

“Valuation of Health Effects due to Urban Air Pollution in Kanpur City, India”

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DECLARATION

I hereby declare that the synopsis entitled “Valuation of Health Effects due to Urban Air Pollution in Kanpur City, India” to be submitted for the Degree of Doctor of Philosophy is my original work and synopsis has not formed the basis for any degree, diploma, associate ship or fellowship of similar other titles. It has not been submitted to any other University or Institution for the award of any degree or diploma.

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I. INTRODUCTION

While large-scale industrialization increases the production of material goods and urbanization creates mega cities, the ill effects of these activities are reflected in the form of various environmental problems. One such problem is the deterioration of urban air quality in India and other developing countries. The main contributing factors to air pollution are the overwhelming concentration of vehicles, poor transport infrastructure and the establishment of industries in urban agglomerations. Deterioration of air quality severely impacts quality of life and compromises the objective of sustainable development (World Health Organization, 1997). Epidemiological studies have shown that there is a significant association between the concentration of air pollutants and adverse health impacts (Ostro et al. 1995). Air pollution contributes to illnesses like eye irritation, asthma, bronchitis, etc., which invariably reduce efficiency of people at work.

Among the different types of air pollutants, suspended particulate matter (SPM), especially Respirable Suspended Particulate Matter (RSPM), is recognized as the most important in terms of health effects (Gupta, 2006). It can

penetrate deep into the respiratory tract and cause an increase in cardiac respiratory illnesses, even mortality; contribute to daily prevalence of respiratory symptoms; and decrease pulmonary lung function in children and adults. These illnesses cause functional limitations as reflected by loss of workdays, absence from school, restrictive activity days, and an increase in the visits to doctor and emergency rooms for aggravated asthma and other respiratory illnesses (COMEAP, 1998; M.El-Fadel and M. Masood, 2000; CEAP, 2004).

Kanpur is one of the largest & most populous industrial city as well as an important center for trade and commerce of Uttar Pradesh. Over the years, the Kanpur has faced huge changes not only in terms of pollution load increase, but also the infrastructure requirement (road network, water supply, solid waste management). As a result, the ambient air quality, surface water quality, ground water quality has deteriorated considerably. There is evidence of a high percentage of chronic illnesses like asthma, BP, tuberculosis, heart disease, etc., and this has created widespread concern in Kanpur. One of the main sources of air pollution is the industry associated with textiles, heavy engineering and tanneries. The city is also a major distribution center for finished leather products, textiles and fertilizer. Moreover, lack of opportunities for gainful employment in rural areas has led to an ever-increasing migration of poor families to the urban city of Kanpur resulting in the growth of urban slum clusters and an increase in urban poverty. This has exerted extra pressure on the environmental resources of the city.

Given the significant impact of air pollution on health, it is important that it be explicitly accounted for in economic planning. This requires economic valuation of the benefits of remedial measures taken to reduce air pollution impacts. Since environmental attributes have the

characteristics of public goods, market prices that allow us to estimate the benefits of decreasing air pollution are unavailable. However, using non-market valuation techniques, the benefits of air pollution reduction can be evaluated (Gupta, 2006). Such economic valuation will enable policy makers to compare benefits of reduced air pollution to the cost of air pollution abatement and to provide inputs for designing policies for air quality improvement and its control mechanism. In developing countries, however, very few studies of this sort have been conducted so far. The present study is an attempt to evaluate health effects due to urban air pollution in Kanpur.

