Chapter 2
Analytical Framework and Methodology

2.1 Introduction
In this chapter the framework for analysing the negative externality caused by radiation induced pollution in terms of health effects and detailed methodology of the current study is presented. The framework is explained on the basis of the theory of Valuation. Valuation plays an important role in the sustainable development of the developing countries (Kadekodi, 2001). The chapter is divided into the following sections. The second section deals with the analytical framework by addressing the different theoretical aspects of Valuation of negative externality over the years. The valuation of health effects due to environmental pollution along with the methods for valuing health effects along with their advantages and disadvantages are examined in the third section. The detailed methodology for the current study, which includes the profile of study area, sampling frame, the details of questionnaires and methods of analysis are discussed in section four. The last section gives the conclusion.

2.2 Analytical Framework
The analysis of pollution has been a concern for economists right from the classical school. Marshall (1890) spoke of the external economies of production, a much broader notion of external effects. It was Pigou (1920) whose basic insight could be explained very simply in the modern terminology of private and social cost. Suppose a firm’s production generates a spill over or externality that directly affects other economic agents, then the marginal social cost of production will diverge from the marginal private cost and the firm will produce too much if the spill over is unpleasant. The implied
policy according to Pigou was to levy a tax equal to the difference between the marginal social cost and marginal private cost. The tax will induce the firm to produce the right socially efficient output at that point at which the price equals marginal social cost. This later came to be known as the Pigouvian Tax Structure or the Polluter Pay Principle.

However, Coase (1960) criticised this solution on the grounds that in the absence of transactions and strategic behaviour the distortions associated with externalities would be revealed through voluntary bargains among the interested parties. The allocation of resources will be identical, whatever the allocation of legal rights. The allocation will be efficient, eliminating the problem of externality. This meant that the Pigouvian solution had no relevance. However, the Coasian solution was also criticised on the grounds that the pollution problems always involved a large number of polluters and victims and the transaction cost would be very high to have a perfect Coasian outcome. The efficient resolution of environmental externalities calls for polluting agents to face a cost at the margin for their polluting activities equal to the value of the damages they produce.

According to Baumol and Oates (1988) externality is present whenever some individual’s say (A’s) utility or production relationships include real (non-monetary) variables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effects on A’s welfare. So the policy problem here is how to design the incentive structure facing the parties to an externality so as to induce a socially desirable behaviour.

Valuing the damages or assigning a monetary value to the environmental assets thereby gives an idea about the resolution of externalities. However, the use of a
monetary yardstick to value environmental assets has been a debatable issue among economists. People pay for environmental assets either directly or indirectly. They pay directly when they spend money and time to travel to a park and pay indirectly when they pay higher prices or rents for a house in a less polluted locality. Economists consider the maximum sum individuals are willing to pay for an increase in the provision of some environmental amenity (given income level and other relevant attributes) to be a reasonable expression of its value to its consumers. It is considered to represent the ‘price’ the good or asset would have fetched had the markets existed. And in perfectly competitive markets, equilibrium prices reflect the change at the margin in consumers’ utility from the consumption of the goods or service that is the marginal improvement in the level of well being (Folmer and Gabel 2000).

Nevertheless, as an attempt to monetize welfare changes valuation involves an important implicit assumption, namely, that the individual possesses all the relevant information regarding the effect of environmental amenities, either negative (pollution on health) or positive, on their welfare. In reality, people do have misconceptions about the true effects and act upon mistaken perception rather than on the basis of accurate knowledge. For example, in dealing with air quality, it is doubtful that individuals are completely aware of the full consequences of air pollution on their health, and hence on well being. However this qualification is not a common characteristic of environmental assets only. It can be seen that in the case of a potential buyer of cars or stereo sets, he may not be fully aware of all necessary details.
Even the most fervent advocates of a monetary yardstick would probably agree that there are a number of weighty measurement issues unique to environmental amenities that cannot easily be resolved. Still monetary measures provide an explicit and clear expression of the degree of public concern with an environmental issue, via the willingness of members of a society to pay for the environmental good; in a sense it measures the intensity of the public's preferences and concerns. Furthermore, in many policy contexts decision-makers make implicit monetary valuations. Take for instance, the case of health care. Life expectancy of the entire population or of a certain group of patients is at stake. But when investments are channelled to one programme and not to another, implicit monetary values of the number of lives saved, or number of injuries avoided, as a result of undertaking programme X and not Y is implicitly made. The same is true in the case of investments in alternative highway safety programmes to reduce traffic accidents. A second argument supporting monetizing environmental quality is that the use of monetary measures makes comparisons possible with other monetary benefits and costs arising from alternative uses of public funds.

