Chapter 2

Locale and Methodology

2.1 Region of Study

Kerala’s 570 km long coastline is well known as one of world's most potential fishing area with unique biodiversity. The southern coast of Kerala is also rich with some of the rarest minerals in the world. Sand dunes here are enriched with ilmenite, rutile, zircon, monazite, leucoxene (brown ilmenite), sillimanite and garnet. These mineral deposits are found in their immensity in the 150 km long coastline of the districts of Kollam and Alappuzha. The high density population and the widely spread chronic disorders that a good number of people are victims of, make the area an important geographical location for researchers (1).

Scientists from different parts of the world have always given great prominence for the radiation emitting sands on the Kerala coast. The importance of the coastal line of Kerala in this regard has only increased since 1957 when the World Health Organisation’s (WHO) expert committee report found that the Chavara-Neendakara belt in Karunagappally taluk was best suited for epidemiological studies of high level natural background radiation (2). The presence of the Indian Rare Earths (IRE), Chavara in Kollam district of Kerala, which very often conducts extensive mining operations and soil-mineral separation, the public awareness of the presence of radiation has increased considerably. People have very often expressed their concern regarding health effects, particularly in relation to cancer induction (3). In 1990, the Regional Cancer Centre (RCC) in Trivandrum initiated an epidemiological study of the relationship between cancer incidence and the natural background radiation in the Karunagappally taluk with support from the Department of Atomic Energy (DAE) of Government of India.

As stated in the previous chapter, the study investigates the correlation between natural high background radiation and congenital malfunctions namely mental retardation and cleft Lip/palate in human beings. The region chosen for the study, spread over 135 sq.km, comprises nine panchayats in Kollam and Karunagappally taluk. They are Chavara, Thevalakkara, Karunagappally, Thodiyoor, Thazhava, Clappana, Alappad (Karunagappally taluk); Eravipuram and Thrikkovilvattom (Kollam taluk). Of these panchayats, Chavara, Karunagapally and Alappad are classified as High Background Radiation Areas (HBRA)
while Thevalakkara, Thodiyoor, Thazhava, Clappana, Eravipuram and Thrikkovilvattom are placed into the category of Normal Background Radiation Areas (NBRA). The criteria for the classification are dealt with in the section 2.5 of the present chapter.

The radiation levels in the southern coast of Kerala vary from 1.0 to over 35.0 mGy/y. The increased radioactivity in the region for the study proposed is due to the local abundance of monazite, a mineral containing nearly 10% thorium phosphate. We can easily identify high background radiation areas by the presence of the black monazite sand whereas in normal areas one would find white non-radioactive sand. The radioactive strip measures an area of only 10 km by 1 km, but supports a population of several thousand\[^{(4)}\]. Around 100,000 people live in close proximity to the monazite sands and are thus exposed to high background natural radiation. The level of naturally occurring background radiation here is almost 7.5 times higher than in areas lying to the interior of this region. This raises serious questions on health effects due to high background radiation.

### 2.2 Latlong Details of the Study Area

The study area is bound by the latitude of $8^\circ 51'$ 0'' N and $9^\circ 6'$ 1'' N and the longitude of $76^\circ 29'$ 0'' E and $76^\circ 40'$ 1'' E approximately. The latitude and longitude details of the 9 panchayats chosen for the study are given below:

- Chavara ($8^\circ 59'$ 43''N, $76^\circ 31'$ 58''E)
- Karunagapally ($9^\circ 0'$ 16'' N, $76^\circ 32'$ 7'' E)
- Thazhava ($9^\circ 0'$ 60'' N, $76^\circ 31'$ 60'' E)
- Thevalakkara ($9^\circ 0'$ 1'' N, $76^\circ 35'$ 1'' E)
- Thodiyoor ($9^\circ 0'$ 4'' N, $76^\circ 33'$ 1'' E)
- Clappana ($9^\circ 0'$ 6'' N, $76^\circ 30'$ 0'' E)
- Alappad ($9^\circ 0'$ 53'' N, $76^\circ 29'$ 0'' E)
- Thrikovilvattom ($8^\circ 53'$ 0'' N, $76^\circ 40'$ 1'' E)
- Eravipuram ($8^\circ 51'$ 0'' N, $76^\circ 37'$ 0'' E)

### 2.3 Maps of the Study Area

The following maps indicate the area of study. In figure 1 the area of study is marked with a dark shade while in figure 2 the nine Panchayats in Kollam district from where the cases and controls selected have been marked using different colours.
Figure 2.1: The state of Kerala indicating the area of investigation
2.4 Demography of Kollam District

Before going into the details of the methodology of the study, it would be apt to portray a short but comprehensive demography of the Kollam district.