II. REVIEW OF LITERATURE

Air Pollution: A Threat to Sustainable Prosperity

Air pollution has emerged as one of the world's leading health risks. Each year, more than 5.5 million people around the world die prematurely from illnesses caused by breathing polluted air. Those illnesses include lung cancer, heart disease, stroke, acute respiratory infections, and chronic obstructive pulmonary diseases such as bronchitis and emphysema (GBD 2013 Collaborators 2015). In fact, exposure to air pollution is now the fourth leading fatal health risk worldwide behind metabolic risks, dietary risks, and tobacco smoke (Table : 2.0). More than six times as many people die from air pollution each year as from malaria, and more than four times as many die from air pollution as from HIV/AIDS. Air pollution takes many forms. One of the most damaging pollutants is PM 2.5, which is very fine particulate matter (PM) with an aerodynamic diameter of less than 2.5 micrometers. Because of their small size, these particles are capable of penetrating deep into the lungs. Their chemical makeup varies, depending on their source. They often consist of carbon, sulfate, and nitrate compounds, but also may include toxic substances such as heavy metals. Very fine particles may be emitted directly from combustion sources such as motor vehicles or power plants, or they may form when gases such as ammonium from fertilizers react with other pollutants in the atmosphere. They may also include concentrations of natural windblown dust. Air pollution is especially severe in some of the world's fastest-growing urban regions, where the combination of more people, more vehicles, energy derived from dirty fuels, construction

Environmental Burden of Diseases (EBD)

Study on health effects of ozone has shown increased emergency hospital visits due to increase

in respiratory illness and lung function decrements. Studies on different pollutants like CO have also shown that CO exposure is associated with death due to formation of carboxy-hemoglobin in the blood (WHO, 2000). Studies suggest that populations living in cities with high levels of air pollution in developing countries experience greater adverse effects of air pollution (Romieu and Hernandez, 1999). A study by Smith et al. (1999) demonstrates that 40-60% of acute respiratory infection is due to changes in the ambient air quality.

During 2000, WHO estimated burden of disease in terms of deaths and disability- adjusted life years (DALYs) for 26 major risk factors by age, sex and illness worldwide in 14 regions. The burden of disease attributable to urban air pollution (particularly the PM and its effect on mortality) has revealed that outdoor air pollution is responsible for 3 percent adult cardiopulmonary disease mortality; approximately 5 percent of trachea, bronchus and lung cancer mortality; and approximately 1% of mortality in children from acute respiratory infection. This amounts to 0.80 million premature deaths and 6.4 million loss of life years (Cohen et al., 2004, WHO 2005).

A study carried out by ENHIS (Environment and Health Information System) project of WHO, to measure the health impact assessment of air pollution in 26 European cities during 2004 (Gothenburg City Report, 2004) has revealed that a reduction of annual mean concentration of PM₁₀ by 5 µg/m³ is estimated to reduce the number of hospital admissions by 22 per year and number of pre-mortality deaths by 23 (15–31) per year. It also increases the life expectancy by 2.5 months among the citizens.

The premature mortality related to long-range transported particles is estimated to be 3,500 deaths per year for the Swedish population, corresponding to a reduction in life expectancy of 7 months. The influence of local sources could cause 1800 deaths per year, corresponding to a reduction in life expectancy of 2–3 months (WHO, 2004).

A study conducted by Central Statistical Organization (2000) shows that urban air pollution has grown to an alarming level across India in the past decade (between 1990 to 2010) due to high dependency on personal vehicles. The growth of vehicular population has contributed to 72% of the total urban air pollution followed by industries (20%) and domestic activities (8%) (Navade, 2002).

According to recent survey by CPCB 23 Indian cities are critically polluted by urban air pollution. There are 12 major metropolitan cities in

India that produce 352 tonnes of oxides of nitrogen, 1916 tonnes of carbon- monoxide from vehicular emission and 672 tonnes of hydrocarbon per day. The CO₂, SO₂ and NO_x in the ambient air are above the standard** prescribed by WHO (CPCB, 2002). Particulate pollution on its own or in combination with SO₂ leads to an enormous burden of ill health, causing 500,000 premature death and 4-5 million new cases of chronic bronchitis each year (World Bank Report, 1992).

Another study by Lehoeaki Z (2000) has revealed that the health damage cost are 9 per cent of the respective income (GDP/capita) in the 12 large Indian cities, implying the cost to the society as direct productivity loss due to urban air pollution. It is as high as 10 percent of the income generated in these cities from all economic sources. The study also estimates the social cost of US\$ 3 billion due to urban air pollution, of which 64 percent is only towards health cost.