2.3 Valuing health effects due to Environmental Pollution

Having justified the use of money as a yardstick to value environmental amenities, let us examine the valuation of health effects due to environmental pollution. Obtaining Values of health hazards due to environmental pollution has always posed a challenge to economists. Cropper and Freeman (1990) argued that the standard economic theory for measuring changes in individuals' well being was developed to interpret changes in the prices and the quantities of goods purchased in the markets. During the past 15 years, this theory has been extended and applied to a wide variety of non market or
public goods and social programmes including public housing and other transfer programmes, public investment in parks, transportation, the development of water resources and improvements in environment quality and health. This theory is based on the assumption that individuals' preferences are characterised by substitutability between income and health. The trade-off that people make as they choose among various combinations of health and other consumption goods reveal the value they place on health.

Environmental pollution impairs human health that can reduce people's well being through the following six channels. 1) Medical expenses associated with treating pollution-induced diseases including the opportunity cost of time spent for obtaining the treatment. 2) Lost wages 3) defensive or averting expenditures associated with attempts to prevent pollution induced diseases. 4) Disutilities associated with the symptoms and lost opportunities of disease and 5) changes in life expectancy or risk of premature death and 6) changes in consumption pattern. The first three effects have readily identifiable monetary counterparts or can be directly quantified. The last three effects cannot be valued directly. Reducing pollution may be beneficial to all individuals because it reduces some of these adverse effects and hence a comprehensive measure should capture all of these effects (Cropper and Freeman 1990).

Methods for finding monetary values for impairments in health can be classified as those that rely on observed behaviour and choices (revealed preferences) or on responses to hypothetical situations posed to individuals (contingent valuation or bidding games). The first category includes all of those techniques that rely on
demand and cost functions, market prices and observed behaviour and choices. The second category includes asking people directly to state their willingness to pay or accept compensation for a postulated change or how they would rank an alternative situation involving different combination of health and income or consumption.

2.3.1 Physical Linkage Method

One of the most important methods for the valuation of health effects is the Physical Linkage Method. In this approach, environmental values are estimated by establishing the relationship between physical effects of some environmental change factors such as human health. These methods first establish cause-effect or dose-response relationships and then value the impact of environmental change to reflect the value of environmental change. Here the first step is to identify the logical sequences of the cause and effect relationships, with regard to the deterioration of the environmental attribute and its impact on human health and welfare (Parikh et al. 1997). The procedure for estimating health and productivity effects involves three steps. The first step is to determine the relationship between changes in exposure to environmental pollution, for example human health as explained by morbidity and mortality estimates. The second step is to use this relationship to predict the change in the mortality and morbidity associated with specific changes in environmental

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² Parikh et al (1997) considered the Physical Linkage Methods as scientific because of the causal connection between environmental change and its effect on persons.

³ Dose-response technique is an indirect valuation technique, which aims to establish a relationship between environmental damage (response) and some cause of the damage such as pollution. (dose) such that a given level of pollution is associated with a change in output that is then valued at market.
pollution and exposure to pollutants. The third step is to derive monetary measures of changes in human health.

The first task in the physical linkage method is to arrive at a suitable dose-response function. For human health, this is derived through a combination of bio-medical studies and statistical analysis. Damage functions could be either on mortality or on morbidity. Studies by Lave and Seskin (1977) focused on mortality while studies by Ostro (1983, 1987) and Krupnick et al (1990) concentrated on morbidity effects. Another approach is to rely on the epidemiological studies done on the environmental problem to arrive at the cause-effect relationship. These studies not only look into the clinical aspects of the problem but also study the distribution and determinants of disease prevalence. The agent factor, host factor and environmental factor for the occurrence of disease are studied in the epidemiological studies. It means that what is causing the disease, in whom the disease is usually occurring and under what environment this condition is seen are all looked into. In other words, when this disease is occurring (Time), what is the geographical area where this disease is occurring (Place), how many people are affected and what type of people are affected (Person) all these factors are studied in epidemiological studies.

2.3.1.1 Cost of Illness Approach

The next step in the physical linkage approach is to measure the cost of environmental damage. This approach called Cost of Illness approach measures the cost of environmental damage mainly in terms of direct and indirect outlays. Direct costs represent the value of resources used to prevent, detect, treat and rehabilitate the health impairment or its effects. They include within the health sector, expenditures
for emergency assistance, hospitalization, physicians' services, special paramedical services, outpatient clinical care, nursing home care, drugs, medical appliances etc. In addition, there are often non-health sector direct costs borne by the patient and others. These can run the spectrum from expenses for structural modifications to a patient's home necessitated by his or her condition and extra expenditures for household help to institutional costs, such as the administration expenses incurred by insurance companies and government agencies in funding illness expenditures. Thus the health expenditure made, the value of the resources used in supplying health care is referred to as the direct 'Cost of Illness'.

