Chapter-(I): Introduction ----------------------------------------------- (1-16)

1.1 Background

1.2 Statement of the problem and Relevance of the Study

1.3 Research Questions

1.4 Objectives of the Study

1.5 Research Hypothesis

1.6 A Brief Profile of Methodology
  - Theoretical Framework
  - Data Source
  - Method for Estimation

1.7 Findings

1.8 Chapter Organization for the Thesis
Chapter-(1) Introduction

Healthy life is an outcome of sustainable development, as well as a powerful and undervalued means of achieving it. We need to see health both as a precious asset in itself, and as a means of stimulating economic growth. –Dr Gro Harlem Brundtland

1.1 Background:

In this study, a trial has been attempted to explore the linkages between the ‘environment’ and ‘health’ in opencast coal mining area, in the Talcher region of Angul district Odisha. In the recent years many research has been carried out on ‘environment’ and ‘health’ by medical scientists, environmentalists as well as by economists. This ‘environment and health’ linkages pave a pathway for the significance of environmental quality in determining the quality of health and well-being.

“Health” is a precious asset in itself and an absolutely essential factor for human development and productivity (Grossman, 1972). Good health with mental well-being is termed as both a ‘resource’ and ‘means’ for stimulating economic development and also as an outcome of economic development (Brundtland, 2002).

Environmental deterioration, inefficiency of natural resources management, sedentary lifestyles and unhealthy consumption patterns may impact human health adversely. While WHO (2005), argues that the “quality of health” is not only related to freedom from diseases but also highly associated with healthy and hygienic environment. So
the environmental quality is an important determinant of human health. Rapport and Mergler in (2004) reported that traditionally human health was interpreted solely on account of the individual’s physical well-being without considering the environmental and social backgrounds around him. This concept of health is a restriction to discover the affiliation between the environment and health. One new criterion i.e. - ecosystem approach to human health came in 1990s (Costanza et al., 1992; Rapport et al., 2002; Kay and Scheneider, 1994; and Kay et al., 1999) to strengthens the traditionally (biomedical based) health theory, which is well known as ‘ecosystem health’ approach. This approach establishes interlinkages between environment and human health, by not focusing only on physical or biomedical domain of health but also giving priority to environmental, social and political domain. The foundation of this approach was started to delve the association between toxic chemicals and human health and the environment in early 1960s by Rachel Carson and Murray Bookchin. This approach may be considered as a fundamental pillar to understand the health impact of air pollution in coal mining region.

Coal as an important source of fuel and power, is the core mineral associated with the production of steel, cement, fertilizers, etc. Thus in the context of a transition economy (like India) with a voracious appetite for energy and infrastructure creation, coal is critically important for its growth and development. Given that it has the highest forward linkage with a number of other industries, extraction of coal may invent direct & indirect employment possibilities, foreign exchange earnings, tax revenues and provides necessary under building to remote areas. However coal production is treated as “dirty industry” as it is the most polluting natural resources. Apart from the direct impact of the occupational hazards of the coal miners, coal mining activities, particularly open cast coal mining, imposes highly negative
environmental externalities (through air pollution, water pollution, fertile land loss and forest loss and degradation) in terms of poor quality of health among the local communities, who are living closer to opencast coal mining region. Specially the air pollution level (Respiratory Suspended Particulate Matters or PM10) often exceeds the standard prescribed level by Central Pollution Control Board, along with other severe environmental concerns (e.g. water pollution, loss of forest land, land degradation and displacement).

Coal Mining as a decisive economic activity mostly in developing countries, creating some irreversible damage to the local environment, producing huge amount of wastage and pollutants which can have dangerous effects for human health in the neighboring regions of the opencast coal mining belt. Coal production, loading and transportation process have many stages involving various activities, which are all having serious adverse impacts on the local environment and society. The health risk due to air pollution is highly prevalent in the regions where the open caste coal mining activities are rampant. Several research findings show (Gupta, 2006; Chowdhury and Imran, 2010) high concentrations of lower atmospheric pollution especially RSPM (PM$_{10}$) contribute to human morbidity, increase respiratory syndromes & reduced lung functions.

There is no doubt that such health problems have economic cost arising from expenses incurred in treating the diseases and loss of productivity or productive days. Hence in order to improve effective techniques for air pollution control and also to design appropriate policy prescription, it is critically important to estimate both the costs and benefits of air pollution control.

