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EVALUATION THE IMPACTS OF COAL FIRED POWER PLANT ON HEALTH AND SOCIAL ENVIRONMENT: A NEW PHENOMENON IN BANGLADESH CONTEXT

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Abstract: Electricity is a part and parcel of our modern civilization. We cannot do for a single day without it. Most of our power plants use fossil fuel for electricity generation. Barapukuria power plant is using coal from the nearby coal mine for electricity generation. Although this power plant is a merciful for northwestern population, but it is emitting serious air pollutants into the air. This study is concerned about environmental impact assessment of the coal-fired power plant of Barpukuria. The socio-economic and land use pattern impacts of the power plant were evaluated through a questionnaire survey. Metrological situation of the study area was assed through preparation of wind rose diagram and determining the stability class of the atmosphere, which control the transport and dispersion of air pollutants emitted from the power plant. The pollutants (SO_2, NO_2, CO_2, PM) emission rates from the power plant were estimated using the quantity of fuel combusted and the emission factor for each pollutant. The environmental effects of the plant on the surrounding air were predicted by using a Gaussian Dispersion Model developed by Pasquill and Gifford. In the study, an attempt was made to evaluate the health impacts of PM_{10} emitted from the combustion of coal in the power plant. An evaluation of economic loss due to the adverse health impacts of PM_{10} was also performed. Results from the analysis show that the number of excess death per annum due to PM_{10} pollution in the study area would be 530. For estimating the afforestation required to minimize the CO_2 emitted from the power plant, a computer-based model 'Plant Mod 2.1', developed by Thornley and Johnson, was used and required forest is about 25 km^2. The study will provide useful information on the impacts of power plant on the environment as well as planning and decision taking processes regarding air pollution management.

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Key Words: Impacts, Assessing, Dispersion, Afforestation and Concentration.

Introduction

Bangladesh is a developing country with a vast population. The population is growing at an alarming rate. But only forty percent of the total population has access to electricity. The per capita electricity generation in the country is one thirty six kWh. The amount is one of the lowest among the developing countries. With the increasing population, the country is passing through a sever power crisis; which is disrupting the social as well as economic activities. To meet the rapid increase of electric power demand, the Bangladesh Power Development Board (BPDB) under took a power system master plan study project during 1990-1991 and appointed M/S Japan Consulting Institute (JCS) for this study under this power system master plan study. The JCI constructed the feasibility study of installing a required capacity of coal fired thermal power plant at Barapukuria near the vicinity of the proposed coal mine at Barapukuria

Bangladesh government gives the responsibility for construction of 250 MW coal based power plant to Chinese Company CMC (China Manufactured Company). Electricity generation from coal causes unbearable pollution. The power plant will burn 70,000 metric ton coal in a year and will emit a huge amount of CO_2, SO_x, NO_x, PM_{10}, Ash, volatile organic matter and various organic matters through the Chimneys.

Pollutants emitted from the plant into the atmosphere undergo transport, dispersion, transformation and ultimate removal from the atmosphere. Transport is through the action of the mean wind in carrying the pollutant away from the sources, whereas dispersion results from the turbulent characteristics of the atmosphere in different diffusing the pollutant in all direction (Lyons and Scott, 1992). Since most industrial pollutants are injected into the atmosphere near the surface of the earth, the physics of atmospheric boundary layer controls the transport and dispersal of pollutants. Wind speed, temperature, pressure, solar radiation, rainfall, humidity etc. every thing effects the fate and dispersal of pollutants.

Exposure to a high level of pollutants results in serious health hazards. The high concentration of pollutants in air often results in respiratory problem. The large particles that may be inhaled get trapped in the nose. The finer particles reach the air passage; the deposition of these particles in the tracheobronchial tree is followed by their ascent through

the mucociliary mechanism to the back to the alveoli. Macro phases or scavenger cells pick up these particles and carry them into the interstitial of the lungs which causes lungs diseases. The people living near power plants have a high occurrence of respiratory problems, lung diseases, problem in the nasal system.