Indirect costs however, bear an implicit relationship to the health impairment. They are expenditures not directly tied to the treatment of the impairment. Instead, the loss of labour earnings due to sickness, the value of the lost product of labour is referred to as the indirect cost of illness. This is normally measured in terms of the wages that would have been earned by these individuals if they were not ill. The out of pocket expenses associated with injury or illness, the foregone earnings or the imputed value of the restrictive activity days and the avertive or defensive expenditures owing to pollution are considered in this approach. Output losses also extend to the imputed market value of the unperformed house keeping services. It is extremely important to include the value of housekeeping services since its omission may result in a serious underestimation of indirect costs of illness, especially when the health condition in question has a disproportionate effect on women.
It can also be observed that output losses may be generated not only by patients, but also by family members. It is possible for these individuals either to lose time from work or homemaking activities or to suffer reductions in their productivity because of the patient's condition. This can happen in the case of family members when someone must remain at home to care for an ill person. 'Cost of Illness' approach, therefore, is also referred to as the damage avoidance approach or the earnings expenditure approach. 'Cost of Illness' studies facilitate economic comparisons of different conditions. It is also useful in describing how much health care expenditure has to be allocated for the decision-making authorities at a macro level. Drummond et al (1997) suggested that 'Cost of Illness' studies are useful in examining the progress of an illness over time, and for comparing the monetary effects of different treatment programmes. Such lifetime indicators of cost generated by this method would enable public health professionals to show the long-term economic impact of eradicating or reducing a particular illness.

Although the cost of illness approach is a direct measure of morbidity it is just a lower bound of the total costs of health. It does not consider the value of personal pain, suffering, inconvenience, losses in leisure and impacts on individuals and their families' well being. If the people affected by diseases do not approach hospitals for lack of awareness, accessibility and affordability, the estimate of cost of illness tends to be a lower bound. When the entire health system is heavily subsidised, the estimate based on actual expenditure will be far below the true expenditure and associated opportunity cost. In the case of valuing health costs due to pollution, this approach can be applied only if a cause and effect relationship between the pollutant and the
health hazard is developed. This approach warrants a clear cause effect relationship between the cause and effect of diseases either through a dose response function or through epidemiological studies. There are differences in methodological issues involved when the dose-response functions of the developed countries are directly applied to the developing country context. This is due to the fact that assumptions like the baseline concentration of pollution both indoors and outdoors are considered to be the same for both developed and developing countries and also the general health status as well as the characteristics of the diseases are assumed to be the same. This brings inaccurate results for the developing country context. As discussed earlier this problem can be rectified to some extent if epidemiological studies are conducted to find out the cause and effect relationship.

There are other problems involved in this approach to convincingly prove the cause-effect relationship (Parikh et al 1997). For example, in the case of air pollution it may not be really possible to establish that an increase in incidence of bronchitis is a function of increase in sulphur dioxide concentration in the ambient air. While such a medical relationship may indeed exist, it can always be questioned on counts of synergistic effects. In a locality where there is both high SO₂ and high Suspended Particulate Matter (SPM), an increase in respiratory diseases cannot be completely attributed to either sulphur dioxide or high SPM. Computing the economic cost is even more complicated when one has to establish a numerical relationship between levels of a pollutant and the incidence of a certain disease. There are, however, possible ways of arriving at reasonable policy conclusions using physical linkage methods by making some simple assumptions. Consider the example of air pollution.
The first task is to identify the dominant pollutant in a given city. The dominant pollutant can be defined as one, which has demonstrated health effects (supported by medical literature) and is widely prevalent and is increasing at a rate faster than other pollutants in the city. Once we have identified the dominant pollutant, we could take this pollution in isolation and estimate the health damages due to them. By a careful selection of the dominant pollutant, we can obtain a reasonable lower bound on the estimate of environmental degradation.

The Cost of Illness approach is one of the most popularly used and simple methods of measuring health costs and has been used extensively all over the world. Berger et al (1987) reported data on medical expenditure net of insurance payments plus lost earnings for some of the respiratory symptoms due to pollution. Similarly Chestnut et al (1988) estimated the cost of illness for angina sufferers. Studies by Dixon (1994), Ostro (1994) and Baulista et al (1996) used Cost of illness to study the costs of air pollution. In India Cropper et al (1997) and Parikh et al (1997) used cost of illness approach to study the costs of air pollution in Delhi and Mumbai respectively.

