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# NATURAL RADIOACTIVITY MEASUREMENT IN WETLANDS BORDERING THE HILLOCKS OF WESTERN GHATS, KANYA KUMARI DISTRICT, TAMIL NADU, INDIA

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## Abstract

This paper deals with the estimation of natural radioactivity levels in soil (sediment), plants and water samples of three different wetlands, where the soil and sediment were used as building material and the plant and the water were consumed by cattle grown by the residents of the pond area. The water is also consumed by human beings of this area. The activity profile of radionuclides shows low activity across the study area. Radiation hazard indices like radium equivalent activity, absorbed dose rate, annual effective dose, external hazard index and internal hazard index were calculated. All the calculated hazard indices are well below their recommended limits. The soil and sediment from the study area provide no excessive exposures for inhabitants and can be used as the building materials without having any threat to the population. The water and the plants are also not having any radiation dose through ingestion.

***Key words :*** Natural radionuclides, lake sediment, wetland ponds, hazard indices.

## Introduction

Human exposure to ionizing radiation is one of the scientific subjects that attract public attention. Everyone on the earth is exposed to some background level of radiation. Hence, human should be aware of their natural environment with regard to the radiation effects due to the naturally occurring radioactive elements. Knowledge about the distribution of radioactive element enables one to asses any possible hazard to mankind by the use of such materials (Narayana *et al.*, 2007; Ramasamy *et al.*, 2004; Kumar *et al.*, 2009 and Suresh *et al.*, 2011). Human beings are exposed to natural background radiation every day from the ground, building materials, air, food, the universe and even elements in their own bodies. The radioactivity of soil is essential for understanding changes in the natural radiation background. Among the various building materials, lake sediment (sand) is one of the major mixing materials for building in the field of construction in India, especially in Tamil Nadu (state). Sediment acts as a medium of migration for transfer of radio nuclides to the biological systems. Natural radiation in river sediment generates a significant component of the background radiation exposure of the population (Degerlier *et al.*, 2008). Estimation of the radiation dose distribution is vital in assessing the health risk to the population and serves as a reference for documenting changes in environmental radioactivity due to anthropogenic activities (Obed *et al.*, 2005). Humans are also exposed by contamination of the food chain, which occurs as a result of direct deposition of radionuclides of plant leaves, root uptake from contaminated soil, sediment or water (Arogunjo *et al.*, 2004).

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### Study area

The study area is situated bordering the hillocks of western-ghats. It is located at about 5-8 kilometres north east of Nagercoil, Kanya Kumari district (Tamil Nadu), India. The three selected wetlands I, II and III lie between $8^0$ 12' 20.15" north latitude and $77^0$28' 22.19" east longitude, $8^0$12'46.47" north latitude and $77^0$24' 31.95" east longitude and $8^0$15' 30.19" north latitude and $77^0$26'10.10" east longitude, respectively. These are perennial freshwater bodies. All these water bodies lies within 15 km distance from the NHBRA existing along the coastal stretch of K.K. district. The main aim of the present study is to see weather the NHBRA has any influence on these water bodies. The water of these fresh water bodies are used by the public for drinking, cooking, bathing, washing and to feed the cattle. The soils of these ponds are used as building materials for the construction of their houses. Plants of these ponds are given to the cattle grown by the residents of the study area.