The major objectives of the present study are: i) to assess the socio-economic impacts of the plant, ii) to assess the impacts on the land use pattern, iii) to identify and quantify the environmental effects of the plant, iv) to estimate the pollutants emission rates from the power plant, v) to analyze the transport and dispersion of pollutants using Gaussian dispersion model, vi) to perform risk assessment and economic evaluation of health impacts and vii) to estimate the afforestation required to minimize the effect of CO_2 emission from the power plant.

Materials and Methods

Study Area: Barapukuria Power Plant

The power plant is located at Barapukuria ($25^0$40' North and $88^0$57' East) of Parbattipur-Phulbari thana in Dinajpur district. The installed capacity of the under-construction plant is 250MW. It will burn 70,000 metric ton coal in a year from the nearby coalmine. The total population of the study area (Parbattipur and Phulbari Thana) is about 476,280 and total area is about 625 km^2. Most of the people of the study area is farmer (38%), followed by business man (34%) and service holder (22%).

Methods for Evaluating the Socio-economic Impact

There is no doubt that the coal fired power plant has significant effect on the local people and their occupational pattern, income, agricultural production and land ownership. The impacts were evaluated through a questionnaire survey.

Method to Estimate Pollutant Emission Rates from the Power Plant

Pollutants emission rates from the power plant are calculated by using the fuel consumption rate and emission factors (Kato and Akimoto, 1992) for the unit consumption.

Method to Analyze the Transport and Dispersion of Pollutants

The Gaussian Plume Model (Peterson, 1978) was used to estimate the pollutant concentration at a selected location (x, y, and z) in the three dimensional field downwind of the point source and it can be expressed as:

$$C_{(x,y,z)} = \frac{Q}{2\pi u\sigma_y\sigma_z}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right]+\exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

Where,
C = Concentration of pollutants at point x,y,z, $\mu g/m^3$
Q = emission rate of pollutants, µg/s
δ_y = horizontal dispersion co-efficient, m
δ_z = vertical dispersion co-efficient, m
u = average wind speed at the effective stake height, m/s
H = effective stake height, m/s

Method for Prediction of Risk

The most responsible air pollutant of health effects from power plant is PM_{10}. The risk assessment of PM_{10} for mortality and morbidity are estimated following Ostro (1994) as given below.

Estimation of mortality

Excess death resulting from exposure to PM_{10} is estimated from the dose response relationship given below:
Excess death = $0.00112 \times [PM_{10}\text{-}41] \times P \times C$
P = Number of people exposed; C = Crude mortality rate (0.0076 assumed).

Estimation of morbidly

a) Bronchitis: The total number of yearly cases of chronic bronchitis per 1,00,000 person is:

No of case = $6.12 \times (PM_{10} - 41) \times P$

b) Change in restricted activity days per person per year is estimated as (WHO standard):

The change = $0.0575 \times (PM_{10} - 41) \times P$

c) Change in respiratory disease per 1,00,000 person is estimated as,

$1.2 \times (PM_{10} - 41) \times P/1,00,000$

d) Number of emergency room visits per 1,00,000 person is estimated as,

$23.54 \times (PM_{10} - 41) \times P/1,00,000$

e) The change in daily attacks per asthmatic person is estimated at $0.0326 \times (PM_{10} - 41)$.

f) Respiratory symptom days per person per year is estimated at $0.183 \times (PM_{10} - 41)$.

Finally these impacts of both mortality and morbidity are evaluated in monetary value.