2.3.1.2 Human Capital Approach

It is not just enough to account for expenditure on illness. Illness and disability—temporary or permanent has private and social costs that need to be accounted for. The human capital approach for valuing morbidity assumes that the value of individuals is the potential of production the person possesses. Once the damage function is obtained, the essential factor is the unit economic value of the physical damage (mortality/morbidity). A product of the numerical values of both the number of people affected or dead and the unit cost of treatment or death will provide the
monetary value for health damages. (OECD, 1989). It is therefore essential to arrive at numerical values for the value of statistical life as well as the cost of WLD (Work Loss Days) and RAD (Restrictive Activity Days) consequent to morbidity and mortality. According to Milshan (1982) the present value of the person’s expected future earnings may be calculated as

\[ L = \left[ \sum_{t=1}^{T} \frac{Y_t}{(1+r)^t} \right] \alpha \]

Where \( T \) = the remaining life time \( Y_t \) = after tax labour and non-labour market income. \( r \) = rate of change in opportunity cost of individuals for investing in risk reducing activities and \( \alpha \) = a risk aversion factor. Both \( r \) and \( \alpha \) are assumed to remain constant over time. This method however fails to capture the intangibles like pain and suffering. Moreover there is also the question of what is the appropriate discount rate to measure the present value of life. The human capital value of children and young adults is particularly sensitive to the choice of a discount rate. The most important criticism of the human capital approach is that it is inconsistent with the fundamental premise of welfare economics; namely, that it is each individual’s own preferences that should count for establishing the economic values used in benefit-cost analysis. In this respect, the human capital approach is fundamentally at odds with the individualistic perspective of welfare economics. (Cropper and Freeman, 1990) Still it is considered an appropriate method for evaluating environmental policies that affect human life. (Parikh et al, 1997). In India Brandon and Homman (1995) has used this approach to value health effects due to air and water pollution.

\[ \text{Viscusi (1993) has written extensively on the valuing the statistical life by looking into the risks to life and health. Linnerrooth (1979) has reviewed the theoretic models that value the human life.} \]
2.3.2 Disability Adjusted Life Years (DALY) Method

Disability Adjusted Life Years (DALY) method\(^5\), introduced in the World Development Report of 1993, is a measure that takes into account healthy life years lost from all causes, whether due to premature mortality or as a result of disability. (Homedes, 1996) This measure can be useful for policy makers because it can measure the burden of disease and help identify those interventions that may result in the largest improvement in health. Thus DALY is intended to set health service priorities, identify disadvantaged groups and target health interventions and to provide a comparable measure of output for intervention program and sector evaluation and planning.\(^5\) There are also methods like Health Adjusted Life Years (HALY) Method and Quality Adjusted Life Years (QALY) method, which measure the burden of disease\(^6\).

2.3.3 Contingent Valuation Approach

A direct method of valuing health effects due to a change in pollution can be done using a willingness to pay and willingness to accept approaches. These approaches, known as direct valuation methods or Contingent valuation studies are mostly used by economists due to its strong footing in welfare theory. The dissemination of CVM to health economics has passed through the sub discipline of Environment Economics\(^7\).

\(^5\) DALY is calculated as follows

\[ \text{DALY} = \text{YLD} + \text{YLL} \]

where

YLD = years lived disabled

YLL = years of life lost

\(^6\) The DALY approach is also widely criticized especially in the writings of Murray and Lopez (1996), but still is considered a reliable approach to measure mortality and morbidity in a global context.

and also from the Economics of Risk and Uncertainty (Johannessen 1996). This method is used extensively to value the health effects due to environment pollution\(^8\). These methods use surveys to elicit peoples' valuation of increases or decreases in the health status due to the environment problem considered by constructing a hypothetical market. In a Contingent valuation survey individuals may be asked about their attitudes, expectations, needs and opinions related to the amenity in question. These probing provide powerful insights into the attitudes and behaviour of the people with respect to the health effects due to environment pollution. This method is also used to value increases and decreases in morbidity and also the factors affecting the willingness to pay for health insurance. According to Johannessen (1996a) Willingness to Pay and Willingness to Accept Measures are the theoretically correct benefit measures in Welfare theory. With the CV method the equivalent or compensating Variation is measured.