### Experimental procedure

The sediment samples were manually collected with the help of plastic spade in polyethylene bags from upper surface of the ponds. About 1 kg of the sand sample was collected from each location. From each pond at a maximum of 5 locations were selected for the sample collection. The samples were first air dried for 2 or 3 days, then dried in an oven at 100 – 110° C for about 24 hrs. The dried samples were sieved through sieve of 2mm mesh size. The homogenized samples were placed in an air tight PVC container for about a month to ensure equilibrium between $^{226}Ra$ and its daughter products before being taken for gamma ray spectrometric analysis (Ramasamy *et al*., 2004). The concentration of primordial radionuclide in the sample was determined by using high efficiency NaI (Tl) detector coupled with a multi channel analyzer (MCA). The spectrometer was calibrated using different standards. To determine the activity concentration of various radionuclide, the spectrum was analyzed by employing simultaneous equation method (Abani, 1994). The activity of $^{40}K$ was evaluated from the 1461 keV photo peak, activity of $^{226}Ra$ from 1764 keV gamma line of $^{214}Bi$ and that of $^{232}Th$ from the 2614 keV gamma line of $^{208}Tl$ (Quindos *et al*., 1994). The activity was counted for sufficiently long time (10000s) to reduce the counting error. The background spectrum was recorded immediately after or before the sample counting. From the measured activities of $^{226}Ra$, $^{232}Th$ and $^{40}K$, the radiological parameters are calculated. About 450 to 500g of samples were used for measurements. The exact net weight of the samples was determined before counting. All samples were counted for a period of 10000s. The activity levels of the samples obtained for $^{226}Ra$, $^{232}Th$ and $^{40}K$ are expressed in Bq $kg^{-1}$.

The plants around the boarder of these ponds are given to the cattle grown by the residents of the pond area. The plant samples from the boarder of the pond are collected. They are dried using sunlight. After drying they are crushed and then placed inside the muffle furnace to get the ash of the sample for 12 hours. Now the sample in the form of ash is ready for further analysis. So the plants are collected and made in the form of ash with the help of muffle furnace and are analyzed just like soil samples.

### Radiological parameters

The distribution of $^{226}Ra$, $^{232}Th$ and $^{40}K$ in soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity ($Ra_{eq}$) in Bq/kg to compare the specific activity of materials containing different amounts of $^{226}Ra$, $^{232}Th$ and $^{40}K$. It is calculated through the following relation (Yu *et al*., 1992).

$$Ra_{eq} = C_{Ra} + 1.43\ C_{Th} + 0.07\ C_K \quad (1)$$

A widely used hazard index called the external hazard index, $H_{ex}$ is defined by Mariya *et al*. (2008).

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_k/4810 \quad (2)$$

In addition to external hazard index, radon and its short lived products are also hazardous to the respiratory organs. The internal exposure to radon and its daughter product is quantified by the internal hazard index. The internal radiation Hazard $H_{int}$ was calculated using the formula:

$$H_{int} = C_{Ra}/185 + C_{Th}/259 + C_k/4810 \quad (3)$$

The absorbed dose rate (D) due to gamma radiations in air at 1 m above ground level for the uniform distribution of naturally occurring radionuclides were calculated using the following relation (UNSCEAR, 2000).

$$D = 0.462\ C_{Ra} + 0.604\ C_{Th} + 0.042\ C_k \quad (4)$$

Where, D is the absorbed dose rate in nGy $h^{-1}$ and $C_{Ra}$, $C_{Th}$ and $C_k$ are the activities (Bq/kg) of $^{226}Ra$, $^{232}Th$ and $^{40}K$, respectively.

To estimate the annual effective dose rate, the conversion coefficient from absorbed dose in air to effective dose (0.7 $SvGy^{-1}$) and outdoor occupancy factor of (0.2) proposed by UNSCEAR 2000 were used. The annual effective dose rate in units of mSv $y^{-1}$ was calculated by the following formula.

$$\text{Annual effective dose} = D \times (24 \times 365)\ h \times 0.7 \times 0.2 \times 10\ mSv\ y^{-1} \quad (5)$$

## Results and Discussion

From the gamma spectrum photo peaks the naturally occurring radionuclides were determined ($^{232}Th$, $^{226}Ra$, $^{238}U$ and $^{40}K$) in soil and plant samples. The obtained values are for the sediment samples presented in table 1. The activity concentration of Radium–226 ranged from 4.33 Bq/kg to 18.95 Bq/kg. The maximum concentration was found in pond 1 and the minimum concentration in pond 2. The Thorium- 232 concentration ranged from 0.18 Bq/kg to 0.58 Bq/kg. In this the maximum concentration was found in pond 1 and the minimum concentration in pond 3. The activity concentration of