2.4.1 Historical Background

Kollam, known by different names like Desinganadu and Quilon, is one of the fourteen districts of Kerala state. It is an old sea port town on the Arabian coast that boasts of a long history of commercial relationship that begins from the time of Phoenicians, Romans, Arabians, Chinese and Greeks and extends still further to the times of the Portuguese, the
Dutch and the British. The connection between Kollam and China regarding trade was so great that they even exchanged embassies leading to Chinese settlement in Kollam. Ibn Battut, a Moroccan explorer of the 14th century considers Kollam as one of the five main ports dealing in Chinese trade. Kollam became very active during the rule of Velu Thampi Dalawa of Travancore and in the year 1835 Kollam became one of the headquarters of Travancore. In 1949 when Travancore and Cochin were desegregated, Kollam was one of the three revenue divisions in the state which soon got the status of a district.

2.4.2 Geographical Location

Kollam district is bound on the north by Alappuzha and north east by Pathanamthitta districts on the east by Thirunelveli District of Tamilnadu, on the South by the Thiruvananthapuram district and on the west by Arabian Sea. Latitudinal and longitudinal extends of the district are 8.80°N 76.6°E respectively, and spans 2,491 km².

2.4.3 Topography

Kollam, a beautiful sea port is also known as God’s Own Capital and Cashew Paradise of Kerala. It is gifted with sea, lakes, rolling plains, dominant hills and mountains, wide rivers, streams, back waters vast green fields and also dense forest. The beautiful city is nestled between the Ashtamudi Lake and the Arabian Sea. The rivers and the natural lakes are an integral part of Kollam geography. Kallada and Ithikkara rivers flow through this district and the Sasthamcotta lake, the only major fresh water lake in the state is also in Kollam. Ashtamudi and Paravoor lakes are two important water bodies in Kollam district. Kollam is also fringed with dense forests, which abound in teak, sandalwood and other softwood trees. Pathanapuram, Anchal, Kottarakkara and Chadayamangalam are blocks having large areas of forest. The forest divisions are at Thenmala and Punalur.

2.4.4 Climate

Climate of Kollam is substantially influenced by its topography and geographical location. The district has a tropical humid climate and the city experiences plenty of seasonal rainfall. The hot season lasting from March to May is followed by the South West Monsoon from June to September. The rest of the year is generally dry. Kollam geography along with its pleasant climate makes it one of the most favourable sea side tourist destinations of Kerala.
2.4.5 Abundance of Minerals

The beach sand of the district is immensely rich in mineral resources. The beach sands of the district have concentrations of heavy minerals like ilmenite, rutile, monazite, and zircon. Away from coastal region there are large deposits of China clay in Kundara, Mulavana and Chathannoor regions of the Kollam district. Lime shell deposits in Ashtamudi Lake, Bauxite deposits in Adichanallur and disseminated graphite in Punalur are other mineral resources in the district.

2.4.6 Administrative Divisions

The Quilon district is divided both on geographical and functional basis for purposes of general administration. Geographically it is divided into one Revenue Division, five taluks and 104 Villages. Kollam district comprises five taluks namely Kollam, Karunagappally, Kunnathur, Kottarakara, and Pathanapuram and the total population is about 26,35,375 (2011 census). There are two coastal taluks – Kollam with 30 villages and Karunagappally with 17 villages. The Kollam district has 13 block panchayats, 2 municipal councils and 1 corporation.

2.4.7. Trade and Commerce

Even now Kollam occupies a fairly important place in the sphere of trade and commerce of Kerala state. It is not only the centre of the country’s cashew trading and processing industry but also an important hub for the state’s marine products industry, with the port of Neendakara being the centre for trawlers and ice plants. The recent development of Kollam as a seaport has enhanced the trade and commerce of Kollam district.