Economic Quantification of Urban Air Pollution Impact

The economic valuation methods are classified as physical linkage method and behavioural linkage method. In physical linkage method, the dose response functions are estimated in terms of monetary valuations of changes in the environmental services. These methods are also called damage function or dose-response function approaches and are meant for measuring the effects of deterioration of air quality using market prices.

Behavioural linkage method is based on the behavioural linkages between a change in the supply of an environmental good and its effects. The measurement of damages or benefits from a change in the supply of the environmental good depends on the behavioural responses of users in the observed or hypothetical situations (Murthy, 2003). The values of three categories of health impact are generally considered while carrying out the economic analysis of air pollution impact (Ready, 2003). They are as follows:

- The social costs of providing medical treatment to the victim.
- Loss of labour productivity resulting from ill health.
- The pain, discomfort, loss of working days and inconvenience suffered by the victim

The economic valuation of urban air pollution helps to measure the benefits of remedial measures taken to reduce urban air pollution. It enables the policy makers to compare benefits of reduced air pollution to the cost of air pollution

abatement and provide inputs for designing policies for air quality improvement and its control (Usha Gupta, 2006).

Few studies carried out in Indian context have focused on the health effects of urban air pollution. Brandon and Homman (1995) have estimated the cost of inaction by valuing the cost of environmental degradation in India. In this study, the cost of air pollution is calculated in terms of public health and labour productivity loss. The study considered association between environmental degradation and public health, particularly urban air pollution and respiratory diseases. Using HCA, mortality, morbidity and the value of human life are estimated. The dose-response function used in the study was based on the studies of developed countries. The individual's disutility (i.e. discomfort, suffering and opportunity cost of time) was not considered in this study.

Abubacker (1994) studied industrial air pollution on human health due to cement industries in Tiruchanapalli District of Tamil Nadu. The study found that respiratory and skin diseases are reported frequently among the workers. Cropper et al. (1997) reported the results of the study relating the concentration level of PM to daily death in Delhi between 1991 and 1994. This study concluded that the impact of PM on total non-trauma death was smaller when compared to the US. The impact of air pollution on death by age group is different in developing countries than in the US, where peak effects occurred among the people aged 65 and above. In Delhi, peak effects occurred between the age group of 15 and 44, implying that a death associated with urban air pollution causes more loss of life years.

Murty et al. (2003) have analyzed the impact of higher levels of SPM in the Indian metropolitan cities of Delhi and Kolkata. The study reveals that, the annual marginal benefit is Rs 2086 in Delhi and Rs 950 in Kolkata, if the level of SPM is reduced from the higher level to the prescribed safe level (standard).

III. OBJECTIVES OF THE STUDY

1. To estimate the economic cost of health damage caused by urban air pollution in Kanpur city.
2. To assess the extent of environment burden of disease (EBD) prevailing among different Socio economic groups.
3. To estimate the quantitative health benefits due to reduction of the pollutant concentration.
4. Propose policy suggestion to reduce EBD and

air pollution in the city

IV. METHODOLOGY SURVEY METHODS

A primary survey will be carried out using structured questionnaire in the study and control area households, to elicit the information on morbidity and health. The questionnaire to be used for the household survey will consist of five sections (Socio economic profile, Knowledge about air pollution, Environmental burden of Disease, Health Cost Measurement and Valuation to elicit Willingness to Pay to Reduce Air Pollution) with detailed subsections to facilitate the collection of relevant data on key variables covering various socio-economic and demographic features such as religion, family background, age and sex composition of household members, level of education, marital status, occupation and the size of the accommodation / house and current health status.

The details of expenditure will also be collected. This will extract the information on how much a family spends per annum towards health as a proportion of the total expenditure.

