ISSN : 0974 - 7451 Volume 8 Issue 12

Environmental Science
An Indian Journal
Current Research Paper

ESAIJ, 8(12), 2013 [467-474]

Household level cost of industrial pollution: A study in the industrial areas of Khulna city in Bangladesh

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ABSTRACT

Urban air pollution, water pollution, improper disposal of industrial waste and noise pollution are some notable dimensions of environmental degradation in Bangladesh. These dimensions of environmental degradation are more severe in the city areas. Khulna is the third largest metropolitan city of Bangladesh which is situated in the south-west region of the country. Various types of industrial firms are located at Khalispur area of the city. The dwellers of the area face various types of environmental problems arisen from industrial pollution. This study narrowly defines industrial pollution as water pollution and air pollution generated from industrial units. The industrial firms dispose inorganic substances like mercury, sulphur compounds, lead, nitrates, cadmium and petrochemicals into water bodies which cause water pollution. Similarly, by emitting Nitrogen Oxides (NOx) and Sulphur Dioxide (SO_2), industrial firms pollute the air in the study area. The effects of water and air pollution are far-reaching which affect not only the environment, but also human health. Industrial pollution generates adverse effects on health and increases household costs leading to economic losses. This study tries to address household level costs associated with industrial pollution and finds that environmental awareness is required among citizens to take mitigating and averting measures.

KEYWORDS

Environmental degradation;
Industrial pollution;
Water and air pollution;
Khalispur industrial area;
Household level cost.

INTRODUCTION

The industrial revolution of the mid-19th century has introduced new sources of air and water pollution. That pollution is one of the leading sources of global environmental pollution. The industrial development of an area creates jobs, money, economic opportunity and industrial waste[11]. Gürlük[16] tries to explain the relationship between economic growth and industrial pollution in the European, Euro-Asian and African-Mediterranean countries. Reinert et al.[12] provide an assessment of the impact of increased economic integration within North America on industrial pollution intensities in the Great Lake states of the United States. In addition, Hettige et al.[9] find the relationship between trade policy and the toxic intensity of industrial production in

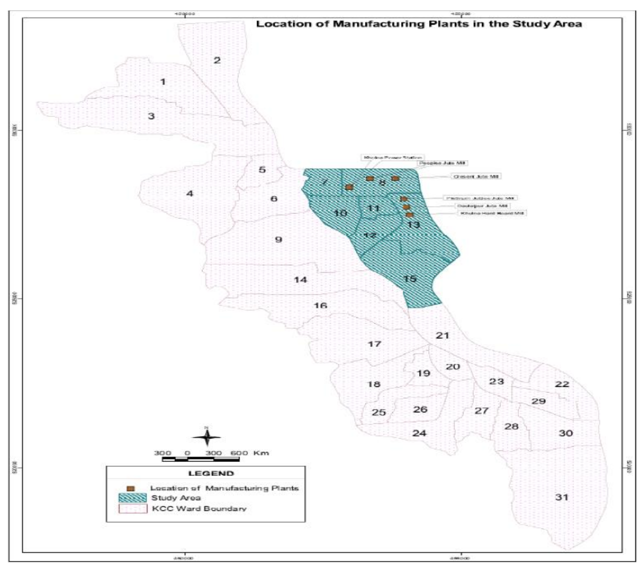
Least Developed Countries (LDCs). Dasgupta et al.[15] use data from Brazil and Mexico to analyze relationships among economic development, size distribution of manufacturing plants and exposure to industrial pollution. Wang[10] reports an empirical analysis of industrial water pollution discharge in China. Streets et al.[7] find that considerable air pollution is caused by the manufacturing firms and power plants in the south coast of China. Leman et al.[2] try to develop an industrial air pollution monitoring system for improving workplace environment. Fleshler et al.[6] state that South Florida is a center of industry, which generates a significant amount of air pollution from sugar production, power plants and scores of small manufacturers. By the middle of the 20th century, the effects of industrialization and urbanization have been spreading in countries around the world. Ostro[4] states that air pollution represents a significant public health hazard to residents of Jakarta and other cities such as Bangkok, Mexico City and Santiago, which are consistently exposed to high levels of air pollution.

