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Assault of Coal-Fired Thermal Power Plant on Pulmonary Health of School Boys Aged 7 To 15 Years

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***Abstract**: With the advancing of civilization demand for electricity generation increases gradually. Coal-fired thermal power plants are the major contributors of electricity. Among power plants, coal-fired power plants produce most serious air pollution. Children are more susceptible to it. Therefore this study was planned to assess the pulmonary health status of school going boys aged 7-15 years living in the vicinity of thermal power plant. Subjects were divided into two groups: experimental(living within 5km radius from power plant) and control (living more than 25km away from power plant) group. Anthropometric parameters such as height and weight were measured and body mass index and body surface area were derived. The lung function parameters studied were FVC, FEV1, PEFR and FEF25-75%.Spirometric findings suggest that living within vicinity of a coal-fired thermal power plant can result in obstructive lung disease as there is significant reduction of FVC, FEV1 and PEFR. Both asthma and COPD involve in obstructing the small airways. FEF 25-75% is significantly lower (p,<0.001) in people living within 5km from thermal power plant than people living more than 25km from it. This finding suggests that children and adolescent living near coal-fired thermal power plant have every possibility of an asthma-attack at an early age. Here we conclude that spirometric findings are worse for those living within the vicinity of a coal –fired thermal power plant suggesting particularly obstructing small air ways from asthma attack. So, Children reside within the locality of coal-fired thermal power plant should undergo immediate lung function test to detect asthma and its management besides ambient air monitoring.*

***Keywords**: Spirometry, thermal power plant, asthma, respiratory health, coal*

I. Introduction

The demand of electricity generation increases gradually with the ever- increasing growth of human civilization. Throughout the world thermal power plants are major contributors of electricity. Coal-fired thermal power plants generate 41% of world electricity (1). Coal-based thermal power plants have been a major source of power generation in India, where 75% of total power obtained is from coal-based thermal power plants (2). Among power plants the coal-fired powers plants are reported to turn out the most serious pollution (3). After the combustion of coal in boiler 20% of the ash collected at the bottom called bottom ash remaining 80% is carried along with the gases called fly ash. Coal fumes contribute to infect the air with nitrogen oxides (NO_x), sulfur dioxide (SO_2), suspended particulate matter (SPM) and secondary ozone which can cause or exacerbate different respiratory conditions. Asthma exacerbation has been linked specifically to exposure to ozone (O_3), a gas produced when NO_2 reacts with volatile organic compounds in presence of sunlight and heat (4). NO_2 and very small particles, known as PM2.5 adversely affect lung development and reduction of forced expiratory volume (FEV) among children (5). A 10 ug/m^3 increase in $PM_{2.5}$ is associated with a 1% to 3.4% decrease in FEV1, a measure of lung function, in asthmatic children (6). In addition to respiratory illness, long term exposure to $PM_{2.5}$ is causally linked to the development of lung cancer (6). When asthmatic children are exposed to NO_2 they can experience increase in wheezing and cough (7). NO_2 exposure at high concentration (1-2 ppm) causes airway inflammation and low concentration (0.2-0.5 ppm) causes decrement in lung function in asthmatics (7). Exposure to SO2 emitted by coal burning power plants causes inflammation and hypersiveness of the airways aggravates bronchitis, and decrease lung function (8).

Children are particularly susceptible to air pollutants because they breathe more air in respect to their body weight and spend additional time outside. It may also be due to the immaturity of their enzyme and immune systems, which assist in detoxifying pollutants, combined with incomplete pulmonary development (9). These factors appear to act in concert to make children highly susceptible to airborne pollutants such as those emitted by coal-fired power plants (10).

Thus this study was carried out at Kolaghat, Purba Medinipore, West Bengal in order to detect the respiratory effects of coal-fired thermal power plant using pulmonary function test and by comparing the spirometric parameters of the children living within the vicinity of Kolaghat coal-fired power plant with the children those living more than 25 km away from power plant.