Method for Estimating the Rate of Afforestation Required

For estimating the afforetation required to minimize the CO_2 emitted from the power plant, a computer-based model, 'Plant mod 2.1' (Thornly and Johnson, 1990), was used to calculate the net photosynthesis rate i.e , CO_2 sink by the plants. The model is based on the following equation.

$$Fg = Ef \times \frac{S_{ad}}{EC}$$

Where,
Fg = Gross Photosynthesis Rate daily (Kg/m^2/day)
Ef = efficiency
S_{ad} = Absorbed PAR summarizing over layers (w/m^2)
EC = Energy in Carbohydrate, 15.7 MJ/Kg.

Finally calculation was done to estimate how much afforestation is required to sink the total CO_2 emitted from the power plant.

Results and Discussion

Socio-economic Impact Due to Change in Land Use Pattern

The amount of area covered by the different land use types have been measured and recorded. Further the percentage of the area covered by each of the types has been calculated and recorded to get the land use pattern. It has been noticed in the fig. 1 that from 1954 to 2003 the amount of land occupied by settlement is increased and agricultural land has decreased.

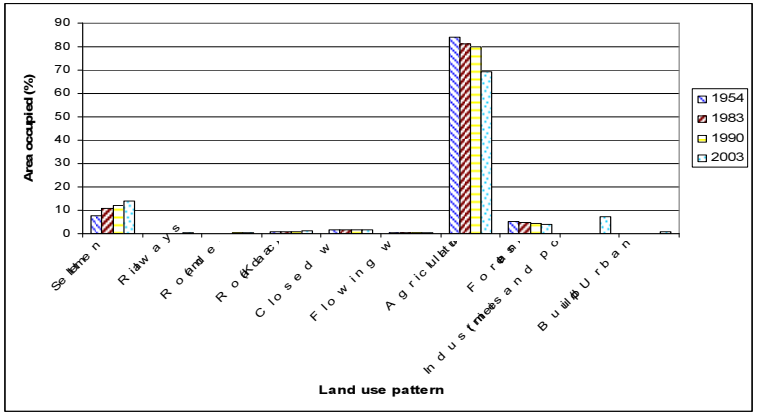

Fig 1: Different land use pattern in different years in Barapukuria.

Estimated Pollutants Emission Rates from the Power Plant

The emission rates of pollutants were estimated by multiplying the coal consumption rate, 70,000 metric ton per year, with the emission factors and the values are given in Table 1. It shows that the emission rate of CO_2 is relatively very high compare to others.

Table 1: The emission rate of the pollutants

Pollutants	Emission rate (g/sec)
CO_2	5574.91
SO_x	34
NO_x	22.34

Pollutants Dispersion in the Surrounding Area

The predicted downwind concentrations of SO_x and NO_x emitted from the power plant in winter are depicted in fig 1. There is a sharp rise in concentration up to 500 m, and then there is a gradual decrease as in Gaussian distribution. It also shows that the concentration of SO_x is higher than NO_x.

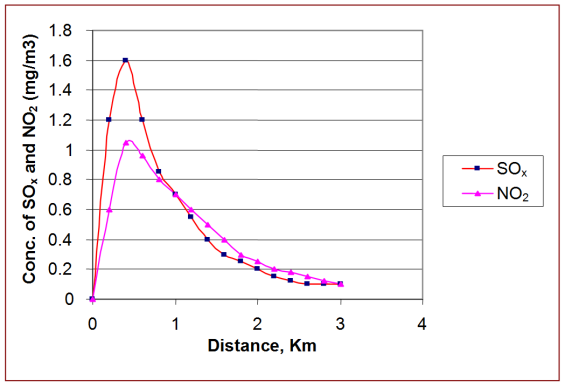

Fig 2: Comparison between SO_x and NO_2 dispersal from power plant.

Risk Assessment of the Pollutants Specially PM_{10}

Table 2 shows the mortality and morbidity resulting from exposure to pollutants especially PM_{10} in the year 2003. In this study, three categories of exposures are adopted and thus the population was is put into three categories- high exposure, moderate exposure and average exposure. The findings of the study are excess death = 530 and total morbidity = 11392882.