The details of air pollution induced diseases among the household members will be collected along with types of health expenditure such as amount spent on medicine, number of days of medicine taken, number of visits to the doctor, fee paid to doctor, etc. The frequency of illness in a year, duration of illness (i.e. number of days of suffering), and details of health care will also be obtained.

Air Quality Monitoring Procedures

Sampling procedure as recommended by CPCB for collection and analysis of PM (PM₁₀ and PM_{2.5}) will be applied. According to the air sampling manual (CPCB, 2000), air is drawn through a size-selective inlet of high volume sampler through a 20.3 × 25.4 cm (8 × 10 in) filter at a flow rate, which is typically 1132 L/min. Particles with aerodynamic diameter less than the cut-point of the inlet are collected by the filter. The mass of these particles is determined by the difference in weight of the filter paper before and after sampling. The concentration of PM₁₀ in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled. The filter paper was given an identification number or a code. Take initial weight of the filter paper (W_i) before sampling. Condition the filter paper by placing in a conditioning room where temperature is maintained within 20–30°C and 40–50% relative humidity or in airtight

desiccators for 24 h. Take final weight of the filter paper (W_f) after passing the dusty air for a definite period of time. The calculation of the PM concentration is carried out using the formula as below.

Calculation

$$C_{PM_{10}} \mu g/m^3 = (W_f - W_i) \times 10^6 / V$$

Where,

C_{PM₁₀} = Concentration of PM₁₀ in $\mu g/m^3$

W_f = Final weight of filter paper in grams,

W_i = Initial weight of filter paper in grams,

10⁶ = Conversion of grams to μg and

V = Volume of air sampled in m³

Estimation Of Environmental Burden Of Disease (EBD)

The estimation of EBD attributed to urban air pollution is carried out by assessing the extent of burden of disease in terms of changes in the health status of population, who are exposed to pollution in comparison with non-polluted environment.

The model used for estimating the EBD is as follows:

1. Calculation of relative risk

$$RR = \exp \{ \beta (X - X_0) \}$$

Where

β = Range 0.0006 – 0.0010; (proposed best estimates = 0.0008).

X = Current annual mean concentration of particular pollutant ($\mu g/Nm^3$).

X₀ = Base line concentration of pollutant ($\mu g/Nm^3$)

2. Calculation of the Environmental Burden of Disease (EBD)

$$AF \text{ or } IF = \frac{\sum PiRRi - 1}{\sum PiRRi}$$

Where

AF = Attributable factor or IF = Impact fraction.

Pi = Proportion of the population in exposure category 'i' including the unexposed.

RRi = Relative risk at exposure category 'i' compared to the reference level.

3. Calculation of expected number of mortality cases

$$E = AF \text{ (or } IF) \times B \times P$$

Where

E = The expected number of deaths due to outdoor air pollution.

B = The population incidence of the given health effect.

P = The relevant exposed population for the health effect.

Once the EBD is measured, then the economic cost of air pollution impact can be measured.

ECONOMIC COST OF POLLUTION

The household health production function model consists of health production function, demand function for mitigating activities and demand function for averting activities. It is estimated to measure the benefits of reducing air pollution from the higher level to a safe level. The general model of health production function is considered as

$$S_d = f(E_q, M_a, A_a, H_c, S_c)$$

where

S_d = Number of sick days due to exposure to pollution.

E_q = Existing environmental quality.

M_a = Mitigating activity.

A_a = Averting activity.

H_c = Stock of health capital.

S_c = Stock of social capital (education level, income etc.).

It is known that the air pollution affects individual utility indirectly through the health production function and directly by affecting the outdoor recreation and other amenity services. Hence an individual's utility function, health production function and the budgetary constraint can be defined as follows:

$$U_F = f(M_g, L_t, W_d, A_p, I)$$

Where

U_F = Individuals utility.

M_g = Consumption of marketed goods.

L_t = Leisure time available/period to an individual.

W_d = Loss of work days/week due to air pollution induced sickness.

A_p = Ambient air pollution concentration of particular pollutant.

I = Individual income.

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