The industrial units are generating diversified forms of pollution like water, air, noise and so on. Industrial wastes often contain hazardous chemicals and metals. These wastes pollute surrounding environment. Industry disposes its wastes into rivers and municipal sewage systems. Water pollution is caused by dumping industrial waste into waterways, which leakages into groundwater and waterways. Drinking water is contaminated with the presence of these chemicals into water bodies. Use of contaminated water creates waterborne diseases which lead to long term health hazards. Air quality drops sharply in industrial areas which results in high level of health problems, cancer and premature death. Therefore, this study tries to address health problems and household level health costs, specially costs due to work days lost, associated with water and air pollution resulting from waste disposal form industrial units located at *Khalispur* area in Khulna city of Bangladesh.

MATERIALS AND METHODS

Study area

Khulna is the third largest industrial city of Bangladesh. It lies to the south of Jessore and Narail districts, east of Satkhira district, west of Bagerhat district and north of the Bay of Bengal. This city is located on the banks of the Rupsha and Bhairab rivers in Khulna District. It is an important port city of Bangladesh. *Khalispur* is an urban thana under Khulna city corporation. *Khalispur* is well known as an industrial area. It is the largest jute industrial area of Bangladesh which was established in 1986. The thana occupies an area of 11.47 sq. km, which is bounded on the north by Daulatpur, on the east by Dighalia, on the south by Sonadanga and on the west by Dumuria upazila. This study follows an area sampling procedure to select seven wards of *Khalispur* thana as study sites. Since a majority of the large-sized industrial firms of this thana are located in ward number seven, eight, ten, eleven, twelve, thirteen and fifteen, this study has considered these wards as study area (see Map 1).



Source: Authors' compilation

Map 1: Location of manufacturing plants in the study area

TABLE 1 lists the demographic features of the selected wards. The tabulated data indicates that ward no. 12 holds the top position from both the number of households and total population. Ward no. 7 takes the lowest position form both the perspectives.

Data collection

This study has used both primary and secondary data. Secondary data has been collected from various books, articles and websites. Publications of the Khulna Development Authority (KDA), the Department of Meteorology, the Department of Environment and Central Pollution Control Board are the main sources of secondary data for this study.

TABLE 1: Basic features of the selected study sites

Ward No.	Area (in acre)	No. of Household	Population in 2001
7	102	3,741	14,808
8	115	4,448	18,545
10	237	4,004	18,518
11	90	4,793	19,398
12	250	11,408	52,036
13	301	5,256	19,959
15	595	6,072	25,724
Total	2,535	51,586	224,597

Source: BBS, 2001

To collect primary data, this study has followed well structured questionnaire survey procedure. A pilot survey has been undertaken through using a draft questionnaire in consultation with local people to grasp an overall idea about the study area, and to assess the impact of water and air pollution on the health of households in selected areas. After completing the pilot survey, necessary modifications are made to finalize the questionnaire. Primary data is collected by administering a structured questionnaire survey through a face-to-face interview with the head or any other working member of the household. The population of this study covers the dwellers of the selected wards in *Khalispur* thana. This study has considered 105 households as samples. A total of 15 respondents are surveyed from each of the selected seven words.

Model specification

This study follows the Freeman[1] model of household production function to estimate the willingness-to-pay for safe drinking water and clean air that the citizens' of industrial areas breathe. An individual's utility function may be defined as:

$$U=U(X, L, H, Zi) \quad (1)$$

Where, X is the individuals' consumption of goods and services, L denotes the amount of time spent in leisure of an individual, H represents the work days lost due to water and air pollution induced sickness, Z_i is a vector of characteristics of the individual like education, health status and wealth.