II. Materials And Methods

Area of the study:

The Kolaghat thermal power plant ($22^o24'56"N$ $87^o52'12"E$) is situated on the right bank of the Rupnarayan river at Mecheda in the Purba Medinipur district of West Bengal State. It is located approximately 55km away from Kolkata. It is one of the major thermal power stations in West Bengal. This power plant has 6 units of 210 MW each for a total capacity of 1260 MW. The units were commissioned in two stages during the period of 1984 to 1995. Coal is primary fuel of this power plant.

Gopalgange village which was located within 5 km from the power station was investigated as the experiment-village very near to the power plant. Control- village was similar to experiment-village as far as climate, culture and life style werre concerned and it was located more than 30km away from power station.

Subjects:

The present study was conducted among school children aged 7-15 years studying in Primary and Secondary schools of above mention villages. The prior written permission of the school authority was taken. Written consent from the parents of the students experimented in the study was obtained. Subjects were divided into two groups: experimental (living within 5km radius from power plant) and control (living more than 25km away from power plant) group. 448 students (188 under experimental group and 260 under control group). Boys of both control and experimental group were further divided into two depending on age: children (aged 7-9 years) and adolescent (aged 10-15 years).The students who did not complete the lung function test correctly, who reported being active smoker, who had allergic diseases and who had been hospitalized with respiratory or cardio vascular complaint were excluded.

Spirometry: Spirometry was done using portable computerized spirometer (Medikro Spirostar USB Spirometer , Model: M929 , Finland) following the method of Pramanik, 2015 (11) . The complete procedure was explained and demonstrated. All doubts if any were cleared. The subjects were instructed to take a full breath in, close the lips around the mouth piece and blow out as hard and fast possible in standing upright posture. Inspiration should be full and unhurried and expiration once begins should be continued without a pause. Three consecutive spirometric measurements were carried out. The highest values were recorded. Following spirometric parameters were recorded:

Forced vital capacity (FVC): It is the volume of air that can be maximally forcefully exhaled.

Forced expiratory volume in 1st second (FEV1): It is the volume of air that is forcefully exhaled in one second.

Ratio of FEV1/FVC: It is expressed as percentage of FEV1 to FVC.

Peak expiratory flow rate (PEFR): It is the maximum velocity with which air is forced out. It is expressed as liter/sec. Forced expiratory flow between 25% and 75% (FEV25-75%): It is the flow rate (Liter/sec) over the middle of FVC. A low spirometric FVC together with a normal or high FEV1/FVC ratio has been classified as a restrictive abnormality (12, 13). The fall in FEV1, PEFR and other flow rates indicate obstructive lung changes (14).

Questionnaires: Structured questionnaires were administered as face to face interview to collect demographic data and smoking habit.

Statistical analysis: Data obtained from the study were given as mean $\pm$ SD. The statistical significance was determined by student's t test. Two tailed p values were used throughout and p value less than 0.05 were judged as statistically significant .

III. Results

Comparison of physical characteristic of study subjects:

Study subjects (aged 7 to 15) were divided into two categories-children (7 to 9 years) and adolescents (10 to 15 years) on the basis of their age. Both experimental and control group of subjects were nonsmokers and

coming from same socioeconomic status. There was no significant difference of anthropometric parameters between control and experimental group of children (table-1).

Table-1: Comparison of physical characteristic of study subjects

Characteristic	Children (7-9 years)			Adolescent (10-15 years)		
	Control (n=67)	Experimental (n=56)	p	Control (n=121)	Experimental (n=204)	p
Age (years)	8.01 ± 0.83	8.06 ± 0.771	>0.05	12.65 ± 1.71	12.54 ± 1.38	>0.05
Height (cm)	123.50 ± 6.64	121.51 ± 6.13	>0.05	150.42 ± 12.44	147.93 ± 10.69	>0.05
Weight (kg)	22.00 ± 4.03	20.05 ± 3.07	>0.05	38.67 ± 11.44	36.67 ± 9.22	>0.05
BMI (kg/m^2)	14.40 ± 1.87	13.51 ± 1.24	>0.05	16.77 ± 3.14	16.30 ± 2.68	>0.05
Smoking habit	Nonsmoker	Nonsmoker	----	Nonsmoker	Nonsmoker	----
Food habit	Nonveg	Nonveg	------	Nonveg	Nonveg	-----
Habitat	Rural	Rural	-----	Rural	Rural	----
Main source of income	Cultivation	Cultivation	------	Cultivation	Cultivation	----

Comparison of spirometric findings of children living around and away from coal-fired thermal power plan: Table-2 represents the spirometric findings of children. It was observed that there were statistically significant differences between the control and experimental group of village boys in spirometric findings except for the FEV1/FVC values.