In the contingent valuation method (CVM), survey and questionnaire techniques are used to extract estimates of the willingness of individuals to pay for the good or service under consideration. The term "contingent valuation" derives from the nature of the method - responses are sought from individuals as to their actions contingent on a particular market-like situation existing. For example, an individual might be asked how much they would be willing to pay to enter a national park, conditional on the existence of a particular charging scheme. The "prices" suggested by the respondents are, therefore, conditional upon the constructed (hypothetical) markets presented to them. Using survey techniques, willingness to pay (or willingness to accept

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compensation) can be estimated using a number of techniques, including open-ended, payment card, dichotomous choice (Mitchell and Carson, 1989) and more recently the payment ladder approach (Folmer and Gabel 2000). The measure elicited by a Contingent Valuation survey is Hicksian willingness to pay measure (Compensating Surplus) a dollar measure of preferences. It is equivalent to a change in income coupled with a change in the amenity under study that leaves the consumer's utility level unchanged. CVM has been applied to a very wide range of issues in an environmental context, including biodiversity, air and water quality, environmental risks, landscape quality, wildlife conservation, outdoor recreation, and cultural heritage conservation (Bateman and Willis, 1999). The range of applications in health care has also been broad (again, see Diener et al, 1998; Olsen and Smith, 2001; Reid 1996). The use of Contingent Valuation surveys to gauge the value of health and life • is linked with the environment literature in a large number of studies valuing health and environmental quality.  

However these methods are also not free from limitations. These surveys are based on hypothetical questions and the respondents should be fully aware of what the investigator is intending. The answers of the respondents may be not reliable for two reasons. The first is that individuals are not incurring actual expenses, so they may not be really considering their budget constraint while answering questions. Secondly,

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9 For a detailed review on such studies refer Kenkel (1994). They find that once the studies control for differences in reporting the contingent valuation estimates are relatively consistent.

individuals may not give reliable answers if the commodity valued is not familiar to them. (Cropper and Freeman, 1990).

The estimation of morbidity and mortality estimates using contingent valuation surveys has been done quite frequently among economists. The Willingness to pay approach was used in five different studies (Loehman et al 1979; Rowe and Chestnut, 1985; Tolley et al 1986; Dickie et al 1987 and Chestnut et al 1988). While the three studies Loehman et al, Dickie et al and Tolley et al looked into the minor respiratory symptoms in general population, Rowe and Chestnut and Chestnut looked into the reductions in symptom frequency for asthmatics and patients with angina. Rowe and Chestnut asked the patients how much they are willing to pay in increased taxes to reduce half of the number of asthma days they experienced each year, with the assumption being that tax dollars could be used to reduce pollen dust and other air pollutants. Rowe and Chestnut and Chestnut used cost of illness too in their studies to have a comparison and they found out that the willingness to pay measure gave an accurate result. Arrow (1983) looked into the economic costs of environmental health effects in USA using the cost of illness as well as the willingness to pay approach. A more recent study by Johnson et al (1997) supports the case for using the willingness to pay studies in measuring morbidity. The authors go a step further by using a health status index called the quality of well being index. The willingness to pay estimates of the five studies done earlier (Loehman et al, 1979, Rowe and Chestnut 1985, Tolley et al, 1986, Dickie et al, 1987 and Chestnut et al 1988) are pooled into a quality of well being index which then provided a measure of each health condition's severity. However this study did not consider the cost of illness of the various diseases as well
as the lost earnings. The studies by Arana and Leon (2002), Kartman et al. (1996), Slothuus et al. (2000), Narbro and Sjostrom (2000) and Eastaugh (2000) looked into the willingness to pay for reductions in attacks caused by different illnesses as well as for treatment of diseases. There are also studies by Johnson et al. (2000), Onwujekwe (2001), O'Connor and Blomquist (1997), Blumenschein et al. (2001), Kennedy (2002) and Bala et al. (1998) used different approaches in willingness to pay for measurement in improvements of health care. In recent years, local and state governments in developing countries increasingly required information about the costs and benefits associated with reduced levels of pollution to assist them in setting (or revising) standards and imposing pollution control measures. To determine the value of the damages to health (both morbidity and mortality) due to air pollution, analysts have traditionally relied on concentration-response functions linking pollution levels to health effects in the population, and estimates of willingness to pay to avoid such effects. For lack of original studies in the countries where the benefits are to be estimated, analysts have sometimes resorted to extrapolating concentration-response functions estimated in the United States to the levels of pollution in the target country (Ostro 1994). This approach has been criticized as potentially invalid on the grounds of the different cultural, behavioural and institutional circumstances, and of the difficulty of finding places with matching environmental conditions from which predictions can be made for the target country. Similar techniques have been applied to produce WTP figures, after adjusting for the income differential between the two countries. Two recent studies, however, have questioned whether this approach is satisfactory, showing that willingness to pay to avoid illness can be higher in Taiwan and Thailand than one would expect from extrapolations from United States studies.
(Alberini and Krupnick 1997; Chestnut et al, 1997). There are also studies, which have used the Contingent Valuation approach to measure the factors affecting the willingness to pay for health insurance. There are only few studies like Markandaya and Murthy (2000) and Sankar (2001), which have used Contingent Valuation in the analysis of health effects due to pollution.