An individual derives his/her utility from the consumption of X, Z_i and L, while H results in disutility. An individual produces good health by combining mitigating and averting activities with the given level of water and air pollution (Q), his health status and other socio-economic characteristics. Therefore, the household health production function can be written as:

$$H=H(M, A, Q, Z_i) \quad (2)$$

Where, H is the number of work days lost due to sickness, M is mitigating activities, A is averting activities, Q is level of ambient water and air pollution, Z_i is a vector of socio-economic characteristics of an individual.

Individuals determine consumption expenditures of goods and services and cost of mitigating and averting activities based on household income. An individual's budget constraint can be specified as:

$$I=Y+W(T-L-H)-X-PmM-PaA=0 \quad (3)$$

Where, Y is non-wage income, w is wage rate, (T-L-H) is time spent at work, T is total time, P_m is the price per unit of mitigating activity and P_a is the price per unit of averting activity. For the given prices of mitigating activities (P_m), prices of averting activities (P_a), wage rate (w), income (I), individuals maximize equation (1) with respect to X, M, A and L given the budget constraint of equation (3). The corresponding Lagrangian function is:

$$L=U(X, LX\,H, Z_i)+\lambda[Y+w(T-L-H)-X-P_mM-P_aA] \quad (4)$$

Where, λ is the Lagrange multiplier. It refers to the marginal utility of investment in mitigating and averting activities to get rid of sickness.

Empirical specification

Empirically, we can estimate the following regression model consisting of the household health production function.

$$H=\beta_0+\beta_1M+\beta_2A+\beta_3Age+\beta_4BCJ+\beta_5Cho+\beta_6Dys+\beta_7Typ+\beta_8HD+\beta_9RD+\beta_{10}SD+\beta_{11}Ast+\beta_{12}EP+\upsilon \quad (5)$$

The dependent variable of equation (5) is H (Work days lost), which represents the number of workdays lost per person due to diseases / symptoms associated with air and water pollution. The considered explanatory variables of equation (5) are:

Mitigating activities (*M*)

M indicates medical expenses to recover from illness, which covers the expenditures incurred due to water and air pollution related diseases.

Averting activities (*A*)

A represents costs of averting activities.

Age

Age refers to the years of age of a working individual.

Job nature (*BCJ*)

BCJ stands for blue collar jobs, which includes individuals having floor jobs in factories, roadside shopkeeper, hawkers and rickshaw pullers. This variable depicts work place environment. It takes value one if a person has a blue-collar job and zero otherwise.

Chronic illnesses

Chronic illnesses such as cholera (*Cho*), dysentery (*Dys*), typhoid (*Typ*), heart disease (*HD*), respiratory disease (*RD*), skin disease (*SD*), asthma (*Ast*) and eye problem (*EP*) are taken as dummy variables. It takes the value one if an individual has a particular disease, otherwise it takes the value of zero. This variable accounts for the individual's health stock. Chronic illnesses are used as proxy for the level of water and air pollution.

RESULTS

In the study area, large-scale industrial units such as Platinum Jublee jute mill, Crescent jute mill, People's jute mill, Daulatpur jute mill, Khulna hard board mill and Khulna power station (see Map 1) are operating. These industrial units are discharging waste into water supplies and in the air, which pollutes air and water quality. The discharged wastes have been causing widespread environmental problems in the study area, which intern have been creating serious health problems. Factory workers and people who are living in and around the industrial zones are especially vulnerable. According to the Environmental Science Engineering Program at the Harvard School of Public Health, about 4 percent of deaths in the United States can be attributed to air pollution. More than 500,000 Americans die each year from cardiopulmonary disease linked to breathing air pollution[8]. According to Shareefa[3], about 40 percent of a French hospital attendance is linked to industrial pollution. Cropper et al.[14] state that long-term exposure to pollution can reduce life expectancy by making people more susceptible to chronic obstructive pulmonary disease.

Socio-economic features of the sample households

Age of the respondents

Average age of the respondents is 39 years with a minimum age of 16 years and maximum age of 68 years respectively. About 28 percent of the respondents fall in 41-50 age-group. Another 27 percent and 23 percent respondents fall in age-groups 31-40 and 21-30 years respectively. The rests belong to 50^+ age-group.