Table-2: Comparison of spirometric parameters between control and experimental group of children

Pulmonary function indices	Control (n=67)	Experimental (n=46)	p
FVC (liter)	1.243 ± 0.244	0.992 ± 0.185	<0.001
FEV1 (liter)	1.215 ± 0.231	0.983 ± 0.132	<0.001
PEFR (liter/sec)	3.000 ± 0.550	2.719 ± 0.442	<0.005
FEF25-75% (liter)	3.304 ± 0.597	2.002 ± 0.370	<0.002
FEV1/FVC (%)	97.40 ± 2.13	98.12 ± 3.12	>0.05

Comparison of spirometric findings of adolescent living around and away from coal-fired thermal power plant:

Table-3 represents the spirometric findings of adolescent school boys. It was observed that there were statistically significant differences between the control and experimental group of village boys in spirometric findings except for the FEV1/FVC values.

Table-3: Comparison of spirometric parameters between control and experimental group of adolescent boys

Pulmonary function indices	Control (n=121)	Experimental (n=204)	p
FVC (liter)	1.976 ± 0.514	1.654 ± 0.326	<0.001
FEV1 (liter)	1.959 ± 0.509	1.574 ± 0.374	<0.001
PEFR (liter/sec)	4.818 ± 1.395	3.964 ± 0.885	<0.001
FEF25-75% (liter)	3.409 ± 1.156	2.849 ± 0.689	<0.001
FEV1/FVC (%)	99.58 ± 3.95	95.39 ± 4.12	>0.05

Age wise comparison of spirometric findings:

In this study population residence of control village were found to have better spirometric measurement (except for FEV1/FVC) in all age group than counter part of residence of experimental group. Difference was more significant for age limit 13-15 year

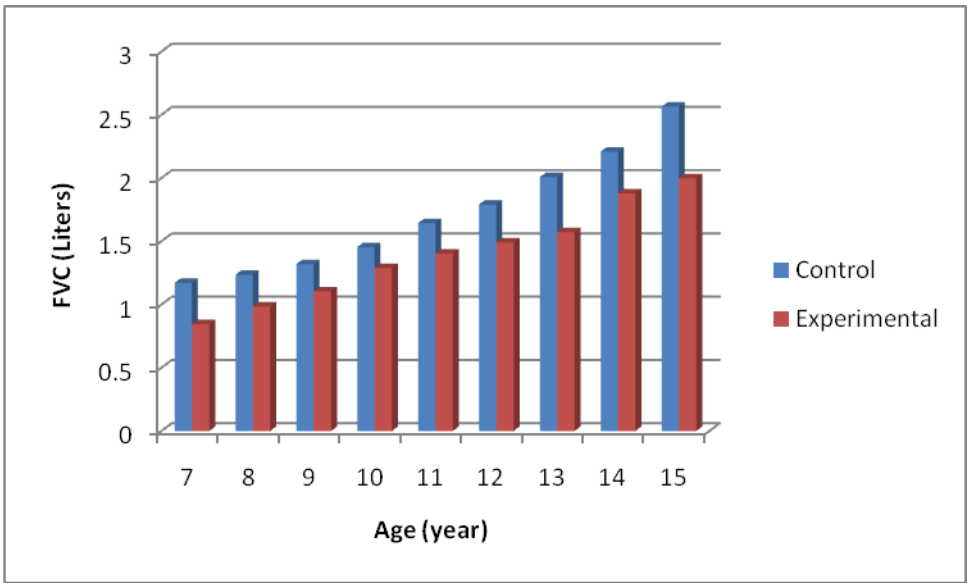

Fig-I: Age wise comparison of FVC of school boys living within 5km (experimental) and more than 25 km (control) from coal-fired thermal power plant. Data represent mean value. P <0.05 in all the cases.

