Journal of Environmental Radioactivity 127 (2014) 64–74

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

# Role of sediment characteristics on natural radiation level of the Vaigai river sediment, Tamilnadu, India

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ARTICLE INFO

*Article history:*
Received 11 April 2013
Received in revised form
19 August 2013
Accepted 26 September 2013
Available online 23 October 2013

*Keywords:*
Radioactivity
Sediment characteristics
Organic matter
Multivariate statistical analysis

ABSTRACT

The sediment characteristics such as granulometric contents (sand, silt and clay), organic matter, magnetic susceptibility (low and high frequency) and weight percentage of magnetic minerals and the natural radionuclide ($^{238}$U, $^{232}$Th and $^{40}$K) contents have been analyzed for the sediment samples of Vaigai river with an aim of evaluating the radiation hazard nature and assessing characterization of sediment. Granulometric analysis confirmed that the sand is major content. The organic matter content is ranged from 0.30 to 8.62% and comparison shows that the present river has high organic content. The magnetic measurement results indicated that the sites $S_{16}$, $S_{18}$ and $S_{25}$ may be affected anthropogenically. Frequency dependence magnetic susceptibility is calculated to know the contribution of grains to magnetic susceptibility. Average of activity concentrations (except $^{40}$K) and all calculated radiological parameters are within the recommended level. Multivariate statistical analyses (Pearson correlation, cluster and factor analysis) dictated that the role of sediment characteristics on the level of radioactivity in the river sediments. The content of organic matter and clay, and magnetic parameters are positively correlated with important radioactive variables. The measurement of organic matter and magnetic susceptibility in various granulometric contents show some higher values in silt and clay fractions. Radioactivity level was also measured for the samples (after removing silt and clay fractions from bulk samples) and the results show decrease in radioactive variables. The present study stated that the lower grain sized fractions have the ability to absorb the contents such as organic content and magnetic minerals as cations on their surface and raise the level of radioactivity. Percentage of decrease in the natural radionuclides of $^{238}$U, $^{232}$Th, $^{40}$K and absorbed dose rate of the samples (after removing the silt and clay fractions from bulk samples) to the bulk samples are 13.59, 33.37, 20.52 and 26.13% respectively. Thus, it is concluded that the radiation effect does not pose to the public those who are using these sediments.



## 1. Introduction

The human population is always exposed to ionizing radiation due to background radiation. Besides man-made radiation, the main source of background radiation is natural radioactivity. Natural radioactivity has existed since the beginning of the universe due to long half-live of the natural radioelement found in the earth's crust (Mavi and Akkurt, 2010). These radionuclides of $^{238}$U, $^{232}$Th and $^{40}$K can be found almost in all geological formations like soils, sediments, rocks, plants, sand, water and air. Hence, humans should be aware of their natural environment with regard to the radiation health effects. Continuous exposure to even low level radiation may adversely affect human health. Exposure to ionizing radiation can damage living organisms and cause health effects in humans, including leukaemia and other cancers (IAEA, 2006). As well as, the knowledge about the concentration of the radionuclides is of great interest since it provides useful information in the monitoring of environmental contamination by natural radioactivity. Therefore now a days, human exposure to ionizing radiation is one of the scientific subjects that attracts public attention, since radiation of natural origin is responsible for most of the total radiation exposure of the human population.

Among the various geological formations, sediment plays a predominant role in aquatic radioecology and plays a role in accumulating and transporting contaminants within the geographic

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http://dx.doi.org/10.1016/j.jenvrad.2013.09.010

area. It is the basic indicator of radiological contamination in the environment. However, sediment depositions on the bottom of rivers are frequently consist of sand and gravel particles, which make them particularly valuable for the building construction in Tamilnadu and nearby states, India. Therefore, the radionuclides concentrations and their distributions, and its associated dose rates in the Tamilnadu river sediments should be monitored. With this aim, function of minerals in the natural radioactivity level of Vaigai river sediments has studied and published by Ramasamy et al. (2014). In that article, Activity concentration of radionuclides ($^{238}$U, $^{232}$Th and $^{40}$K) and their radiological parameters were measured. Moreover, the mineralogical characterization of the Vaigai river sediments and its accompanied nature with natural radioactivity were also studied.

Generally, specific activities of radionuclides in river sediments mainly depend on geological, geographical and geochemical conditions of the materials. The activities of the radionuclides in any given environment also depend on human economic and technological activities, etc. (Jibiri and Okeyode, 2011). Specifically, activity concentrations and their mobility in the sediment depend on the some important physico-chemical parameters such as organic matter, pH and granulometric contents, and magnetic characterization (Narayana and Rajashekara, 2010; Aytas et al., 2012; McCubbin et al., 2004; Suresh et al., 2011a). The organic matter is a component of great importance because it tends to form soluble or insoluble complexes with the heavy elements (Al-Trabulsy et al., 2010). The content of organic matter is indirectly stated the pH value of the sediment. If the organic matter content in sediment is high, pH value is shifted to low acidic condition (Narayana and Rajashekara, 2010). Thus, the influence of sediment characteristics/physico-chemical properties on natural radioactivity level in the river sediment should also be analyzed. For this, core radioactivity data and their discussion are taken from Ramasamy et al. (2014) to correlate them with sediment characteristics such as granulometric content (sand, silt and Clay (%), organic matter and magnetic susceptibility.