Table 2: Mortality and morbidity from pollutants specially PM_{10}

Case	Items	Health exposure	Moderate exposure	Average exposure	Total
Mortality	Excess death	124	176	230	530
Morbidity	Chronic bronchitis	890	1272	1650	3812
	Restricted activity days	835852	1195022	1548858	3579732
	Respiratory hospital diseases	175	250	323	748
	Emergency room visits	3422	4892	6341	8941
	Asthma attacks	33172	47427	61470	142069
	Respiratory symptoms days	2660190	3803285	4929407	11392882

Economic Valuation of Health Effects

It has been found that about 4265 million Taka comes as the total costs for excess death case, 145 million Taka as cost of bronchitis, 251 million Taka as cost of restricted activity days, 4 million Taka as cost of respiratory hospital diseases, 3 million Taka as cost of emergency room visits, 213 million Taka as cost of asthma attacks, 570 million as cost of respiratory symptoms days. Thus the total cost comes out to be 2.5 billion Taka, which shows a tremendous loss potential on our country.

Afforestation Required for Minimizing the CO_2

The seasonal variation of CO_2 sink rate by the plants as estimated by modelling study is shown in Fig. 2. It is found from the modelling study that the winter concentration of CO_2 is very high but the CO_2 sink rate is low. And in summer the CO_2 concentration is very low but sink rate is very high (Table 3). As a result the air become more polluted in winter. For minimizing the CO_2 emitted from the plant it needs 25 sq. Km afforestation annually.

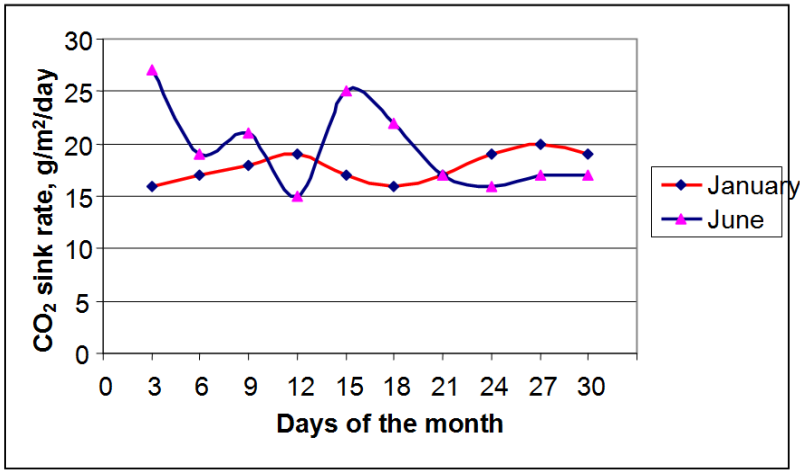

Fig 3: Seasonal variation of CO_2 sink rate by the plants (C_3).

Table 3: Result of afforestation required

Seasons	Maximum CO_2 concentration (mg/m^3)	CO_2 sink rate $gm/m^2/day$	Annual afforestation required (Km^2)
Winter	260	18	25
Summer	55	20	

Conclusions

In this study the impacts of the Barapukuria coal fired power plant on the surrounding environment have been assessed. The overall findings of the study could be summarized as follows: i) The power plant will emit a huge amount of pollutants and ash. The people living there will be exposed to a high level of pollutants and suffer severely from the diseases caused by the pollutants; ii) From the dispersion analysis using Gaussian plume model it is found that the maximum concentration of pollutant occurs at about 500m directly downwind from the plant; iii) Estimation shows that the number of mortality and morbidity per annum due to PM_{10} pollution from the power plant is about 530 and 11392882 respectively; iv) The total estimated cost of health effects due to pollution from the plant comes out to be about 5.4 billion Taka, which shows a tremendous loss to our economy; v) The model results show that the required afforestation for minimizing the CO_2 emitted from the power plant is about 25 Km^2 annually.

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