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*Research Paper*

# A study on the distribution pattern of radioactivity in the heavy minerals of coastal sands of Kanyakumari District

***Ragel Mabel Saroja R.[1], Isac Sobana Raj.C[2], Subala J.[3]**
[1]Department of Chemistry and Research, Scott Christian College, Nagercoil, INDIA
[2]Department of Chemistry and Research, Nesamony Memorial Christian College, Marthandam, INDIA
[3]Department of Chemistry, Ruben College of Arts and Science, Thadikkarankonam, INDIA

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**Abstract**

**The study of gross α and β activities of samples collected from five different locations between Colachel and Chinnavilai, spanning across a distance of 6 km indicate wide variation in their activity. Colachel beach sands recorded maximum activity, the values are lowest in the samples collected along the Chinnavilai beach. An examination of the activities of different size fractions of the beach sands has established the presence of the maximum quantities of fine samples of heavy minerals in the finest fraction. The highest α-activity of sand samples is recorded in Colachel beach and the lowest α-activity is recorded in Chinnaviali. The highest β-activity of soil samples are observed in Colachel station and the lowest β-activity of soil are samples observed in Chinnavilai station.**

**Keywords**: Radio Activity, Heavy Minerals, Coastal Sands, *α*-activity, *β*- activity

## Introduction

All forms of life on earth including man have evolved in the presence of radiation and have always been exposed to them from the natural environment. These radiations are produced during decay of radioisotopes. These radioisotopes are present in the ground we walk on, the air we breathe, and the food we eat. Some are more exposed than others because of the type of the dwellings, location of habitation, their life styles and the level of medical care they receive. The assessment of the radiation dose in the environment from natural sources is of particular importance, because a major contribution (87%) to the total dose received by human beings comes from naturally existing sources and the manmade sources contribute the remaining. The present study deals with the study of gross α and β activities of samples collected from five different locations between Colachel and Chinnavilai, spanning across a distance of 6 km indicate wide variation in their activity. Colachel beach sands recorded maximum activity; the values are lowest in the samples collected along the Chinnavilai beach.An examination of the activities of different size fractions of the beach sands has established the presence of the maximum quantities of fine samples of heavy minerals in the finest fraction. The highest α-activity of sand samples is recorded in Colachel beach and the lowest α-activity is recorded in Chinnaviali. The highest β-activity of soil samples are observed in Colachel station and the lowest β-activity of soil are samples observed in Chinnavilai station.

## Materials and Methods

### Sample Collection and Processing of the Sample

Five sampling stations were selected along the south west coast from Thenkapattanam to Chinnavilai. The beach surface sands were collected from each sampling site in polythene bags and dried in a hot

air oven at 110°C. The samples were passed through different sieves of size 425µm, 300µm, 212µm, 125µm to obtain four different fractions. Approximately 0.06 g of the sample from each fraction was powdered using agate motor and spread as fine layer in an aluminum planchet and its Gross alpha activity was measured using alpha scintillation counter with ZnS (Ag) detector Gross beta activity was measured using low beta counting system. **(ECIL Model BCS36A)**

**Study area**
The study area includes coastal regions of the south west coast of India from Colachel to Chinnavilai of Kanyakumari District. The deposits of the various sampling stations along the study area are given below.
**Station:** Colachel, Muttom, Kottilpadu, Puthoor, Chinnavilai

**Minerals**
Beach placer deposits around the world are known for their economic concentrations of heavy minerals such as monazite, zircon, ilmenite, rutile, garnet and sillimanite. Those enriched radioactive minerals are of special interest for their use in nuclear industry[1,2], and potential for environmental hazard engendered from natural radiation[3-5].

**Formation of heavy minerals**
In general, the weathered products of country rocks from the interior hinterlands containing radioactivity are transported by the rivers and deposited at the downstream and along the coastal region as placer deposits and this process is controlled largely by the geomorphologic (drainage patterns) and atmospheric (rainfall) set up in the region[6]. The combined effect of weathering, rivers and streams, morphological features of the river basins and their interaction with the sea influenced the distribution of the heavy minerals in the beach sectors along the southwest coastal zone. The study done by in Manavalakurichi also shows that the highest gross β -activity recorded in the finest sand fraction[7].

**Heavy Minerals**
Heavy minerals are volumetrically minor constituents in terrigenous rocks. They are characterized as having a specific gravity greater than 2.85 g/cm$^3$.

**Ilmenite**
Ilmenite ($FeTiO_3$) is an important and most abundant mineral of titanium. It is black in colour, magnetic and conducting. The specific gravity is 4.7 g/cm$^3$. It is mainly used in the manufacture of titanium dioxide (a white pigment) which is used in paints, paper, rubber, textiles etc.

**Rutile**
It is optically homogeneous mineral, with composition of essentially pure $TiO_2$[8] . The alteration Rutile ($TiO_2$) is black in colour. It is non - magnetic, but conducting, specific gravity is 4.25g/cm$^3$.

