Study Area And Sample Collection:

The study area is mainly the coastal stretch between Muttom to Midalam(Naturally High Background Radiation Area) ten major sites namely Muttom, Kadiapattinam, Chinnavilai, , Colachel, Simoncolony, Enayam, Midalam, Melmidalam, Thengaipattinam and Puthenthurai. In Kanyakumari district of Tamilnadu, India.

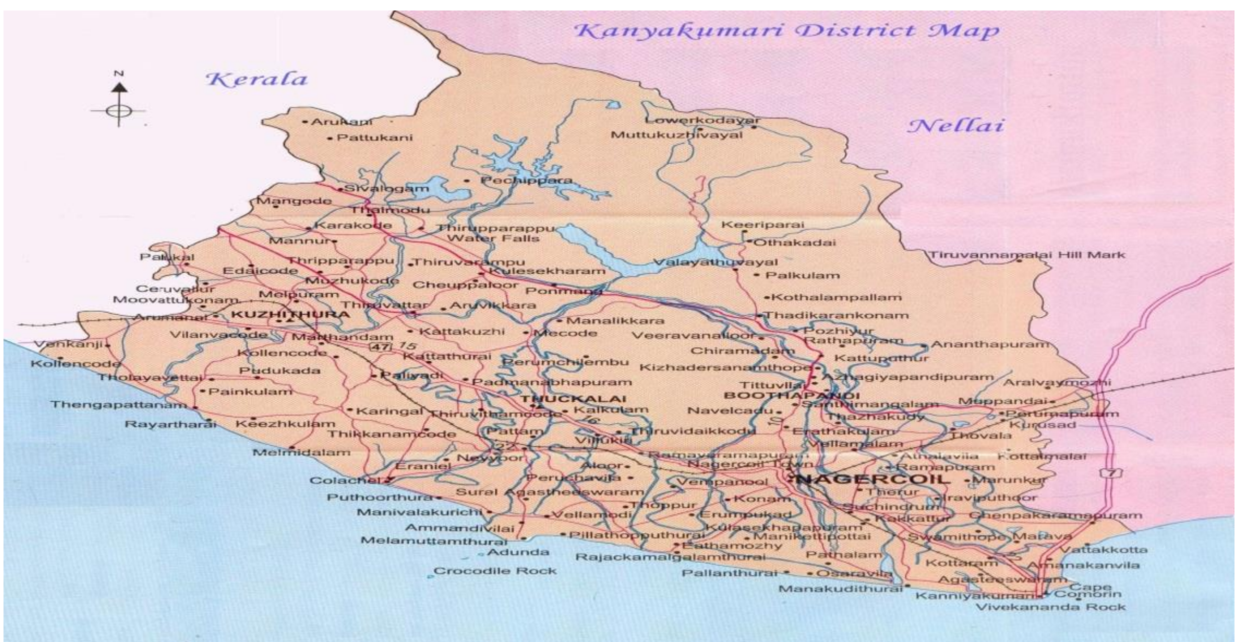

Fig 1: Map of study area

Soil samples collected from various beaches were brought to the laboratory. Organic material roots, vegetation pebbles etc., if present were removed and the samples were initially sun dried by spreading them in a tray. Samples were later dried in an oven at 110^0c for complete removal of moisture for 24hours. These samples were filled in plastic containers. Sample containers were filled with 300-500gm of the samples for uniformity and sealed with adhesive tapes to make them air tight depending on the density of the sample. These sample containers were stored for a period of one month before Gamma spectrometric analysis so as to allow the establishment of secular equilibrium between ^{226}Ra, ^{232}Th and their daughter products. Estimation of ^{226}Ra, ^{232Th} and ^{40}K in the sand samples were carried out by using high resolution Gamma ray spectrometry comprising a high purity NaI(Tl) detector.

10 liters of drinking water taken was filtered using whatmann filter paper. To the filtered water 10 ml of 10% pot dihydrogen phosphate, 2 ml of calcium chloride and drops of ammonia solution was added and left for a night. Decant the super natant liquid, the precipitate was separated and mixed with concentrated hydrochloric acid to get a clear solution. The solution was filtered and then concentrated by heating. One ml of barium chloride solution and one or two drops of concentrated sulphuric acid were added to it. The solution was properly stirred and then cooled. After cooling the precipitate was separated using centrifuge machine. Finally the precipitate was poured into an aluminium planchet and was dried by placing it under an infrared lamp. Then the sample was ready to analyze. The sample along with the planchet was kept in the drawer assembly of the alpha counting system for a period of 5000 seconds to measure the alpha activity of the sample.

Passive dosimeters were used for the simultaneous measurements of ^{222} Rn & ^{220}Rn and its progenies in dwellings around NHBRA of coastal of regions of Kanyakumari District in Tamil Nadu. The dosimeter system consists of a twin chamber dosimeter standardized at HPU of IREL Manavalakurichy. Houses selected for the survey were at random from the NHBRAs of Kanyakumari district from Colachel to Puthenthurai stretch. The dosimeters were installed in different dwellings at a height of 2.5 meters from the ground level. After a stipulated period of time (around 90 days) of exposure the films were retrieved and etched chemically in2.5N NaoH solutions at a constant temperature of 60 degree centigrade for 90 minutes. The etched films were peeled off from the base and dried using UV lamp. Tracks recorded Tracks recorded on peeled LR115 film were counted using microprocessor controlled spark counter.

