Impact of Paper Industry on Environment: A Case Study of the Nagaon Paper Mill

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Abstract**—** Pulp and Paper industry has been considered as one of the major polluting industries in the world. (Sharma N *et al*, 2008). The Nagaon Paper Mill was incorporated with the Hindustan Paper Corporation Limited in 1970 but the commercial production of the mill was started from 1985. It is one of the two mills under the Hindustan Paper Corporation in Assam with annual production capacity of 100000 tonnes. The mill being one of the large industrial units occupies a significant place in the context of industrialization of industrially backward state of Assam. Though the mill has positive externalities from the point of view of employment and income opportunities, urbanization and concentration of commercial activities and property price appreciation, it has also negative externalities that are environmental pollution which arises from the operation of the mill.

This paper attempts to investigate the environmental impact of paper production of the Nagaon paper mill on agriculture and health.

I. Introduction

INDUSTRIALIZATION is necessary for the economic development of a country. Apart from directly contributing to income and employment generation, industrialization induces output and employment growth indirectly through its linkages with other sectors. However, industrialization can also lead to worsening of environmental conditions. This is mainly for two reasons. First, industry uses natural resources as raw materials, that is, there is larger scale of natural resource exploitation. Secondly, it also generates pollution and degrades the environment which may also reduce the productivity of people and industrial units create the problem of negative externalities leading to inefficiency and market failure.

II. Review of Literature

The pulp and paper industry is a chemical process industry with major impact on the environment. The potential pollutants from a pulp and paper mill can be classified into four categories –liquid effluents, air pollutants, solid wastes and noise pollution (Mohanty & Srivastav, 1998).

The major pollutants in a pulp and paper industry are the various gases like sulfur compounds and nitrogen oxides emitted to the air, and chlorinated and organic compounds, nutrients and metals, which are discharged to the wastewater. Pulp and paper production, consumption and wasting have many negative environmental and social impacts. The pulp and paper industry is among the world's largest generators of air and water pollutants, waste products and the gases that cause climate change. It is also one of the largest user raw materials including fresh water, energy and forest fibers.

Pulp and paper mills use and generate materials that may be harmful to the air, water and land. The pulp and paper industry is the largest industrial process water user in the U.S. (U.S. department of Commerce, 2000). A typical pulp and paper mill used 4000-12000 gallons of water per tonn of pulp produced in the US.

Pulp and Paper industry has been considered as one of the major polluting industries in the world (Sharma N & Chakravarty H, 2008). Pulp and paper mills pollute water, air and soil. The pulp and paper industry is the third most polluting industry in North America. Gopalaratnam N (1996) points out some of the important environmental issues associated with the paper industry. These issues are- Large use of water and discharge of coloured effluent, presence of chlorinated by products in the effluent system, odour control, acid deposition and stack emission, solid waste. He further mentions that paper industry is also responsible for denudation of forests. Ghosh & Ghosh (2008) stated that pulp and paper mills have been categorized amongst one of the major energy intensive and highly polluting

III. Nagaon Paper Mill

The Nagaon Paper Mill was incorporated with the HPCL on May 29, 1970 but the commercial production of the mill was started on October 1985. It is one of the two paper mills under Hindustan Paper Corporation (HPC) in Assam with annual production capacity of 1, 00,000 tonnes.

The Nagaon Paper Mill is situated at Jagiroad in the Morigaon district of Assam near the national highway no. 37 (Guwahati-Nagaon Road). The raw material bamboo is available in the area. The mill is also well connected by both the rail and road communication. The distance of the mill from the Jagiroad railway station is only 4 km. It is located only 60 kms away from Guwahati city, the gateway of north east India.

IV. Objectives of the Study

The objective of the study is to investigate the impact of paper production on environment with reference to the Nagaon Paper Mill. The impact on environment will be examined in terms of loss of agricultural productivity and damage to health.

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V. Methodology

The study is based on both secondary and primary data. The secondary data are collected from various sources. The main source of secondary data is the Hindustan Paper Corporation Limited, Nagaon Paper Mill unit. The census data of the Government of India, 2001 is also collected to know the demographic profile of the study area.