Hence, the present study is intended to (i) Analyze the sediment characteristics such as granulometric contents (sand, silt and clay), content of organic matter, magnetic susceptibility and weight percentage of magnetic minerals of the sediment of Vaigai river, Tamilnadu, India. (ii) assess the role of sediment characteristics on natural radiation level of the river sediment using multivariate statistical analysis and finally (iii) compare the radioactivity level of the samples (after removal of silt and clay) with radioactivity level of bulk samples.

## 2. Materials and methods

### 2.1. Study area

In the present study, sediment samples were collected from various sites of the Vaigai River. It is originated on the Varushanadu hills in Theni district and terminated at Ramnad district of Tamilnadu state in Bay of Bengal. It covers five districts (Theni, Dindigul, Madurai, Sivagangai and Ramnad) in Tamilnadu. Vaigai dam was constructed across the river nearer to Andipatti and Theni. Capacity of the dam is nearly 172 M.Cu.metre. It provides water for irrigation to the Madurai and Dindigul districts as well as drinking water to Madurai city and Andipatti town. The sediments of this river are excavated only for building constructions. Other importance of study area was presented in Ramasamy et al. (2014).

### 2.2. Sample collection

The present study area (Vaigai river) covers from Varushanad hills (Theni) (Lat: 9°44′30″ N; Long: 77°30′52″E) to Athangarai (Palk Strait) of Ramnad (Lat: 9°20′45″ N; Long: 78°59′59″E), which covers an area about 240 km, from which 40 successive locations were selected and numbered as $S_1$ to $S_{40}$ (Fig. 1). Each sampling location is separated by a distance of 5–6 km approximately. All sediment samples were collected at 0–10 cm depth during the summer season (April–May 2011). Each sample has a weight of 3–4 kg approximately. The collected samples were dried at room temperature in an open air for two days and stored in black polythene bags. The exact position of each sampling site was recorded using hand held GARMIN GPS meter (Global Positioning System, Model No. 12).

### 2.3. Analysis of sediment characteristics

#### 2.3.1. Granulometric and organic matter analysis

The samples were examined to measure their granulometric fractions such as contents of sand, silt and clay. About 100 g of sediment were taken for separation of sand, silt and clay fractions by sieving (Suresh et al., 2011b). In order to determine the organic matter (OM) in the samples, 20 g of bulk samples and 5–10 g of various grain sized samples were taken for analysis. In the present study, organic matter was determined by the weight loss-on-ignition method at an ignition temperature of 550 °C for 24 h (Al-Trabulsy et al., 2010).

#### 2.3.2. Magnetic susceptibility measurements

*2.3.2.1. Sample preparation and instrument used.* The dry sediment samples (bulk and various grain sized) were sealed with cling film, then packed with palaeomagnetic plastic boxes (8 cm$^3$). To ensure that the variable sample volumes did not influence results, containers were filled to at least half of their capacity. The net weight was determined before magnetic measurements. Such specimens were hardened using a sodium silicate solution. Magnetic susceptibility measurements were carried out using a magnetic susceptibility meter, Bartington Instruments Ltd., linked to MS2B dual frequency sensor (0.47 and 4.7 KHz). For the laboratory measurements, five readings were taken for each sample in two different frequencies (Low and High) and an average is calculated (Ramasamy et al., 2009).

#### 2.3.3. Magnetic mineral extraction method

Magnetic materials were extracted from the dry sediment samples using a ~0.1 T ferrite magnet and a ~0.3 T rare earth magnet. The ~0.1 T ferrite magnet was used to extract strongly magnetic particles (magnetite dominated) and ~0.3 T rare earth

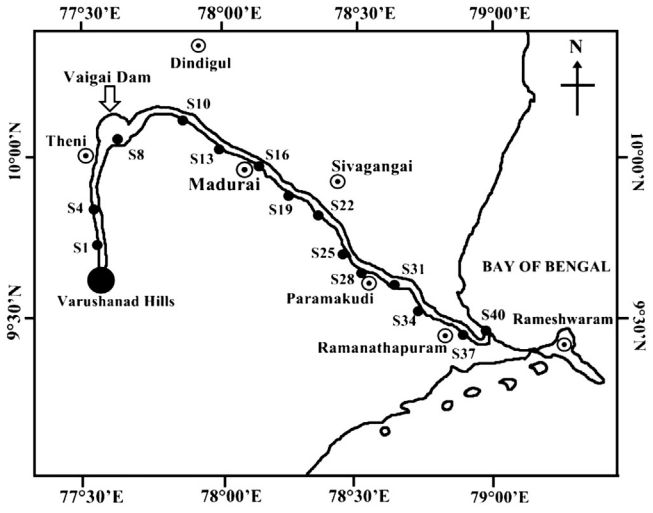


**Fig. 1.** Location of Vaigai river with their experimental sites in Tamilnadu.