The valuation of health benefit due to the reduction of ambient air pollution has been estimated independently as this effect differs in terms of their impacts and
incidence. Benefits of reduced morbidity and mortality from an improvement in the ambient air pollution reduction have been widely studied in the text of developed countries. However, serious studies based on valuations of morbidity particularly due to coal production induced air pollution are relatively scarce in the case of developing countries like India, having a poor record of environmental accounting. Given the trade-off between environmental pollution and economic growth and development in most of the developing countries including India, policy makers and other stockholders need precise and reliable information on the costs and benefits associated with a particular environmental problem in order to make sound policy prescriptions.

As the valuation of social cost and benefits of air pollution control is an expensive and time taking process, for an individual researcher, this study focuses only on the benefits of air pollution reductions by taking into consideration the public health benefits including reductions in acute respiratory illness (RI) related sick days and its mitigating expenditure.

In the present literature not many reliable techniques related to the estimation of the health benefits of air pollution, particularly in opencast coal mining area are available.

According to Ostro (1995), the fundamental steps for health impact estimation rely on the information of the level of air pollution in coal mining area, the predicted effect of health due to high concentration of pollutants (dose-response function), identification of the targeted population who are exposed to the risk and then the economic estimation should be carried out for these effects. Keeping in minds about these steps, this study tries to estimate the air pollution and health hazards effects empirically for Angul-Talcher coal mining region in Odisha.
1.2 Statement of the problem and Policy Relevance of the Study

Developing economies with huge mineral deposits address a challenge in manifesting the perfect harmony between utilizing the mineral resources with equitable sustainable development while safeguarding the local environment and societal well-being. This concept is well accepted as “resource curse hypothesis” (Sachs and Warner (1997, 2001). Odisha as a developing state in India confronts the similar problem in achieving a modest growth through its rigorous reform initiatives through attracting investments in mineral extraction (mining sector) and its allied industries as a vehicle of economic development. Thus the post liberalization period, the state’s economic development has been depending on mineral based industrial growth, where mining contributes significantly to the states GDP (7% to GSDP & industry contributes 6.6% to GSDP, Odisha Economic Survey, 2014-15). The state, rank 1st in the country in terms of value of minerals, royalty on minerals goes to state revenue account (while coal accounts for 70% of this revenue in last 4 years, Odisha Economic Survey, 2014-15).

In the post liberalization period, the resource extraction and utilization activities are rampant in this mineral rich state, leading to the increase in pollution load (both air and water pollution), along with the wide spread phenomena of soil degradation and forest cover loss. Thus unlike other industrial sectors, mining activities particularly opencast coal mines draw serious concerns for its environmental hazards (especially from air pollution point of view). Besides air pollution from burning of coal, combustion of coal also adds heat & increase RSPM (PM$_{10}$) level in air.

Coal mining can have beneficial local impacts in terms of expansion of economic activities and decreasing poverty as it generates employment and attracts investment. Even with its potential for economic growth, coal mining imposes adverse health
impacts through negative environmental externalities in the mining communities. In
the state of Odisha, health hazards associated with coal mining activities is critically
serious issue. The Odisha State Pollution Central Board (OSPCB) has declared all the
coal belt of the state as the most unsafe zones for human health and living conditions,
as the neighborhood of the coal belt witnesses alarmingly high concentration of SPM
(Suspended Particulate Matter) and RPM (Respirable Particulate Matter) which
exceeds the national standard level by several folds.
From mining to combustion, all the intervening process induces severe environmental
pollution, which release toxic pollutants such as-RSPM (PM\textsubscript{10}) , carbon dioxide
(CO2), sulfur dioxide (SO2) which adversely affect the air quality in the surrounding
environment (WHO, 2002). Longer term exposure to air pollution (PM\textsubscript{10}) may lead to
irritation, asthma, high B.P & heart diseases (Pope, et al., 1995 & 2007).All these
health problems no doubt have some economic cost arising from expenses incurred in
treating the diseases and loss of productivity (Ostro, 1994 & Banerjee, 2001).Due to
these high exposures to the toxic elements, the local communities are vulnerable to
many epidemic diseases such as-Acute Respiratory Illness (RI), Gastric, tuberculosis
and skin diseases (Pattanayak, et al., 2011).