The primary data were collected through a sample survey. The sample has been selected through a two-stage sampling design. In the first stage, eleven villages have been purposively selected keeping in consideration the representation of villages within a radius of ten kilometers at different distances from the mill. In selecting the villages the direction from the mill is also considered so that data can be gathered from villages located in east, west, north and south. In the second stage roughly ten percent farm households from each of the selected villages were randomly selected for survey. Total number of households thus surveyed is 110.

Data thus collected have been processed and analyzed using Microsoft Excel and SPSS 11.0. Besides, using usual statistical tools of average, ratio, and percentage, some customized tools have also been used. For instance, to capture the economic status of the sample households in a summary measure, an index of economic status has been designed. This index itself is an average of two constituent indices, namely, the index living conditions and the index of consumption standard. The index of living standard has then been computed for a household by taking the average of the four item indices i.e., indices of house type, electrification status, drinking water source and place of defecation. Index of consumption standard have been similarly computed from a households possession of (a) transportation related consumer durables such as bicycles, two wheelers four wheelers, and/or power tiller, tractor (b) other consumer durables namely radio, television and refrigerators. Households have been given scores on the level of possession, which have been converted to item indices by dividing the households' scores by the maximum possible score in the category, and the item indices have then been combined into the index of consumption standard by taking their arithmetic mean. Finally, the index of economic status has been constructed by taking average of the indices of living condition and consumption standard.

Besides this index, association and correlation about different factors especially those relating to health status with economic status and distance from the location of the industry have been worked out.

To estimate the environmental damages of production activities of the mill, the Damage Cost Approach is used. The Damage Cost Approach measures the actual damage caused by pollution. For the Damage Cost Approach, environmental damages are identified. In this study, the Damage Cost Approach is used to investigate the impact of the pollution generated by the paper mill. There can be four components of this approach namely loss of agricultural productivity, damage to health, adverse effect on property and accelerated corrosion. Here, the damages are estimated in terms of loss of agricultural productivity and damage to human health only. To investigate the effect of pollution on agricultural productivity and on the health of the people of the study area, multiple regression analysis is carried out.

VI. Results and Discussion

VI.1 Impact on Agricultural Productivity

The Nagaon paper mill discharges the waste water or pollutant discharge to the natural watercourse in the nearby cultivable land. This waste water passes through the cultivated land where mainly the rice cultivation is done. The waste water contains various chemicals which may adversely affect in the productivity of rice in these areas. In order to investigate the impact of pollution of the mill on the agricultural productivity the different variety of rice are taken under consideration as per the cropping pattern of the study area.

VI.1.1 Cropping Pattern in the Study Area

As far as the cropping pattern is concerned in the study area, it is found that rice is the main cultivation. Rape and mustard is cultivated but in a very small scale. The percentage of area under rape and mustard cultivation is only 1.46 in the study area while rest of the percentage is under rice cultivation. Again the agricultural officer of the study area informed that mainly high yielding varieties are practiced in the area and this was confirmed by the field survey. It is found in the field survey that traditional rice of summer rice cultivation is not practiced in the area. However traditional variety of winter rice as well as the rape and mustard are practiced in a very small size of holding.

In order to investigate the environmental impact on agricultural productivity, only rice is taken under consideration. This is because of the fact that in the field study, it is found that rice is the chief cultivation in the study area other cultivations like rape and mustard are done by only a few farmers in a very small size of holding. The data were collected for both winter and summer paddy. The winter and summer paddy are again classified into traditional and high yielding varieties (HYV). The study area is divided into three categories on the basis of the distance from the industrial unit, so that we can see the effect of pollution on productivity of rice.

Econometric Modeling:

To investigate the impact of environmental pollution of the mill on agricultural productivity linear multiple regression analysis is carried out for each of the HYV crops and winter rice traditional separately. Here we take yield per hectare of the respective crop as the dependent variable (Y).

To see the impact of pollution on yield of agricultural productivity the distance from the paper mill (DIM) is taken as the independent variable because with the help of this variable we can see the impact whether positive or negative. If the impact is positive we can say that as the distance from the paper mill increases the yield of rice also increases. On the other hand if the impact is negative as the distance from the mill increases the yield of rice decreases.