**Table 1 :** Activity concentration of radionuclides in soil samples.

| Location | Number of samples | $^{226}$Ra Bq kg$^{-1}$ | $^{232}$Th Bq kg$^{-1}$ | $^{40}$K Bq kg$^{-1}$ | $^{238}$U Bq kg$^{-1}$ |
|---|---|---|---|---|---|
| Pond 1 | 5 | 18.95±0.24 | 0.58±0.02 | 12.02±0.12 | BDL |
| Pond 2 | 5 | 4.33±0.03 | 0.39±0.03 | 9.20±0.13 | BDL |
| Pond 3 | 5 | 6.80±0.03 | 0.18±0.02 | 17.59±0.18 | BDL |

**Table 2 :** Radiation hazard indices and the annual effective dose calculated from soil samples.

| Location | $Ra_{eq}$ (Bq/kg) | $H_{int}$ | $H_{ext}$ | Absorbed dose in air (nGyh$^{-1}$) | Annual effective Dose (µSv y$^{-1}$) |
|---|---|---|---|---|---|
| Pond 1 | 20.62 | 0.11 | 0.06 | 9.61 | 11.79 |
| Pond 2 | 5.53 | 0.03 | 0.02 | 2.62 | 3.22 |
| Pond 3 | 8.29 | 0.04 | 0.02 | 3.99 | 4.89 |

**Table 3 :** Activity concentration of radionuclides in plant samples.

| Location | Number of samples | $^{226}$Ra Bq kg$^{-1}$ | $^{232}$Th Bq kg$^{-1}$ | $^{40}$K Bq kg$^{-1}$ | $^{238}$U Bq kg$^{-1}$ |
|---|---|---|---|---|---|
| Pond 1 | 5 | 2.12±0.03 | 0.03±0.01 | 1.98±0.04 | BDL |
| Pond 2 | 5 | 0.46±0.04 | 0.04±0.01 | 2.01±0.01 | BDL |
| Pond 3 | 5 | 0.98±0.06 | 0.01±0.01 | 3.64±0.13 | BDL |

$^{40}$K ranged from 9.20 Bq/kg to 17.59 Bq/kg. Here, the maximum concentration was found in pond 3 and the minimum concentration in pond 2. The presence of Uranium-238 is also estimated in all the three pond soil samples and is found to be the BDL (Below the Detectable Limit) level only. The soil of these ponds is mainly used for the construction of mud houses, by the residents near the pond area. So using the estimated values of $^{232}$Th, $^{226}$Ra, $^{238}$U and $^{40}$K the Radium equivalent activity, absorbed dose in air, the annual effective dose and some hazard indices were calculated and tabulated in table 2. Radium equivalent activity of the soil sample ranges from 5.53Bq/kg to 20.62 Bq/kg. Here, pond 1 is showing maximum value and pond 2 is showing minimum value. The same observation is recorded in internal hazard index and external hazard indices. The calculated value of observed dose is also maximum in pond 1 and is minimum in pond 2. The annual effective dose ranges from 3.33 µSv y$^{-1}$ (pond 2) to 11.79 µSv y$^{-1}$ (pond 1). All the calculated values are well below the permitted dose values recommended by Organization for Economic Cooperation and Development (OECD, 1979). Comparing all the radionuclides potassium only shows little bit high value. The value of $^{40}$K observed may be due to heavy agricultural activities going on in the area that involve the use of potassium fertilizers.

For the plants collected from the study area are also analyzed just like the soil samples. The concentration of the radionuclides $^{232}$Th, $^{226}$Ra, $^{238}$U and $^{40}$K were calculated all the values are very much low and are presented in table 3.