Fishing is the prominent source of economy of the district. Neendakara and Sakthikulangara are the villages those thrive in fishing. An estimated number of about 23,000 persons are engaged in fishing and allied activities. Cheriazheekal, Alappad, Pandarathuruth, Puthenthura, Neendakara, Thangasseri, Eravipuram and Paravoor are eight among the 26 important fishing villages. There are 24 inland fishing villages also. The average fish landing is estimated to be 85,000 tons per year.
Thousands of traditional fishing families have been living here for generations, exposed to the highest levels of natural radiation in the world. The residents are exposed to a naturally occurring radiation dose ten times higher than the worldwide average \(^{(5)}\).

### 2.5 Classification of the Region as NBRA and HBRA

The level of radioactivity due to \(^{232}\text{Th}\) and \(^{238}\text{U}\) in the monazite bearing areas of south-west coast of Kerala are found to be 5-10 times higher than the normal background radiation areas of India. The population living along the Kerala Coast of India is exposed to about 4 times the normal level of natural background radiation (excluding radon progeny in the lung). Because of the presence of monazite in the soil (thorium concentration, 8.0 - 10.5\%, by weight), the average absorbed dose rate for a very large population living in the region has been estimated to be about 3.8 mGy/y. The incidence of Down syndrome as well as chromosome aberrations has been reported to be high in this population \(^{(6)}\).

If the radioactivity level is virtually uniform in a particular region, it may be adequate to classify it as an HBRA (High Background Radiation Areas) or NBRA (Normal Background Radiation Areas). However, in monazite bearing regions of Kerala where the high radioactivity contents are found in patches, labelling a particular region based on isolated patches does not seem justifiable. This is because in a given village or ward the levels may vary from 10 to 20 times of the minimum values in the same region. Cullen, Penna-Franca and Mishra have come up with various solutions to resolve this issue. They have developed a set of criteria for identifying the areas in which the radiation levels due to soil radioactivity contents are higher than normal.

In 1977 Cullen proposed the region to be identified as a High Level Natural Radiation Area (HLNRA) if the region satisfies one or more of the following conditions:

a) The exposure rate from external terrestrial sources, over extended areas, is greater than 2 mGy/y;

b) The long-lived alpha activity ingested through the local diet and water is greater than 1.85 Bq/d;

c) The Cullen and Penna-Franca radon concentration of potable water is greater than 185 kBq/m\(^3\);

d) The \(^{220}\text{Rn}\) and \(^{222}\text{Rn}\) concentrations in the atmosphere are greater than 37 Bq/m\(^3\) \(^{(7)}\).
On the other hand, Mishra proposed that the High Background Radiation Area be defined as one that is characterised by one or more of the following criteria.

a) The exposure rate from external terrestrial sources, over extended areas, should be greater than 4 mSv/y;

b) The long-lived alpha activity ingested as a result of a local diet and water should be greater than 2 Bq/d;

c) The $^{222}$Rn concentration of the potable water should be greater than 200 kBq/m$^3$;

d) The $^{220}$Rn and $^{222}$Rn concentrations of the atmosphere should be greater than 40 Bq/m$^3$;

In addition, the area should have at least a population of 1000 to be considered of significance for epidemiological investigations. (8)

In the present study, we have adopted the later criterion to decide whether an area is HBRA or NBRA. Out of the nine panchayats, most of the regions in Chavara, Karunagapally and Alappad are identified as High Background Radiation Areas (HBRA) while Thevalakkara, Thodiyoor, Thazhava, Clappana, Eravipuram and Thrikkovilvattom generally fall into the category of Normal Background Radiation Areas (NBRA)