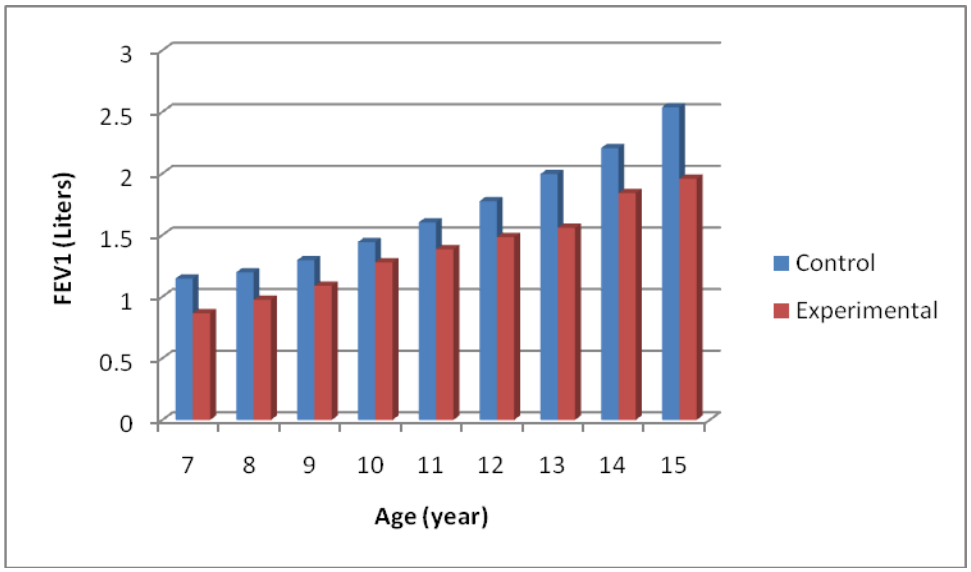

Fig-2: Age wise comparison of FEV1 of school boys living within 5km (experimental) and more than 25 km (control) from coal-fired thermal power plant. Data represent mean value. P <0.05 in all the cases