However, apart from the distance from the paper mill variable, there are some other factors which may also affect on

the yield of rice, these variables are percentage of area under irrigation (PAI), fertilizer used per hectare (FPI) and index of the knowledge on village level extension worker (IEW) which are taken as the control variables. The index of the knowledge on village level extension worker is an average of six constituent scores namely- knowledge on village level extension worker (VLEW) of the respective village, consultation with the VLEW last year, Follow up of the VLEW's advice, Usefulness of the VLEWS's advice, extension officer's visit of the village in the last six months and membership of farmer's association. Each of these is given 1 for yes and 0 for no. Then we take the average of the total score to get the index of the knowledge on village level extension worker.

The model used to investigate the impact of industrial pollution on agricultural productivity can be specified as follows.

$$Y = \alpha + \beta_1 DIM + \beta_2 PAI + \beta_3 FPH + \beta_4 IEW + u \quad \text{---- (1)}$$

Where, Y represents yield per hectare of respective crops. α is the intercept, β_1, β_2, β_3 and β_4 are the coefficients to be estimated and *u* is the disturbance term. The model has been estimated by ordinary least square method. The results of Regression Analysis of yield of Winter Rice (HYV) are shown in Table V.

TABLE I
RESULTS OF REGRESSION ANALYSIS OF YIELD OF WINTER RICE (HYV)

Variables / Items	Co-efficients/ values	Standard error	t-values df=25
DIM	(-).053	.018	(-)2.94***
PAI	.0062	.002	3.00***
FPH	.135	.078	1.723***
IEW	.146	.277	.527
Constant(α)	1.07	.207	5.168***
R^2	.14		
$F(\mathfrak{y}_1=4, \mathfrak{y}_2=25)$	1.0		

Note: *** indicates significance at .01 levels.

The value of R^2 is very small. F value is also small. The variables fertilizer used per hectare (FPB) and the percentage of area under irrigation (PAI) are significant at .01 levels and positive. That means the yield of winter paddy (HYV) increases as the quantity of fertilizer used per hectare and percentage of area under irrigation increases. The index of the knowledge of extension worker (IEW) is not significant but positive. Therefore this variable has positive impact on the yield of the winter rice (HYV). The main variable distance from paper mill (DIM) is significant at .01 levels and negative. So we may say that as the distance from the mill increases the productivity of winter rice (HYV) decreases.

The value of R^2 is fairly high. The F value is also high. The value of R^2 is fairly high which implies that the model gives a good fit. Moreover, the large F value implies the high overall significance of the fitted regression. The control variables fertilizer used per hectare (FPB) and index of the knowledge of extension worker (IEW) are significant at .01 levels and positive.

TABLE II
RESULTS OF REGRESSION ANALYSIS OF YIELD OF SUMMER RICE (HYV)

Variables / Items	Co-efficients/ values	Standard error	t-values df=54
DIM	(-).036	.017	(-)2.08**
PAI	.022	.069	.149
FPH	.234	.043	5.40***
IEW	1.33	.315	4.248***
Constant(α)	1.9	.149	12.787***
R^2	.51		
$F(\mathfrak{y}_1=4, \mathfrak{y}_2=54)$	14.01***		

Note: **and*** indicates significance at .05and .01 levels respectively.

That means the yield of winter rice (HYV) increases as the quantity of fertilizer used per hectare increases. The index of the knowledge of extension worker has also positive impact on the yield of winter rice (HYV). Therefore both of these variables have positive impact on the yield of the summer rice (HYV). The main variable distance from paper mill (DIM) is significant at .05 levels and negative which implies as the distance from the mill increases the production of summer paddy (HYV) decreases.

TABLE III
RESULTS OF REGRESSION ANALYSIS OF YIELD OF WINTER RICE (T)

Variables / Items	Co-efficients/ values	Standard error	t-values df=7
DIM	(-)1.279	.456	(-)2.808
PAI	.595	.181	3.296
FPH	1.683	.378	4.452**
IEW	(-).753	.225	(-)3.35
Constant(α)	8.5	2.75	3.0**
R^2	.86		
$F(\mathfrak{y}_1=4, \mathfrak{y}_2=7)$	32.6		

Note: ** indicates significance at .05 levels.

The value of R^2 is high. The F value is also high. The high value of R^2 implies that the model gives a good fit. Moreover, the large F value implies the high overall significance of the fitted regression.

The control variable fertilizer used per hectare (FPB) is significant at .05 levels and positive which indicates that fertilizer has a positive impact on the productivity of winter rice (T). The percentage of area under irrigation is not significant and positive while the index of the knowledge of extension worker (IEW) is neither positive nor significant.