2.6 Methodology

Epidemiological studies on the population residing in the High Back Ground Radiation Areas in Kerala is of considerable interest from the point of view of the understanding the effects of low and chronic radiation exposures on the health of human population. Epidemiological methods can assess the frequency of occurrence of various malformations including cancer. Evaluating the overall risk and dose effect relationships requires statistically validated large data collected from the exposed people for which cohort approach is necessary. The case control methodology is a powerful tool for assessing the risk factors. A case control study involves the identification of individuals with (‘cases’) and without (‘controls’) a particular disease or condition. The prevalence of exposure to a factor is then measured in each group. If the prevalence of exposure among cases and controls is different, it is possible to infer that the exposure may be associated with an increased occurrence of the outcome of interest. The present study investigates the effect of radiation dose as a cause for occurrence of certain congenital malfunction namely mental retardation and cleft lip/palate in human beings in the
high background radiation area along the south west coast of Kerala. A Population based 1:3 matched case-control study is adopted for the study.

2.7 Data Acquisition of Cases

As already shown through the maps, the cases in the study are the inhabitants in and around the high background radiation areas of Kerala with congenital malfunctions, namely mental retardation and cleft lip/ palate. Mental retardation refers to sub-average intellectual function combined with deficits in adaptive behavior and is a common feature associated with many genetic disorders with varying degrees of expression (9). Cleft lip (cheiloschisis) is the presence of one or two vertical fissures (clefts) in the upper lip, and cleft palate (palatoschisis) is an opening in the roof of the mouth (the palate) as a result of faulty fetal development of the face. Cleft lip/palate has a complex etiology, and both genetic and environmental determinants are considered to be involved in the pathogenesis (10).

Low Level Radiation Research Laboratory, Kollam (LLRRL), a subsidiary of Bhabha Atomic Research Center (BARC), Mumbai has done the panchayat wise and anganwadi wise enumeration of the cases. The data related to the congenital malfunctions (cases) were provided to the Fatima Mata National College, Kollam by BARC under a Memorandum of Understanding between the institutions. The actual number of cases provided by LLRRL was 626 from all the nine panchayats. People with either mental retardation or cleft lip/palate in the study area are identified through a detailed investigation. The investigation is realized with the help of parents and neighbours of cases and local Anganwadi Workers, who are the grassroots-level health workers under the Ministry of Social Welfare, Government of Kerala.

2.8 Selection Criteria of Cases and Controls

There are a number of criteria for selecting a case and the foremost among them may be summed up as follows. A case should be a genetically disordered person, more specifically should be a mentally retarded (MR) or cleft lip/ palate (CLP) one. He/she should have been impregnated within the study area and the mother should have continued to live in the same area consistently for at least her early six month pregnancy period. For the study only those individuals with either congenital mental retardation or cleft lip/palate, who are not more than 35 years old, are considered. Selecting cases and controls from nine Panchayats of Kollam district that included interspersed high-level and normal-level natural radiation areas are
made possible mainly with the help of Anganwadi workers. These workers are instrumental in identifying and motivating target groups for implementation of various health schemes of the State/ Central government. The Anganwadi workers are familiar with every household in the Anganwadi area, so there is hardly any chance of missing mental retardation/ cleft lip/palate cases. While cleft lip/palate cases were confirmed visually, mental retardation cases were confirmed by the disability certificate issued by medical board established by State Government of Kerala.

Three ‘controls’ without congenital malfunctions but with specific characteristics like age, parental status, locale and the type of dwelling as that of each ‘case’ selected for the research. Cases and controls are selected based on a scientifically designed exclusion criteria as follows.

- The incidence of the malformation must be congenital.
- Children born of singleton deliveries without any assisted reproductive techniques and without any previous stillbirth or recurrent abortions have to be selected.
- Mother of the child must be alive at the time of initiation of the study.
- Parents stay together after marriage, at least till conception of the child.
- The residential house of the father-mother-child trio during conception through first two trimesters should exist in the study area.
- The case’s and control’s houses for dosimetry should not be close to each other.
- Age differences of the mothers of case and control should not be more than one year.

All cases in the present study were selected strictly based on these criteria.