III. RESULTS AND DISCUSSION

Table 1: Activity concentration of Radionuclides in Soil Samples (Bq/kg)

Sampling sites	**Average activity in Bq/kg**			
	^{226}Ra	**^{228}Ra**	**^{40}K**	**^{232}Th**
Muttom	131	116	85	1480
Kadiapattinam	126	114	76	1327
Chinnavillai	268	233	98	2650
Colachel	179	165	97	1875
Simoncolony	102	89	68	1189
Enayam	157	136	72	1623
Midalam	135	116	64	1415
MelMidalam	138	127	77	1399
Thengaipattinam	159	134	84	1582
Puthenthurai	141	119	88	1474

Table 2: Absorbed dose and Annual Effective Dose due to sand in air in the study area

Sampling sites	**Absorbed Dose(nGyh^{-1})**	**Annual Effective Dose (mSv)**
Muttom	958.01	1.17
Kadiapattinam	862.9	1.05
Chinnavillai	1728.5	2.11
Colachel	1823.2	2.23
Simoncolony	768.1	0.94
Enayam	1055.8	1.29
Midalam	918.79	1.12
Melmidalam	911.98	1.11
Thengaipattinam	1032.14	1.26
Puthenthurai	959.13	1.17

Table 2 gives the absorbed dose in air and the annual effective dose. The absorbed dose in air ranges from 768 to 1823 nGyh$^{-1.}$ To estimate the annual effective dose, the indoor occupancy factor and the conversion coefficient from the absorbed dose in air to effective dose must be taken into account. The annual effective dose ranges from 0.94 mSv to 2.23mSv.

Table 3: Annual Effective Dose received by the residents of the study area through drinking water

Sites	^{226}Ra (mSv)	^{228}Ra (mSv)	^{232}Th (mSv)	Annual EffectiveDose(mSv)
Muttom	0.008	0.016	0.007	0.031
	0.008	0.019	0.008	0.035
Kadiapattinam	0.010	0.023	0.010	0.043
Chinnavillai	0.011	0.024	0.009	0.044
Colachel	0.007	0.016	0.007	0.030
Simoncolony	0.008	0.015	0.008	0.031
Enayam	0.004	0.009	0.006	0.019
Midalam	0.006	0.019	0.007	0.024
Melmidalam	0.008	0.017	0.009	0.034
Thengaipattinam	0.009	0.018	0.009	0.036
Puthenthurai				

Table 3 gives the total annual effective dose received by the residents of the study area through drinking water. It is clear that the residents of Midalam receive the low dose rate of 0.019mSv/y and the residents of Chinnavilai receive a high dose rate of 0.044 mSv/y through drinking water, but even though it is high it does not exceed the limit of 1mSv/y prescribed by WHO. The results obtained are similar to that observed in other countries . According to ICRP recommendations the limit for public exposure should be 1 mSv/y. Table 4 gives the indoor radon and thoron levels measured using SSNTDs and the effective dose due to inhalation of radon and thoron estimated from the study area. It is evident from the table that the concentration of Radon is higher than that of thoron in all the study area.

Table 5 gives the annual effective dose due to the inhalation of radon and thoron. It is clear from the table that the average annual effective dose due to radon is nearly 20 times higher than that of thoron. There are many reasons for this. One of the reasons is that the thoron emanation from the thorium bearing mineral monazite is very low. It is less than 0.04 % whereas for radon it is more than 90%. This is again attributed by the radiological half life of radon which is 3.8 days and that for thoron is only 55 seconds. Hence the emanation rate for thoron is expected to be lower than that of radon. The ventilation pattern in the study area also plays an important role for the high concentration of radon. Under the influence of fast wind, the thoron concentration was not allowed to build up in the high background radiation areas.

Table 4: Inhalation Exposure due to Radon and Thoron measured using SSNTDS in the Study Area

Sampling sites	Indoor Equilibrium Equivalent Concentration (Bq m-3)		Effective Dose Equivalent (nSv/Bq m-3)	
	Radon	Thoron	Radon	Thoron
Muttom	24.18	11.14	36.27	16.71
Kadiapattinam	26.14	12.15	39.21	18.23
Chinnavilai	45.10	21.07	67.65	31.61
Colachel	31.37	14.57	47.06	21.86
Simoncolony	21.63	7.06	32.45	10.59
Enayam	15.69	8.34	23.54	12.51
Midalam	20.92	12.7	31.38	19.08
MelMidalam	30.07	14.45	45.11	21.68
Thengaipattinam	32.03	15.15	48.05	22.73
Puthenthurai	36.60	18.78	54.9	28.17

Table 5: Annual Effective Dose received by residents of the study area due to the inhalation of Radon and Thoron

Sampling sites	Annual Effective Dose (µSv)		Total Dose in (µSv)	Total Dose in (mSv)
	Radon	Thoron		
Muttom	4062	167	4229	4.2
Kadiapatinam	4392	182	4574	4.6
Chinnavilai	7577	316	7893	7.9
Colachel	5271	216	5487	5.5
Simoncolony	3634	106	3740	3.7
Enayam	2636	125	2761	2.8
Midalam	3515	191	3706	3.7
MelMidalam	5052	216	5268	5.3
Thengaipattinam	5382	227	5604	5.6
Puthenthurai	6149	281	6430	6.4

IV. CONCLUSION

The effective radiation dose received by the villagers in the study area was assessed in soil,water and in air using SSNTDs for measuring the indoor radon and thoron concentration. The results obtained show that the effective doses received by villagers of Chinnavilai, Thengaipattinam and Puthenthurai are higher when compared to other villages. These high doses indicate higher concentration of radioactive nuclides like thoron and uranium in the soil of these areas. It should also be noted that the effective dose estimated from Chinnavilai 10.85 mSvy-1 exceeds the ICRPs recommendation limit. As the excess of radiation is harmful to life, it is necessary to take steps to reduce the radiation level. The external and internal dose present in the study area can be reduced by removing the monazite content present in the soil, by mineral separation. The internal dose due to radon and thoron can also be reduced by providing proper ventilation to the houses.

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