Educational attainment of the sample respondents

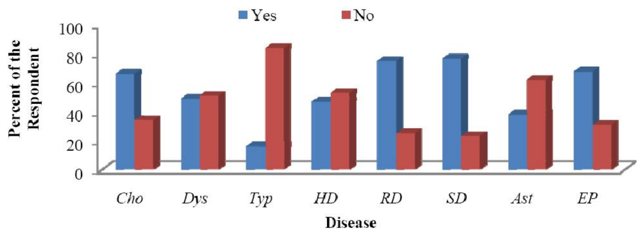
The lowest educational attainment level of the respondents is class one and the highest level is master's degree with mean educational attainment is class ten (SSC). The collected primary data indicate that all of the respondents are literate. However, about 41 percent of the respondents failed to cross the SSC boundary. About 12 percent respondents passed only the SSC level and another 16 percent passed only HSC level. Approximately 28 percent of the respondents have higher than HSC level education.

Job status of the respondents

This study considers day labors, factory workers, roadside shopkeepers, hawkers, rickshaw-pullers, other non-motorized vehicle pullers and motorized vehicle pullers as blue collar job (*BCJ*). In contrast, business, government job, private job and semi-government jobs are considered as white collar job. Among various white collar jobs, government job dominate over other available types followed by business. Among various blue collar jobs, the dominating three types are rickshaw puller, hawker and factory worker.

Health assessment

Human health is very closely linked to environmental condition. Due to pollution exposure in industrial area, human health may be seriously degraded. People living in the industrial zone suffer from various diseases. Dwellers of industrial areas of *Khalispur* are facing varieties of environmental problems. They have to bear several costs due to pollution exposure. The primary data reveals that the respondents and their family members of the study area are suffering from several waterborne diseases and air pollution induced diseases. The symptom and severity of air pollution related diseases is higher than that of water-borne diseases. The field level data indicates that approximately seventy two percent have water-borne diseases, while more than ninety percent of the respondents are suffering from air pollution related diseases.



N.B.: *Cho* = Cholera, *Dys* = Dysentery, *Typ* = Typhoid, *HD* = Heart disease, *RD* = Respiratory disease, *SD* = Skin disease, *Ast* = Asthma and *EP* = Eye problem.
Source: Field survey, 2012

Figure 1 : Prevalence of diseases in the study area

The most common water-borne diseases in the study area are cholera, dysentery, typhoid. In addition, heart disease, respiratory disease, skin disease, asthma and eye problem are considered as industrial air pollution induced diseases. Primary data reveals that about two-third of the respondents suffered from cholera, about half of the respondents suffered from dysentery; while only about sixteen percent of the respondents suffered from typhoid in year 2012 (see Figure 1). More than three-fourth of the respondents suffered from respiratory and skin diseases and about two-third of the respondents suffered from eye problems in year 2012. The data also indicate that about half of the respondents have heart disease and about one-third of the respondents have asthma problem.

Estimation of work-days lost due to sickness

This study uses equation (5) to estimate work days lost (*H*) due to sickness. *H* represents the number of work days lost per person per year due to diseases associated with air and water pollution. According to the literature, this *H* depends on *M*, *A*, *Age*, *BCJ*, *Cho*, *Dys*, *Typ*, *HD*, *RD*, *SD*, *Ast* and *EP* respectively. Here, *M* and *A* refer to mitigating and averting activities respectively. Age refers to the age (in years) of a working individual. *BCJ* stands for blue collar jobs. *Cho*, *Dys*, *Typ*, *HD*, *RD*, *SD*, *Ast* and *EP* refer to cholera, dysentery, typhoid, heart disease, respiratory disease, skin disease, asthma and eye problem respectively which are considered as the water and air pollution related diseases. An individual who has a chronic illness is more susceptible to air pollution exposure and is likely to have higher medical expenses and higher number of work-days lost.