2.9 Preparation of Data Sheet

A detailed and comprehensive data sheet is prepared in consultation with Bhabha Atomic Research Center, Mumbai. The data sheet helps to gather wide-ranging information on all variables of interest pertaining to the study population and their dwellings. Apart from general information like age and sex, many confounding variables like family history of diseases, menstrual periodicity of mother, information on socio-demographic aspects, reproductive history, risk factors and diseases during the relevant pregnancy period etc are also noted. This has helped me in achieving most comprehensive result as far as the correlative study is concerned.
The data sheet given below is one that is used for recording the various information of a case. The same sheet, without the column “Birth defect, if present and % of disability” mentioned at top right of the data sheet, is used for gathering facts about controls too.
# Case-Control Study of Mental Retardation and Non-syndromic Cleft Lip/Palate

<table>
<thead>
<tr>
<th>Name of the Child</th>
<th>Sex</th>
<th>Age</th>
<th>Date of Birth</th>
<th>Birth defect, if present and % of disability</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tbody>
</table>

## Details of the Parents

<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Age in Years</th>
<th>Age at Marriage</th>
<th>Date of Marriage</th>
<th>Region/Ethnicity</th>
<th>Consanguinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father*</td>
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</tbody>
</table>

* If father is no more, indicate the same with ‘(Late)’ and give the age at death instead of age.

## Address of the Family

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th></th>
<th>During pregnancy of the child</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Ward No:____</td>
<td>House No:_______</td>
<td>Ward No:__</td>
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<tr>
<td>House Name</td>
<td></td>
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<tr>
<td>Place</td>
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<tr>
<td>Panchayat &amp; AW No.</td>
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<tr>
<td>Duration of Stay</td>
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<td>Father:</td>
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<tr>
<td>Father:</td>
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<td></td>
<td></td>
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<tr>
<td>Mother:</td>
<td></td>
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</tbody>
</table>

## Reproductive History

(Age at termination, type of termination** and gender of the baby)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Type</td>
<td>Sex</td>
<td>Age</td>
<td>Type</td>
<td>Sex</td>
</tr>
</tbody>
</table>

**SA – spontaneous abortion, IA – induced abortion, SB – still birth, BAD – born alive but died immediately without any physical stress, LB – live birth. Circle the birth order of the child. Indicate later deaths, if any, with a cross in birth order column.

Birth weight of the child in kg: ______ Gestation at birth: Full-term (1)/Pre-term (2)

Neonatal Jaundice: Yes (1) No (2) Don’t know (9)

Developmental milestone: Normal (1) Delayed (2) Don’t know (9)

Schooling: Nil (0) Special (1) Normal (2)

Education: Completed (1) Student (2) Class: ____

No. of members, if any, with the condition in the family (parents’ siblings and offspring): ______

## Parental particulars during the pregnancy of the child

<table>
<thead>
<tr>
<th></th>
<th>Father</th>
<th>Mother</th>
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<tbody>
<tr>
<td>Occupation</td>
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<tr>
<td>Smoking (Yes/No)</td>
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<tr>
<td>Drinking (Yes/No)</td>
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<td></td>
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<td>Chewing tobacco (Yes/No)</td>
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<td></td>
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<tr>
<td>Chewing Pan masala (Yes/No)</td>
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<td></td>
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</tbody>
</table>
### Other Particulars during the Pregnancy

<table>
<thead>
<tr>
<th>Contraceptives prior to conception of the child (specify the device, if used)</th>
<th>Yes (1)</th>
<th>No (2)</th>
<th>Don’t remember (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
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<td>Hypertension</td>
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<td>Asthma</td>
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<td>Epilepsy</td>
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<td>Hepatitis</td>
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<td>Malaria</td>
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<td>Mumps</td>
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<td>Thyroid problem</td>
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<tr>
<td>Typhoid</td>
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<tr>
<td>Severe Anaemia (Hb &lt; 8 gm/dl)</td>
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<tr>
<td>Presence of any environmental irritants</td>
<td></td>
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<td></td>
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<tr>
<td>Others (specify) (like trauma / accidents)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Diseases during pregnancy of the child</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray during the pregnancy</td>
<td></td>
</tr>
<tr>
<td>Ultra Sonography (Scanning)</td>
<td></td>
</tr>
<tr>
<td>Use of forceps / vacuum during delivery</td>
<td></td>
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</tbody>
</table>

Regularity of menstrual periods: Regular (1). No. of days: _________ Irregular (2)