The main variable distance from paper mill (DIM) is negative and not significant. Therefore we can say that the productivity of winter rice (T) is not affected by the pollution generated by the paper mill.

In the above regression analysis our area of interest is the distance from the mill which is not significant and negative for all the variety of rice. Thus we may conclude that the yields of these crops are not adversely affected by the pollution of the mill.

VI.2. Damage to Health

To investigate the impact of the paper mill's pollution on health, emphasis is given to the diseases which may arise from

the pollution of a paper mill. The highest percentage of population in the study area suffers from endemic diseases followed by chronic diseases which are 38.53 percent and 26.63 percent as presented in the table IV. The percentage of population suffering from respiratory diseases is 19.12.

TABLE IV
INCIDENCE OF SAMPLE POPULATION AFFECTED BY DISEASES

Disease	Percentage of Sample Population Affected
Respiratory Disease	19.12
Chronic Disease	26.63
Endemic Disease	38.53

Source: Field Study

The chronic diseases have been classified in to eight types namely Asthma, Diabetes, Cancer, Blood Pressure, Tuberculosis, Heart Disease, Eye Disease and other Disease. The other diseases include cold and cough, running nose, rheumatic pain etc. Among these diseases the highest percentage of sample population are getting asthma which is 7.51 percent as presented in table V

TABLE V
INCIDENCE OF SAMPLE POPULATION AFFECTED BY VARIOUS CHRONIC DISEASES (AS PERCENTAGE OF TOTAL POPULATION)

Chronic Disease	Incidence of Chronic Disease
Asthma	7.51
Diabetes	.57
Cancer	.28
Blood Pressure (BP)	7.37
Tuberculosis (TB)	1.70
Heart Disease	1.98
Eye Disease	3.12
other Disease	4.11

Source: Field Study

The endemic diseases are again classified into six categories. These are Jaundice, Malaria, Diarrihoea, Skin, Gastritis and 0ther diseases. The other diseases include stomach pain, Indigestation, headache etc.

The percentage of population suffering from gastritis is 21.53. That means the highest incidence of sample population having endemic disease is gastritis. This may be because of the continuous generation of smoke of the mill. This smoke goes in and around the study area depending upon the distance and the direction of the wind. Another cause of high percentage of gastritis may be for the lack of safe drinking water.

The second highest percentage of people getting endemic disease is the skin disease which is 9.21 percent. Before collecting the primary data when a few local doctors were consulted, they also informed that the percentage of patients suffering from skin disease and gastritis is high in the study area. The percentage of population suffering from Jaundice, Diarrihoea and Malaria are 3.40, 2.12 and 1.27 respectively as presented in table VI.

TABLE VI
INCIDENCE OF SAMPLE POPULATION AFFECTED BY VARIOUS ENDEMIC DISEASES

Sl No.	Endemic Disease	Incidence of Endemic Disease
1	Jaundice	3.40
2	Malaria	1.27
3	Diarrihoea	2.12
4	Skin	9.21
5	Gastritis	21.53
6	0thers	2.69

Source: Field Study

In order to investigate the environmental impact of the Nagaon paper mill on the number of sick days of the members of the sample household a multiple linear regression analysis is carried out. First we calculated the average number of sick days by dividing total number of sick days by the total number of family members of the respective household. Then the regression is carried out taking average number of sick days as the dependent variable and three independent variables namely distance from mill, safe drinking water, and index of economic status.

Here, to see the impact of pollution on number of sick days, the distance from the paper mill (DIM) is taken as the main variable because with the help of this variable we can see the impact whether positive or negative. If the impact is positive we can say that as the distance from the paper mill increases the average number of sick days of the sample population also increases. On the other hand if the impact is negative as the distance from the mill increases the average number of sick days of the sample population decreases.

However, apart from the distance from the paper mill variable, there are some other factors which may also affect on the average number of sick days, these variables are safe drinking water (SDW), and index of economic status (IES) which are taken as the control variables.
The regression model is given by the equation:

$$ASD = \alpha + \beta_1 DIM + \beta_2 SDW + \beta_3 IES + u \quad \text{---------- (ii)}$$

Where, α is the intercept, β_1, β_2 and β_3 are the coefficients and u is the disturbance term.