The above methods of valuing health effects and the studies using these clearly showed that the cost of illness approach and the willingness to pay/accept approaches and the human capital approaches are the most used approaches in the developed and developing countries' context including India to study the impact of pollution on health. In the Indian context there are very few studies, which looked into the impact of environmental pollution on health. All these studies mainly used the cost of illness approach. In the Indian context the cause effect relationship between pollution and health impact has been analyzed based on the epidemiological studies unlike using the dose response technique in the developed country context. This is mainly because due to the non-availability of adequate data as the dose response techniques are not fully developed in the developing country. The above review confirms that the cost of illness approach is the most reliable approach to find out the health costs due to pollution although it gives only a lower bound estimate.

Moreover, Cropper and Freeman (1990) argue that a series of comparative studies using different approaches to value the same policy output of the health effect and the loss of productivity should be done to calculate the effect of pollution. This would improve the understanding of the relative strengths and limitations of each method.

\[\text{\textsuperscript{11}}\text{The details of these studies are dealt in detail in Chapter 7.}\]
and help clarify the circumstances in which each method is likely to be applied and perform better.

2.4 Methodology for the Present Study

In this section, the detailed methodology adopted for the study is explained. The profile of the Karunagapally taluk in which the study area is located is provided first. The rationale for selecting Karunagapally Taluk as the study area is also highlighted. The sampling frame and details of selection of sample of the study and control group households and workers are explained later. Thereafter, the questionnaire used for eliciting information on the economic analysis of radiation-induced pollution among the study and control group households as well as the workers is highlighted. The methods used to analyze the economic analysis of radiation-induced pollution in the current study are finally explained.

2.4.1 Profile of Karunagapally Taluk

The study area covered the total Karunagapally taluk of Kollam district in coastal Kerala. The taluk has 12 panchayats spread over 192 Sq.Km as per the District Census Handbook of India (1991). The panchayats of Neendakara, Chavara, Panmana, Karunagapally, Alappad, Kulashekharapuram and Clappana are the panchayats adjoining the coast. These are the area where the radiation levels are high. The mining of the sands for the factories is carried all along the coast of this taluk. The Indian Rare Earth Limited and the Kerala Minerals and Metals Limited are the two major factories in the area, which processes the radioactive compounds like

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12 As mentioned in Chapter 1, in the present study Karunagapally Taluk refers to the taluk panchayat
13 The panchayats here refers to Grama Panchayats
titanium dioxide and thorium. In this taluk, along the coast, there lies a waterway separating a strip of land adjoining the sea from the main land. This coastal belt is about half a kilometre wide and is thickly populated, majority of them are fishermen. Interrupted deposits of ilmenite sands containing radioactive material occur in this strip of land. It is reported that, these sands originate from the hilly rocks and flow down through the rivers and get deposited along the coast. The radioactive sands here contains rich monazite component (1 per cent), which contains thorium, and to limited extent uranium, along with several other rare earth minerals such as rutile, sillimanite zircon and titanium bearing ores. The thorium content ranges from 8 per cent to 10.5 per cent in the monazite sands. Most of the radioactivity (95 per cent) arises from the thorium and its decay products (WHO, 1959). Karunagapally taluk is bounded by Arabian Sea in the west, Alleppey in the north and Kollam district in the south. The taluk has 25-kilometer coastline on the west side. The geographical characteristics show that this place is low land with backwaters and coastal lines. The area is rural as per census of India definition. The major agricultural income comes from cultivation, coconut trees, and paddy fields. Fishing, agriculture, mat making, cashew nut industry and clay works are the most common occupations of the people. The panchayats of Neendakara, Chavara, and Alappad have more fishing population as compared to the other coastal panchayats.

The following three figures (2.1, 2.2 and 2.3) show the location of Kerala in India, Karunagapally Taluk in Kerala and Chavara Grama Panchayat in Karunagapally taluk.
Figure 1
Location of Kerala in India
Figure 2
Location of Karunagappally Taluk in Kerala

KERALA STATE - DISTRICTS.
Figure 3

Location of Chavara Grama Panchayat in Karunagapally Taluk
The review of studies on radiation in the present study area showed that this taluk is one of the areas with the highest levels of radiation levels in the world. The link between the health effects of radiation-induced pollution has also been studied quite substantially here. The factories existing here do the mining near the seacoast and process it. The population density is very high here, and the local fishing community lives near the mining sites and factories. The exposure to radiation is hypothesized to be high, near the mining sites and factories and hence, the sample households for the study are selected from Karunagapally taluk.