Sleeping: On the floor (1) / On the cot (2)  Cooking fuel: Firewood (1) / Gas (2) / kerosene (3)

### Dosimetric Particulars (house where the mother stayed during her pregnancy of the child)

<table>
<thead>
<tr>
<th>Date (TLD &amp; SSNTD)</th>
<th>At the installation of dosimeters</th>
<th>At the retrieval of dosimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey meter reading (μR/h)</td>
<td>Inside 1M:</td>
<td>Ground: 1M:</td>
</tr>
<tr>
<td></td>
<td>Outside 1M:</td>
<td>Ground: 1M:</td>
</tr>
</tbody>
</table>

### Number and reading of TLD (μGy) and SSNTD (Tracks/cm²)

<table>
<thead>
<tr>
<th>TLD</th>
<th>SSNTD</th>
<th>Recorded track density in the SSNTD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Dose</td>
<td>Radon</td>
</tr>
</tbody>
</table>

### Details of the room in which dosimeters are installed

- **Floor**: Mud (1) / Cement (2) / Tiles (3) / Mosaic (4) / Marble (5) / Granite (6)
- **Wall**: Wooden plank (1) / Sheet (2) / Non-plastered bricks (3) / Plastered bricks (4)
- **Roof**: Thatched (1) / Sheet (2) / Tiled (3) / Concrete (4) / others specify (5)

Height at which the dosimeters are installed: ____________ c.m.
The radiological parameters assessed in the present study for health impact evaluation are inhalation dose and external gamma dose resulting from the natural sources of radiation. External gamma, inhalation and ingestion are the main pathways in which human beings are exposed to radiation. The radiation dose caused due to inhalation, ingestion and external is typically about 2.5 to 3 mSv/y. The major contribution to the total dose is from inhalation and external gamma while the influence of ingestion is comparatively small.

2.10 Assessment of Inhalation Dose

The inhalation dose is due to radon, thoron and their progenies. The contribution of indoor thoron concentration is generally considered negligible because of its very short half-life. But while calculating the total inhalation dose, contribution of thoron cannot be ignored. Obviously, the highest radiation dose received is from radon than that from all other natural or man-made sources. Radon exposure is known to be the second leading cause of lung cancer after cigarette smoking. Even at the relatively low radon levels, epidemiological studies have shown a positive association between indoor radon exposure and lung cancer (11).

Radon decay results in promptly decaying progeny therefore the detection and measurements of radon can be performed either directly on radon itself called “radon alone measurement” or indirectly through its daughters. Since radon and most of its progeny decay by emitting α, β and γ radiations, radon detection and measurement can be performed through the detection and measurement of these radiations. Many techniques are available for measurement of radon. These are classified into two main categories:

1. Instantaneous/active methods.
2. Time integrated/passive methods

Active methods are usually used for short-term measurements of radon. Passive methods are more suitable for the assessment of radon exposure over long time scales and can be used for large-scale surveys at a moderate cost. Due to low concentrations of environmental radon and its decay products, the precision and accuracy of the techniques are important issues. The uncertainty in measurements arises from several sources, such as random nature of radioactive decay, variations in detector response, interference by unmeasured species etc. For low radon concentration measurements, uncertainty due to randomness of radioactive decay becomes prominent. One can improve precision of low level measurements by increasing the sampling time or counting time.
A. Active Methods

Instantaneous / Active methods are those that require power for their operation and are used normally for short term measurements. The instantaneous techniques are based upon methods in which grab sample of the air is collected at an instant of time, followed by measurements of radon concentration through its $\alpha$-particle activity. Lucas cell (Scintillation method), Ionization chamber, surface barrier detector, two filter method, continuos radon monitros and working level method etc come under this category.

B. Passive Methods

It is very important to carry out measurements of radon over a long period of time for incorporating the effects of seasonal, weather and environmental conditions on radon concentration in dwellings. It is the long-term average in dwellings that determines the damage to human’s health. The use of integrating devices is the most practical way of obtaining a long term average radon concentration. Hence these techniques are preferred for survey work in order to determine the annual average radon concentration of a specific building. These instruments, which do not require power for operation, are suitable for evaluating short-term and long-term measurements, i.e. determination of radon concentration averaged over a period of a few days to an year. Charcoal Canister Technique, Solid State Nuclear Track Detectors (SSNTDs), Electret ion chambers, Thermoluminescent Detectors (TLDs), Electronic integrating devices, NRPB radon dosimeter etc belongs to this group.