The primary data indicates that on an average more than thirty two days of the respondents are lost due to sickness in a year. TABLE 2 lists simple correlation coefficients among the considered explanatory variables of equation (5). The correlation coefficients indicate how strongly the variables are correlated. In case of moder-

TABLE 2 : Simple correlations of the variables in the work days lost model

	H	*M*	*A*	*Age*	*BCJ*	*Cho*	*Dys*	*Typ*	*HD*	*RD*	*SD*	*Ast*	*EP*
H	1	-	-	-	-	-	-	-	-	-	-	-	-
M	.022	1	-	-	-	-	-	-	-	-	-	-	-
A	-.027	.116	1	-	-	-	-	-	-	-	-	-	-
Age	.021	-.219	-.158	1	-	-	-	-	-	-	-	-	-
BCJ	.163	-.114	-.249	.061	1	-	-	-	-	-	-	-	-
Cho	.374	.212	-.153	-.110	.211	1	-	-	-	-	-	-	-
Dys	.236	-.165	-.046	.083	.167	-.061	1	-	-	-	-	-	-
Typ	.098	-.018	.100	.127	-.081	-.009	-.013	1	-	-	-	-	-
HD	.178	.008	-.120	.219	-.059	-.088	.084	.003	1	-	-	-	-
RD	.173	.092	.083	-.127	-.151	.004	.028	-.047	.139	1	-	-	-
SD	.282	-.112	.036	-.091	-.069	.085	.211	-.130	.055	.213	1	-	-
Ast	.138	.012	-.052	-.132	-.177	-.012	-.135	-.185	-.026	-.004	.007	1	-
EP	.132	-.098	.066	-.085	-.102	-.057	-.081	-.092	-.148	-.103	.022	-.018	1

N.B.: *M* = Mitigating activities, *A* = Averting activities, *BCJ* = Blue collar job, *Cho* = Cholera, *Dys* = Dysentery, *Typ* = Typhoid, *HD* = Heart disease, *RD* = Respiratory disease, *SD* = Skin disease, *Ast* = Asthma, *EP* = Eye problem.
Source: Authors' calculation

ately correlated explanatory variables, as is the case in our study (TABLE 2), the impact of multicollinearity is not too severe in estimating the standard error of the estimated βs.

TABLE 3 lists the estimation results of equation (5). All of the considered 12 explanatory variables come out with the expected positive signs, although not all the variables are statistically significant. The variables Cholera (*Cho*), Dysentery (*Dys*), Asthma (*Ast*) and Eye problem (*EP*) are statistically significant at 1 percent level, Blue collar job (*BCJ*), Typhoid (*Typ*), Heart disease (*HD*) and Skin disease (*SD*) at 5 percent level and Respiratory disease (*RD*) at 10 percent level of significance.

TABLE 3 : Coefficients of the explanatory variables in the work days lost model

Variable	Co-efficient	Std. Error
M	2.05	3.97
A	2.29	2.39
Age	0.10	0.11
BCJ	6.00**	2.51
Cho	11.28***	2.54
Dys	6.41***	2.36
Typ	8.19**	3.16
HD	5.97**	2.36
RD	5.39*	2.73
SD	6.78**	2.86
Ast	8.01***	2.41
EP	8.17***	2.49
Constant	-11.00	8.19
Adjusted R square	0.372	-
F statistics	6.133***	-

***N.B.:* *** p<0.01, ** p<0.05, * p<0.1; Dependent variable: *H* = Work days lost; Explanatory variables: *M* = Mitigating activities, *A* = Averting activities, *BCJ* = Blue collar job, *Cho* = Cholera, *Dys* = Dysentery, *Typ* = Typhoid, *HD* = Heart disease, *RD* = Respiratory disease, *SD* = Skin disease, *Ast* = Asthma, *EP* = Eye problem.**

Source: Authors' calculation

The statistically significant results indicate that all of the considered diseases, such as cholera, dysentery, asthma, eye problem, typhoid, heart disease, skin disease and respiratory disease have significant influence on the dependent variable, the work days lost. Since these diseases are water and air pollution related diseases which are directly linked with industrial pollution, therefore, the study findings indicate that industrial pollution has a significant impact on work days lost. The values of adjusted *R* square and *F*-value show that the overall regression is statistically significant.