TABLE VII
RESULTS OF REGRESSION ANALYSIS OF AVERAGE NUMBER OF SICK DAYS

Variables / Items	Co-efficients/ values	Standard error	t-values (df=106)
DIM (X_1)	(-) 3.192	.722	(-) 4.42***
SDW (X_2)	(-) 2.355	4.117	(-).572
IES (X_3)	(-) 1.042	11.001	(-).095
Constant(α)	53.7312	7.691	6.986***
R^2	.25		
F($\mathfrak{y}_1$=3, ($\mathfrak{y}_2$ =106	11.49***		

Note: *** indicates significance at .01 levels.

The value of R^2 is not very large but F for overall regression is highly significant. Therefore results are credible. Among the three explanatory variables, coefficient of only one

variable distance from the mill (X_1) is significant at 0.1 levels. The sign of the coefficient of this variable is negative which indicates that smaller the distance of the household from the mill more is the average number of sick days.

The coefficients of the other two variables namely safe drinking water (X_2) and the index of economic status are not significant and negative. This means the index of economic status and the safe drinking waster (X_3) do not have an adverse effect on the average number of sick days of the sample population. Since our main area of interest is the distance from the paper mill, we can say that there is positive impact of the environmental pollution of the Nagaon paper mill on the number of sick days of the people in the study area.

The value of the intercept α is significant at .01 level and positive.

The pollution generated by Nagaon paper mill may also affect the people by respiratory diseases. To investigate the effect of this pollution another regression linear regression analysis is carried out taking incidence of respiratory diseases as the dependent variable and three explanatory variables namely distance from mill, safe drinking water, and index of economic status.

The distance of the sample household from the industrial unit is the independent variable and the other two variables namely safe drinking water and index of economic status are the control variables in this regression analysis. Here, the incidence of respiratory diseases (Y) is found out by dividing the total no of persons affected by respiratory disease in the sample household in the village by total population of the sample household in the village.

The model is given as

$$RD = \alpha + \beta_1 DIM + \beta_2 SDW + \beta_3 IES + u \quad \text{---------- (iii)}$$

Where

RD= Incidence of respiratory diseases

DIM= Distance from the paper mill

SDW= Safe drinking waster

IES= Index of economic status

α is the intercept, , β_1, β_2 and β_3 are the coefficients and u is the disturbance term.

TABLE VIII
RESULTS OF REGRESSION ANALYSIS OF INCIDENCE OF RESPIRATORY DISEASES

Variables / Items	Co-efficients/ values	Standard error	t-values (df=106)
DIM (X_1)	(-).0528	.006	(-).8.90***
SDW (X_2)	.059	.034	1.77
IES (X_3)	(-).121	.90	(-).134
Constant(α)	.47	.063	7.48***
R^2	.46		
F($\mathfrak{y}_1$=3, $\mathfrak{y}_2$ =106)	29.82***		

Note: *** indicates significance at .01 levels

The value of R^2 is not very high. Moreover, the large F value implies the high overall significance of the fitted regression.

F for overall regression is highly significant. Therefore results are credible. Among the three explanatory variables, coefficient of only one variable distance from the mill (X_1) is significant at 0.1 levels. The sign of the coefficient of this variable is negative which indicates that smaller the distance of the household from the mill more is incidence of respiratory diseases.

The coefficients of the other two variables namely safe drinking water (X_2) and the index of economic status are not significant. The coefficient of the variable save drinking water (X_2) is positive while the coefficient of the variable index of economic status (X_3) is negative. This means the index of economic status and the safe drinking water do not have an adverse effect on the average number of sick days of the sample population. Since our main area of interest is the distance from the paper mill, we can say that there is positive impact of the environmental pollution of the Nagaon paper mill on the number of sick days of the people in the study area.

VII. CONCLUSION

As far as the environmental impact of the Nagaon paper mill is concerned, it is observed that there is no adverse affect on the agricultural productivity but as the distances from the mill increases the production decreases. This may be because of the fact that the waste water of the mill is treated and some fertilizers like urea are mixed before disposal to the paddy fields. In case of health there is effect of the pollution generated by the mill which is obvious from the regression analysis carried out in study. To estimate the quantum of the health effect a detailed study is required.

Thus we may suggest one policy implication that in order to tackle with the problem of adverse affect of the paper mill's pollution on human health the pollution control standard is to be enhanced.

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