**Kyanite**
It is chemically known as $Al_2Si0_5$. Specific gravity of kyanite is 3.55 - 3.66g/cm$^3$. It is typically a blue silicate mineral, commonly found in aluminium. Kyanite is a member of the aluminosilicate series, which also includes the polymorph alusite and the polymorph sillimanite.

**Leucoxene**
It is chemically known as $Fe_{2-x}\ Ti_{3+x}O_{9+x/2}$. The specific gravity is 3.9-4.2 g/cm$^3$. It is a fine granular alteration product of titanium minerals. It varies in color from yellow to brown. It consists mainly of rutile or anatase. It is observed in some igneous rocks and iron ore deposits as the result of the alteration of ilmenite, perovskite, or titanite[9].

**Garnet**
This is another important heavy mineral found in our coast. It is red in colour and magnetic. But it is non -conductive. Its specific gravity is 4.11 g/cm$^3$. It is chemically known as $Fe_3Al_2\ (SiO_4)_3$.

**Sillimanite**
It is chemically known as $Al_2SiO_5$. It is brownish white in colour non- magnetic and non-conducting. Its specific gravity is 3.25 g/cm$^3$.

**Zircon**
Zircon ($ZrSiO_4$) is brown in colour. It is non-magnetic and nonconducting, The specific gravity of zircon is 4.68 g/$cm^3$.

**Monazite**
The chemical composition of monazite is (Ce, La, Y, Th)$PO_4$ and the molecular weight is 240.21g. Monazite contains 0.2-0.4% uranium as $U_3O_8$ and 4.5-9.5% thorium as $ThO_2$ depending on the region, of occurrence.

**Results and Discussion**

Colachel area, the gross alpha activity varies from 884.95 to 1488.09 Bq/kg with a mean value of 1065.02 Bq/kg. In Muttom area, the gross alpha activity lies between 297.61 to 1724.13 Bq/kg with a mean value of 982.218 Bq/kg. In Kottilpadu area, the gross alpha activity lies between 595.23 to 892.85 Bq/kg with a mean value of 776.2725 Bq/kg. In Puthoor area, the gross alpha activity varies from 303.03 to 1129.94 Bq/kg with a mean value of 783.28 Bq/kg. Chinnavilai sample have recorded the lowest value of with the 292.39 Bq/kg and highest value of 1488.09 Bq/Kg mean value being 741.42 Bq/Kg. It could be noted that the gross α activity is highest at Colachel and lowest at Chinnavilai among the chosen locations.

**Table 1: Gross alpha activity of beach sand samples (Bq/kg)**

| S. No. | Stations | Gross α activity in (Bq/ Kg) in size fractions | | | | |
|---|---|---|---|---|---|---|
| | | 425µm | 300 µm | 212 µm | 125 µm | Mean |
| 1. | Colachel | 884.95 | 696.56 | 1190.47 | 1488.09 | 1065.02 |
| 2. | Muttom | 297.61 | 777.19 | 1129.94 | 1724.13 | 982.21 |
| 3. | Kottilpadu | 595.23 | 747.45 | 869.56 | 892.85 | 776.27 |
| 4. | Puthoor | 303.03 | 579.71 | 1120.44 | 1129.94 | 783.28 |
| 5. | Chinnavilai | 292.39 | 589.97 | 595.23 | 1488.09 | 741.42 |

**Gross β - activity of beach sand samples**
In Colachel area, the activity varies from 456.22 Bq/kg to 8132.71 Bq/kg with a mean value 2989.76 Bq/kg. In Muttom area, the activity varies from 750.61 Bq/kg to 9287.35 Bq/kg with a mean value 4461.745 Bq/kg. In Kottilpodu area,, the activity varies from 308.15 Bq/kg to 2732.24 Bq/kg with a mean value 1555.279 Bq/kg. In Puthoor area, the activity varies from 1636.8 to 8939.58 Bq/kg with a mean value of 3845.325 Bq/kg. In Chinnavilai area, the activity varies from 515.27 Bq/kg. to 8801.334 Bq/kg with a mean value 3137.684 Bq/kg.

It could be noted that the gross β - activity is maximum at Colachel and minimum at Chinavilai among the chosen locations. The values at Muttom area is closely behind that of the Kottilpodu. An examination of different values indicates a close relationship between the size fractions and the activities.

**Table 2: Gross beta activity of beach sand samples (Bq/Kg)**

| S. No. | Stations | Gross β activity in (Bq/ Kg) in size fractions | | | | |
|---|---|---|---|---|---|---|
| | | 425µm | 300 µm | 212µm | 125µm | Mean |
| 1. | Colachel | 456.22 | 1193.30 | 2176.80 | 8132.71 | 2989.76 |
| 2. | Muttom | 750.61 | 2054.30 | 5754.70 | 9287.35 | 4461.74 |
| 3. | Kottilpadu | 308.15 | 1391.20 | 1789.50 | 2732.24 | 1555.27 |
| 4. | Puthoor | 1636.80 | 1753.50 | 3051.40 | 8939.58 | 3845.32 |
| 5. | Chinnavilai | 515.27 | 907.72 | 2326.40 | 8801.334 | 3137.68 |

**Gamma activity of beach sand samples**
The Gamma activity of beach sand samples are given.In Colachel area, the Actinium activity ranges from 0.679 to 7.638 Bq/Kg. Puthoor sample have the minimum of 0.679 Bq/Kg.Bismuth activity varies from 0.2055 Bq/Kg It could be noted that the gamma activity is maximum at Colachel and minimum at Puthoor. The higher gamma activity is due to Actinium activity.