The pervasiveness of all RI diseases is very high through all the seasons (The
Directorate of Health, Bhubaneswar, Odisha, 2013). This is evident from the fact that
a large section of population in Angul-Talcher (53.15%) suffers from RI and other
epidemic diseases (The Community Health Fellowship Programme (CHF), 2009). In
this backdrop the most compelling task is to estimate the environmental health hazard
cost in the coal mining region which will enable designing of an appropriate policy or
intervention for addressing the health impact of the innocent local people.
Although there is a significant trade off in terms of benefits and costs of coal mining activities. Such benefits (in terms of expanding economic activities, industrialization, revenue and income generation, employment opportunities, creation of infrastructure etc.), accrue to the nation as a whole, seem to be more appealing to the policy makers and therefore always win the policy debates. But the stream of costs borne by the lesser privileged communities are highly localized to the neighboring regions (in terms of negative environmental externalities & poor health) though they have a recurring impact over a long period of time. Often they remained unnoticed and un served. There is thus a serious policy implication.

Therefore keeping in mind, the coal has an insatiable appeal for transitional economy and thus the deliberation about coal mining –induced environmental, social, health impacts remains remarkably weighty for policy concern.

1.3 Research Questions

- Does this critical ambient air quality matters to the human health in the neighborhood settlements of the open mining coal belt of Odisha? Moreover, given the adverse environmental externality how the other socio-economic factors affect the health stock of the local community in the coal mining belt?
- If yes, how many productive days (because of illness) they are losing due to respiratory illness?
- Whether their respiratory illness related mitigating expenditure is increasing as RSPM in air is becoming more critical?
- What is the marginal welfare gain if we reduce the air pollution level by one unit?
1.4 Objectives of the Study

- To find out the environmental and socio-economic determinants affecting the health status and their impact on mitigating expenditure.
- To capture the impact of exposure of air pollution on respiratory health status among the residents of Angul-Talcher Coal mining region of Odisha.
- To estimate the relationship between the mitigating expenditure related to respiratory illness and the level of air pollution.
- To measure the welfare gain due to the reduction in air pollution.

1.5 Research Hypothesis

- There is a positive and significant relationship between the level of air pollution (RSPM/PM$_{10}$) & RI (respiratory illness) related sick days.
- A strong and positive association between RI related mitigating expenditure and the level of air pollution.
- There is a positive welfare gain by the reduction of air pollution in coal mining region of Angul-Talcher.
1.6 A Brief Profile of Methodology

1.6.1 Conceptual Framework: The Sources of Environmental Degradation in India

Figure Number-(1.6.1)

Source: Sharmila Banerjee (2001), Oxford University Press
1.6.2 Theoretical Framework: Following Ostro (1994), Cropper et al, (1997), Gupta (2006), Imran, et al., (2010) and Adhikari (2012), we use the dose-response method to find out the relationship between the air pollution and health outcomes in the open cast coal mining region of Odisha. This method relate the magnitude of a “dose” (i.e. - the intensity of pollution to which the local people are exposed) to the responsiveness of the receptor (the response may be any RI diseases, mental stress, even death/mortality) and this degree of effects can be counted as the proportion or the days of illness\(^1\).

This study uses a simplified version of the general “Health Production Function” proposed by Freeman, (1993) .The accepted theory for evaluating the health benefits of air pollution reductions is based on neo-classical utilitarian framework and the normative theory of externality. This framework suggests that an individual can

\(^1\) See the Methodology chapter-(IV) for detail on Dose-Response Function.
preserve the equivalent level of utility while bargain various bundles of goods and services. This bargain can be valuated or estimated indirectly by creating a hypothetical market or directly through health production function, which is established on the theory of utility maximizing consumer behavior. The notable literature including Grossman (1972), Cropper (1981), Gerking and Stanley (1986) and Harrington & Portney (1987) are the fundamental base for the health production model and it was again expanded by Freeman in 1993. The model is briefly defined in below. The basic health production function for an individual can be specified as:

\[ H = f(Q, M, A, Z) \]  

Where (H) represents the health status (respiratory illness) of the individual that are positively correlated to the level of air pollution (Q). (M) Shows the mitigating activities including all medical costs. (A) refers the averting activities to avoid or reduce the pollution exposure. (Z) captures other socio-economic characteristics of individual or individual’s baseline health stock.²

1.6.3 Data Source: The present study is mainly based on the primary survey at the household level, though pollution data are collected from the secondary sources (State Pollution Control Board). This study used two-stage stratification sampling method for selecting households. For first stage stratification, we identified the location of the air pollution monitoring station. We found 4 monitoring station where the PCB (Pollution Control Board) is monitoring the ambient air quality (RSPM/PM₁₀). Out of these four, the MCL area (Mahanadi Coal Field Limited) is selected for the study. The rational for selecting this area is that RSPM/PM₁₀ has often exceeded the national ambient air quality level. Then in second stage, an area of 4 kilometers radius is