CONCLUDING REMARKS

Industrialization is rapidly growing in both developed and developing countries over the time period due to social progress and technological advances. It leads to not only increase in volume of production, but also generate pollution known as industrial pollution. There is a trade-off between industrial growth and environmental quality. Bangladesh, a sovereign state located in South Asia is also facing that trade-off while trying to catch up with the global trend. Like other important cities of the country, Khulna is also comprised with a good number of industrial units. Khulna is the third largest industrial city of Bangladesh. Approximately 593.1 hector (4.48 percent) land of Khulna city is used for industrial purpose[13]. *Khalispur*, the study site of this research is an urban thana of Khulna city corporation which is the largest jute industrial area of Bangladesh. Several large jute mills, one newsprint mill, one hardboard mill, two steel mills and Khulna power station are situated in this densely populated *Khalispur* region. A significant number of people living in the *Khalispur* industrial area are working in various industrial units.

Jute mills in the study area are producing various jute based products and generating solid and liquid wastes. These mills discharge wastes directly into the nature and pollute the surrounding environment, since none of the mills has any waste treatment plant. Small fiber particles of jute and jute products contaminate the air of the study site. Khulna power plant is a thermal power plant, which generates gaseous and liquid wastes. Gaseous waste is disposed into air which generates air pollution and liquid waste is discharged in nearby river which degrades water quality. This power plant discharges flue gas into air at 170-400 degree centigrade temperature. Due to the emissions of flue gas from this power plant, air is contaminated with excessive amounts of carbon dioxide, carbon mono-oxide, black ash and sulfur dioxide. The study area is not a good choice for residential use as several large-sized industrial plants are operating there. The pollution generated from the industrial units has adverse effects on industrial workers and on the mass people living in the vicinity of the industrial firms.

The primary survey findings indicate that the economic condition of the surveyed households is not so good. A majority of the respondents belong to middle class from economic viewpoint. The primary data indicate that a majority of the respondents have been suffering from air and water pollution related diseases. Approximately seventy two percent of the respondents have suffered from water-borne diseases in year 2012. In addition, more than ninety percent of the respondents have suffered from air pollution related diseases in year 2012. This study considers cholera, dysentery, typhoid, heart disease, respiratory disease, skin disease, asthma and eye problem as the water and air pollution related diseases. The presence of moderate correlation among explanatory variables of the multiple regression, as in the case of this study, the authors proceed with the health cost estimation model. The estimation results indicate a statistically significant positive relationship of most of the considered explanatory variables, such as cholera, dysentery, asthma, eye problem, typhoid, heart disease, skin disease and respiratory disease on the dependent measure, the work days lost. Such findings clearly indicate that industrial pollution significantly influences household level cost of people living in the surrounding areas.

Industrial pollution is a serious concern for the study area and it is getting monstrous over the time. It is already a big threat to the safety and health of the people who are working in the industry and/or who are living in the vicinity of the industrial units. To fully cope with the problem, concerned all stakeholders need to work together. Awareness rising among the workers, firm owners and managers, and the mass people of the area is a preliminary but important step for handling the problem. As waste treatment plants are almost absent in the study area, an integrated effort in this regard might help to fight with the burning problem of industrial pollution. The industrial wastes that are discharged without any treatment process have direct, multi-fold and far-reaching consequences. Therefore, this study suggests for initiating waste treatment plant establishment at the earliest possible time. This might reduce the cost of waste treatment due to scale of economies. The government and the industry owners need to work with full co-operation in this regard. Such initiatives might help to reduce the health cost of industrial pollution. However, as this study is based on the data collected from a small sample of a region, therefore, the study findings need to be carefully interpreted. Further study and research covering all other aspects related to the study topic and study on other industrial areas of the country is needed before taking any initiative for generalization of study findings.

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