2.4.2 Sampling frame for the study

Karunagapally taluk consisted of 12 panchayats. It was found in earlier studies (Nair et al, 1999; RCC, 2000) that the coastal panchayats of Neendakara, Chavara and Alappad had the highest levels of radiation and these were the panchayats nearer to the mining sites. In this study Chavara Panchayat was considered because the two factories that do mining and separation of the radioactive sands were located in this panchayat. The two coastal wards in the panchayat Karithura and Kovilthottam were selected for the study, as the factories are located in this area. Population in these wards was predominantly fishing community, and has the same socio-economic characteristics and it provided an excellent sample for the study. The sample size (n) for estimating the prevalence of disease in this study was determined using the following formula:\textsuperscript{14}:

\textsuperscript{14}The sample size formula is taken from the study by Daniel (1998,p.157).
It was found from the earlier morbidity studies (Aravindan and Kunhikannan 2000 and Sundar 1995) that around 25 per cent of the Kerala population was affected by at least one illness. Based on that the sample size was calculated for the study group as follows.

\[ P = 25\% \]
\[ \text{Precision} = 5\% \]
\[ \text{Design effect} = 1. \]
\[ Z = 1.96 \]
\[ N = 50,000 \]

Thus using the above formula the sample size was calculated as 289 households. By considering a non-response rate of 5 per cent, the total sample size for the study group was fixed as 300.

Karithura ward had 450 households and the Kovilthottam ward had 600 households according to the latest report of the panchayat. Of the total 1050 households in these two wards, a sample of 300 households was selected proportional to the size of the population in each ward. Thus, 128 households from Karithura ward and 172 households from Kovilthottam ward were selected.
A control group was also selected for comparing the cost of health care with that of the study group. The control group was selected from the general population where there was no radiation. The control group was selected from the Perayam panchayat in Kollam taluk around 50 kms from the study area. A random sample of 100 households was selected from Mulavana ward using the simple random sampling method. This ward was also dominated by Christian fishing community and had similar socio economic and demographic characteristics and this area has not reported of any radiation problem still.

The study was also done on the workers of the Indian Rare Earths and the Kerala Minerals and Metals Limited. There were two types of workers; permanent and temporary in the two factories\(^{15}\). There were 350 permanent workers in IRE factory and 400 permanent workers in the KMML factory. The total number of temporary workers in IRE and KMML were 1200 and 750 respectively. The ratio of permanent to temporary workers was 7: 13. Based on this ratio a sample of 65 temporary workers and 35 permanent workers were selected. The selection of workers was made proportional to the number of workers working in each section of the factory. Certain sections like security, clerical and accounts were excluded from the study, as they had no direct exposure to radiation.

2.4.3 Questionnaires used in the study

A primary survey was undertaken using structured questionnaires among the study and control group households, and also on the workers of the factory, to elicit

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\(^{15}\) The rationale for classification into temporary and permanent workers is dealt in detail in chapter 6.
information on the morbidity and health costs due to radiation-induced pollution\textsuperscript{16}. The following section deals with the details of the questionnaires used in the study.

Two different questionnaires were administered in the study; one to the local fishing community in the study area and to the households in the control group, and the other to the workers of the factories. In the questionnaire used for the local community, the socio-demographic information regarding the household was first collected. Data was also collected on the occupational status of the head of household and the family members; income of the households, days and hours of work per day and the time of work was enumerated. All details of expenditure incurred by the family were enumerated for a month. This was done to extract the information on how much the family spends for health as a proportion of total expenditure. Different types of health expenditure like use of medicines, routine checkups, and visits to doctors were explored. There were questions on the prevalence of radiation and non-radiation induced illnesses\textsuperscript{17} among the members of the households. The frequency of disease, days of hospitalization, duration of illness and details of health care sought were collected. The details of the outpatient and in-patient care for the past one-year was explored. The details of outpatient care for the past one year like frequency of visit, the number of accompanying persons, the purpose of visit (consultation and checkup), time spent for each visit, the efficiency of service were obtained. The cost of registration fees, cost of payment to doctor, cost of medicines, cost of transport (including accompanying persons), and cost of lab tests was also collected. The

\textsuperscript{16} The questionnaires used for the study and control group households and for the workers are given in the appendix I and II respectively

\textsuperscript{17} The details on the analysis of the morbidity pattern including radiation and non-radiation induced illnesses will be dealt in the chapter 5.
details of in-patient care for the past one year like, frequency of visit, number of days stayed in the hospital was asked. The costs incurred for the accompanying persons such as food and accommodation, costs of payment to doctor, for medicines, transport (including accompanying persons), lab tests and radiotherapy if applicable, were also collected. The personal habits of the respondents were also probed. Information on habits like smoking, drinking, chewing and its frequency and duration of practice of these habits, as well as on the housing and living conditions were also collected. This included the details of sanitary latrines and availability of drinking water.  