² For details about the household health production model, follow the theoretical framework in chapter fourth.
selected around the air monitoring station. Total 10 villages were located within that radius. Thus a total 210 households from 10 villages & 855 household members were surveyed. Out of 855, 254 members were suffered from respiratory illness. These 254 household members are the focus of the study. We also have cross checked from some other sources, namely, Odisha Economic Survey, Bureau of Mines, State of Environment Report, Directorate of Health, Directorate of Economics & Statistics, WHO Reports & OPCB (Odisha Pollution Control Board) reports for collecting the background of knowledge of the study. Through primary survey, we have collected the weekly health diary information (regarding weekly acute respiratory symptoms and its related sick days and mitigating expenditure costs) from respondents. The study also has collected the other environmental, socio-economic and demographic information to control the health impact of air pollution.

1.6.4 Estimation Methods: Different statistical method including percentile, mean, standard deviation, variance, minima and maxima are used to find out the environmental and other socio-economic and demographic factor’s relations with the health. To estimate the health impact of air pollution (dose-response function), the Poisson and Negative Binomial regression model were used. While to calculate the health care medical expenditure demand function, the Tobit model were used. In later part, for comparison purpose, the Probit and OLS regression model were also used.

1.7 Findings: The findings of the study consider there is a positive and statistical significant association between the respiratory illnesses related sick days and the ambient air quality level in opencast coal mining belt in Odisha. It depicts that when we reduce the air pollution level to standard level (prescribed by Pollution Control Board), definitely there will be positive health gain to local people. This study also
established that there is a positive and significant affiliation between the air pollution level and the demand for health care expenses (or mitigating expenses for avoiding the respiratory illness), which reveals that out of pocket expenditure for health care treatment (medical & other mitigating expenses for avoiding the respiratory illness) falls when the air ambient quality improves to national standard prescribed level. By reducing the air pollution level (PM10 level) in Angul-Talcher coal mining belt of Odisha from current average PM10 level (159 µg/m³) to standard prescribed level (90.4 µg/m³) a representative individual can save 0.43 days annually from reduction in respiratory illness (RI) related sick days. Similarly a household member can gain Rs. 372 annually from the reduction in RI related mitigating expenses. By extrapolating these values for Talcher coal mining area, the entire population (144,935 populations as per the 2011 census) can gain the monetary benefits Rs. 60,55,62,70.6 per annum due to reduction in PM10 level to prescribed standard level by Pollution Control Board. (For detail see the chapter 5th).

1.8 Chapter Organization for the Thesis: The dissertation comprises six chapters. First Chapter represents the motivation and the background of the research topic, statement of the research problem, policy relevance of the study, research questions, objectives and hypothesis, a brief discussion about the methodology and the outcomes of the study. In last section of this chapter, the overview of the chapter framework is described.

Second Chapter presents the literature review on environmental externalities, health and valuation theories. In the first section this chapter discusses the normative theory of externalities. The second section discusses the notable theoretical literature on environmental and health. In the third section, the methods for economic valuation of
air pollution reduction discussed, which is based on the neo-classical marginal utilitarian concept. The fourth section of this chapter briefly reported important empirical literature on health and air pollution including international, national and provincial. The fifth section describes the available literature on coal mining activities, air pollution and health effects briefly. At last this chapter concludes by discussing the research gap from the literature review.

Chapter third provides a brief profile of the study area Angul-Talcher coal mining region of Odisha. It discusses the mining and industrial scenario of Odisha, the production and value added status of coal mining to Odisha economy. This chapter also discusses various environmental problems with special focus on air pollution in Angul-Talcher coal mining region.

Chapter fourth describes the methodology part of the dissertation. This chapter deals with the theoretical framework, data sources and estimation methods. This chapter comprises four sections. Section (1) describes the method i.e. dose-response that link the relation between air pollution and health impacts. The second part deals with the theoretical part i.e. the health production theory and its derivation. Third part documents the data source and sampling design in detail. Fourth section describes the estimation methods, econometric specifications and variable discussions.

Chapter fifth deals the empirical analysis of health impact of air pollution in coal mining area. It again comprised by four different sections. 1st section reports the environmental and socio-economic information of respondents that directly or indirectly influence the health. 2nd section shares the results from the dose-response function or RI related sick days by using the Poisson and Negative Binomial model. The third section describes the results from the demand function for the respiratory illness related mitigating expenditure by using Tobit model. And the last section
documents the welfare gain by the reduction of air pollution level from a current average level to standard prescribed level.

Chapter sixth lastly reports the summary of conclusions and findings, discusses how this finding can contribute towards the policy makings. Finally this dissertation closes by outlining the limitations and future scopes of this study.