**Table 3: Gamma activity of beach sand samples (Bq/Kg)**

| S. No. | Samples | Radioactivity(Bq/Kg) | | | |
|---|---|---|---|---|---|
| | | Actinium | Potassium | Bismuth | Thalium |
| 1. | Colachel | 0.679 | BDL | BDL | BDL |
| 4. | Puthoor | 7.638 | BDL | 0.205 | BDL |

The percentage of both the light and heavy minerals in the beach sand samples and their ratio are given and the comparison between those minerals are shown. The concentration of the heavy mineral varies from 5.87% to 21.72% and also the light mineral varies from 59.48% to 81.33%.

In Colachel, the total heavy minerals (THM) present in the samples have 21.72% by weight, out of which the total magnetic minerals (TMM) like ilmenite and garnet are 12.93% by weight, and also the total nonmagnetic minerals are 5.87% by weight. The light minerals ($\rho<2.89$) have 59.48% by weight. In Muttom, 20.74% by weight of THM is reported. TMM and TNMM are 12.64% and 5.06% by weight. Here, the magnetic minerals are less than that of Colachel. The light minerals are 61.56% by weight. In Kottilpadu, THM present in the samples are 14.75% by weight. TMM and TNMM are 11.83% and 4.73% by weight. The light minerals are the quartz and have 68.69% by weight.

Puthoor samples have 10.65% THM by weight. TMM are 10.36% by weight, and the-TNMM are 3.98% by weight. The adjoining Chinnavilai samples have 8.96% THM by weight, which is distributed as 6.98% of TMM and 2.73% of TNMM, Here the TMM and TNMM are almost equally distributed. But the light minerals are 81.33% by weight.

The heavy minerals are dominant in Colachel (21.72%) in the surface sand samples, when compared to other places. Denser minerals are abundantly found in Colachel due to continuous winnowing action of the shoaling waves. Heavy minerals may become concentrated naturally by hydrodynamic sorting, usually in shallow marine or fluvial depositional settings.[10]. But, the light minerals are dominant in Chinnavilai (81.33%), with respect to other places. The result is in agreement with the values reportedin Teri sands (Red sands) of Tamil Nadu. [1] It shows that the light minerals are 81.33% by weight discovered the distribution pattern of radioactivity in the heavy minerals suites of a high background radiation area along the South West coast of India.[12] The higher beta activity could possibly due to higher concentrations of thorium [13].

**Table 4: Relative amount of light and heavy minerals in the beach sand**

| Places | THM (%) | TMM (%) | TNMM (%) | Light Mineral (%) | Ratio (L/H) |
|---|---|---|---|---|---|
| Colachel | 21.72 | 12.93 | 5.87 | 59.48 | 2.73 |
| Muttom | 20.74 | 12.64 | 5.06 | 61.56 | 2.96 |
| Kottilpadu | 14.75 | 11.83 | 4.73 | 68.69 | 4.65 |
| Puthoor | 10.65 | 10.36 | 3.98 | 75.01 | 7.04 |
| Chinnavilai | 8.96 | 6.98 | 2.73 | 81.33 | 9.07 |

THM =Total Heavy Minerals
TMM =Total Magnetic Minerals
TNMM =Total Non – Magnetic Minerals

**Conclusion**

The study of gross α and β activities of samples collected from 5 different locations between Colachel and Chinnavilai, spanning across a distance of 6 km indicate wide variation in their activity. Colachel beach sands recorded maximum activity; the values are lowest in the samples collected along the Chinnavilai beach. An examination of the activities of different size fractions of the beach sands has established the presence of the maximum quantities of fine samples of heavy minerals in the finest fraction. The highest α-activity of sand samples is recorded in Colachel beach and the lowest α-activity is recorded in Chinnaviali. The highest β-activity of soil samples are observed in Colachel station and the lowest β-activity of soil are samples observed in Chinnavilai station. The highest

activity recorded in the Colachel beach samples is an indication of heavy deposits of highly radioactive minerals monazite mixed with ilmenite and zircon. The lowest activity recorded in Chinnavilai beach samples, is an indication of maximum deposits of light mineral quartz than the heavy minerals. A comparison of the gross α and gross β activities of pure heavy minerals with that of various size fractions has indicated the wide distribution of heavy minerals in different fractions. However activities of sand samples are far below the permissible radiation levels.

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