Apart from the above details, the information regarding the worker's occupational status was elicited. This helped to identify their proximity with radiation. The type of work and their description of work were gathered in detail. The timing of work, the number of working days per month, the number of working hours per day, and the total number of years of service were collected. The leave facilities available to the workers for the past three years were collected. The types of leave, total number of days eligible for leave, the actual number of days leave availed and the reasons for taking leave were also explored.

The income details of all the workers were collected. This was important, because workers in the factory were paid different amount of wages, depending on the nature of work. All details relating to their income were collected including wages, bonus, medical allowance, accident allowance, and other allowances. The health insurance or

\[ ^{18} \text{A contingent valuation survey was also conducted among the study group households to look into the willingness to pay for health insurance and it will be dealt in detail in chapter 7.} \]
benefits accruing to the worker were collected. An attempt was made, to find out the benefits given to the workers like medical reimbursement, compensation, loans, paid vacation and paid sick leave. It was also probed whether the factory provides any special allowance for high-risk jobs. The perceptions of the workers on the problem of radiation-induced pollution were explored. For example, what were the measures adopted by the factory to protect them from radiation-induced pollution? Did the factory conduct routine medical check ups? Did the factory have adequate safety measures? Were the trade unions capable of taking care of the worker's health and security?

2.4.4 Measuring Health Costs due to Radiation Induced Pollution in Karunagapally Taluk.

The indirect approach of the valuation of health effects, the Cost of illness approach was done to calculate the costs of health to the local community and to the workers. As explained before, although the Cost of Illness approach gives only a lower bound estimate of the health costs, it gives a reliable estimate. If the people affected by the diseases do not approach hospitals for lack of awareness, accessibility and affordability, the estimate of 'Cost of Illness' tends to be a lower bound. When the entire health system is heavily subsidized, the estimates based on actual expenditure will be far below the true expenditure and associated opportunity cost. The main constraint of the 'Cost of Illness' method is that the value is underestimated mainly because the patients do not always go to hospitals or to doctors for the treatment of all ailments. This can be refuted in the current study on two counts. The health care system in Kerala is well developed with very active public as well as private health care systems. The use of Private health care facilities is very high in Kerala and these
are not subsidized. The people of Kerala are less ignorant in not using the available health care facilities (Panikker and Soman, 1984 and Kannan et al, 1991). Moreover, the diseases mainly involved in radiation-induced pollution are cancer and other specific diseases like heart diseases, Down's syndrome, for which treatment at homes is impossible. The patients will have to depend on the local doctors or hospitals, or the cancer centres for proper treatment. Therefore, the 'Cost of Illness' approach is a reliable method to assess the health cost of the people affected by radiation. It is the simplest method to convey in a quantifiable way the health effects of radiation induced pollution. In the cost of illness approach the respondents will be mainly asked to identify the total costs incurred due to radiation-induced pollution. This would mainly include the actual costs incurred for medicines, for treatment and for preventing the illness. The visit to public or private hospital, or local doctor or private nurse or traditional practitioner, the cost incurred for staying in hospital, and other costs incurred for treatment were considered. The workdays lost due to illness, expenses incurred to prevent the illness are also important. The appeal of the 'Cost of Illness' approach is its seemingly straightforward estimation of clear, well-defined and observable quantities. The willingness to pay approach envisages perfect information about the problem studied as well as the health status. The questions asked are hypothetical and the responses made in monetary terms should go hand in hand with the budget of the respondent. However, in the current study the willingness to pay approach was used to elicit the factors affecting the willingness to pay for health insurance among the households affected by radiation-induced pollution. This

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19 The rationale for using Willingness to Pay approach and the details of analysis is dealt in detail in chapter 7
provided a valid answer to the question as to whether the households affected by radiation induced illnesses and with high health expenditure are willing to pay for health insurance. This supplements the results of the analysis done using the Cost of Illness method covering the study group households.

2.5 Conclusion

This chapter dealt mainly with the framework to analyze the health effects of radiation-induced pollution. Different Valuation techniques, its advantages and disadvantages and the review of selected studies were done in order to find out a suitable method to value the health effects of radiation induced pollution in the study area. The detailed methodology was highlighted in the chapter. The profile of Karunagapally taluk, the study area, and the sampling frame for the study and the questionnaires used for the study were explained in detail. Finally the most appropriate method to analyze the health effects of radiation induced pollution based on the review of earlier methods and studies were done. It was found that the Cost of Illness approach was the best method to value health in the Indian context. The factors affecting the willingness to pay for health insurance based on contingent valuation survey among the study group households was also done in order to supplement the analysis using the Cost of Illness approach.