The water of the ponds was used by the residents of the area for drinking, cooking, bathing and to feed the cattle. So the gross alpha and the gross beta activity of the samples were calculated by sending the samples to the water Analytical Testing Laboratory (SGS – India Private Limited) and the result shows no such activity.

## Conclusion

Natural radionuclides can enter into the human body through inhalation and ingestion. The natural radioactivity due to $^{226}$Ra, $^{238}$U, $^{232}$Th and $^{40}$K were measured in soil, sediment and plant from the three different ponds using gamma ray spectrometer. The activity concentration of the radionuclides clearly showed low activity concentration across the study ponds. Therefore, the soil and the sediment taken from these ponds have no immediate health implication for the inhabitants and they can be used as building material without having any significant radiological threat to the population. The plants collected from the ponds also showed very low activity. Gross alpha and gross beta activity for the water samples estimated were well below the safe limit, so they can be used as cattle feeds without having any fear of radioactivity.

## References


Abani, M. C. (1994). Methods for processing of gamma ray spectra using computers. In: Refresher Course in Gamma Ray Spectroscopy. *BARC*.

Arogunjo, M. A. and I. P. Farai (2004). Impact of oil and gas industry to the natural radioactivity distribution in the delta region Nigeria. *Niger. J. Phys*., **16** : 131-136.

Degerlier, M., G. Karahan and G. Ozger (2008). Radioactivity concentrations and dose assessment for soil samples around Adana, Turkey. *J. Environ. Radioact*., **99** : 1018-1025.

Kumar, M., J. Slivka, E. Varga, I. Bikit and M. Veskovic (2009). Correlations of natural radionuclides in sediment from Danube. *J. Geochem. Explor*., **100(1)** : 20-24.

Mariya Jankovic, Dragana Todorovic and Milovan Savanovic (2008). Radioactivity measurements in soil samples collected in the Republic of Srpska. *Radiation Measurements*, **43** : 1448-1452.

Narayana, Y., K. M. Rajasekara and K. Siddappa ( 2007). Natural radioactivity in some major rivers of coastal Karnataka on southwest coast of India. *J. Environ. Radioact*., **95** : 98-106.

Obed, R. I., I. P. Fari and N. N. Jibiri (2005). Population dose distribution due to soil radioactivity concentration levels in 18 cities across Nigeria. *Journal of Radiological Protection*, **25** : 305-312.

Organization for Economic Cooperation and Development (OECD) (1979). Exposure to radiation from the natural radioactivity in building materials. Report by a group of Experts of the OECD Nuclear Energy Agency, Paris, France.

Quindos, L. S., P. L. Fernandez, J. Soto and J. Rodenos Cand Gomez (1994). Natural radioactivity in Spanish soils. *Health Physics,* **66** : 194-200.

Ramasamy, V., S. Murugasen and S. Mullainathan (2004). Gamma ray spectrometric analysis of primordial radio nuclides in sediments of Cauvery river in Tamilnadu, India. *The Ekologia*, **2** : 83-88.

Senthyl Kumar, B., V. Dhavamani, S. Ramkuma and P. Philominathan (2010). Measurement of gamma radiation levels in soil sample from Thanjavur, using gamma ray spectrometry and estimation of population exposure. *J Med. Phys*., **35** : 48-53.

Suresh, G., V. Ramasamy, V. Meenakshisundara, R. Venkatachalapathy and V. Ponnusamy (2011). A relationship between the natural radioactivity and mineralogical composition of the Ponnaiyar river sediments, India. *Journal of Environmental Radioactivity*, **102** : 370-377.

UNSCEAR (2000). United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Sources, Effects and Risks of Ionizing Radiation Report to the General Assembly, United Nations, New York, USA.

Yu, K. N., Z. J. Guan, M. J. Stoks and E. C. Young (1992). The assessment of natural radiation dose committed to the Hong Kong people. *Journal of Environmental Radioactivity*, **17** : 31- 48.