In this research work, the inhalation doses were assessed using solid state nuclear track detectors (SSNTD) based twin cup dosimeters, developed and standardized by BARC, (Bhabha Atomic Research Center) Mumbai. It is an internationally accepted versatile dosimeter calibrated at Environmental Assessment Division, BARC. With this dosimeter cup we can measure the concentration of radon as well as thoron and their progeny, all simultaneously at a given location.

2.11 Assessment of External Dose

The distribution of external exposure due to terrestrial radiation in a given place depends on the geographical characteristics of that place. Many methodologies exist for measurement of gamma radiation dose and all of them are well-standardised methodologies. G. M. tube based survey meters, scintillometers, Thermoluminescent Dosimeters, Si diode based Direct reading
dosimeters (DRDs) are among the few that have successfully been developed, tested and used world wide. Personal radiation monitoring can be carried out using film badges(Contain filters and film which identify and quantify the type of radiation), Optically stimulated luminescence dosimeter(OSL dosimeters are exposed to a light source to obtain the amount of radiation absorbed by the dosimeter), Thermo-Luminescent Dosimeter Body Badges (Used primarily for monitoring the radiation dose to the trunk of the body), Thermo-Luminescent Dosimeter Rings (for monitoring radiation dose to the hands and wrist) etc.

There are active and passive methods of external gamma dose measurements. Active measurements make use of GM Tube based survey meter giving instantaneous gamma dose, whereas passive measurements give time integrated measurements of external gamma dose. Indoor external gamma dose measurements are important as most individuals spend about 80% of their time indoors. In the present study, GM tube based survey meter was used for the active measurement of gross gamma exposure in the locations. Indoor gamma exposures were assessed using well established thermo luminescent detectors (TLDs). The TL dosimetry is a well-standardized methodology that is being used all over India for many decades successfully for environmental gamma ray dosimetry. It is well known that for the detection of low doses, thermoluminescent dosimeters are better suited than any other known methods. Among Thermoluminescent materials used in this field, the most suitable for environmental monitoring is CaSO₄: Dy mainly owing to its high sensitivity (12). With very sensitive and stable integrating thermoluminescence dosimeters, one can acquire comparable and sufficiently accurate data from numerous locations. The dosimeters can be exposed long enough to smooth any variations in the local dose rates.

2.12 Implementation of the Research Plan

If a case has been accepted as per the criteria, the next step is to gather information about houses with normal individuals of the same age. To foster the reliability of the study, with regard to the age of normal individuals, only completed years with a maximum of 1 year relaxation are considered. Even though identifying many such houses is not an easy task, the involvement of parents/neighbours of cases and Anganwadi Workers were helpful. For selecting three eligible age matched controls for each case, many houses were visited located at least 100 m away from the cases’ houses. On an average, about four to five such houses had to be visited to find an eligible control. Locating a case and its three controls and deployment of dosimeters were carried out consecutively so that concurrent estimation of
radiation dose was possible. Coping with the suspicious stares of people on reaching each house and helping them comprehend the aim of the study sometime turned out to be a herculean task.

Solid-state nuclear track detector (SSNTD) based twin cup dosimeters were fixed at houses of cases and their respective controls for a period of three months. The dosimeters were also fixed with a TLD. As far as possible the dosimeter was fixed in the bedroom. Room dimensions, height of the dosimeter from the ground level, ventilation conditions, nature of construction etc. are also noted in the data sheet. Gamma radiation dose levels, outside as well as inside the houses were also measured using G M Tube based survey meters. While deploying and retrieving the dosimeters in a house, survey meter readings were taken inside and outside the dwellings at ground level and 1 meter height from the ground. Being an active method of measurement of dose it directly gives the external gamma dose. The measured quantities of doses in the dwellings of cases and controls were analyzed using conditional logistic regression.
References


5. http://www.kollam.nic.in/general information