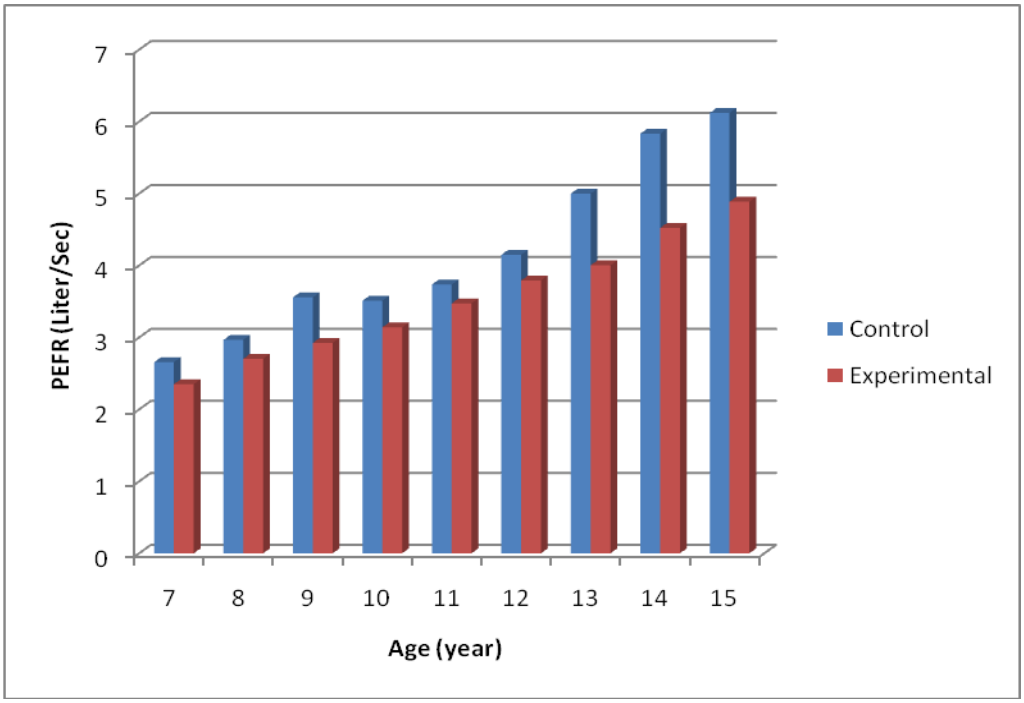

Fig-3: Age wise comparison of PFER of school boys living within 5km (experimental) and more than 25 km (control) from coal-fired thermal power plant. Data represent mean value. P <0.05 in all the cases.

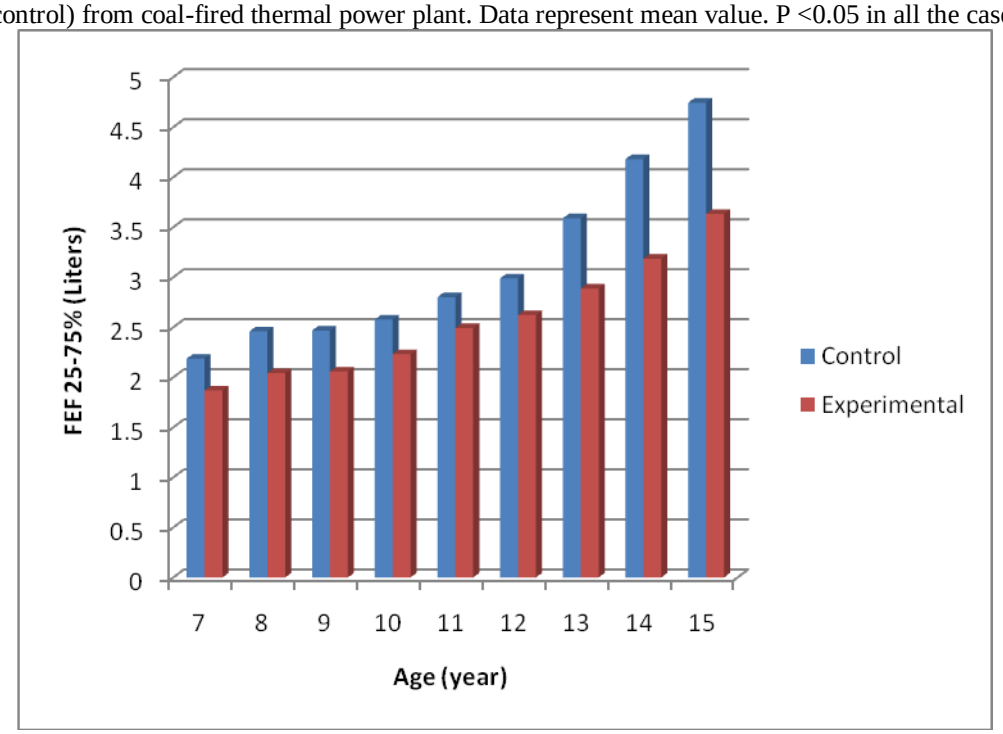

Fig-4: Age wise comparison of FEF25-75% of school boys living within 5km (experimental) and more than 25 km (control) from coal-fired thermal power plant. Data represent mean value. P <0.05 in all the cases.

IV. Discussion

Power generation from coal results in emission of a variety of pollutants including fly ash which is combustion by-product of coal. In India about 79% of the electricity is generated by coal based thermal power plants and annually 65 million tons of fly ash is generated as a waste product (15). The fly ash aerosols and various gases flow with the effluent stream to the exhaust treatment systems which have particle removal devices where most of the fly ash is removed and collected in hoppers. However, some fly ash escapes the collection devices and is released to the environment via the smoke stack. Fine particles of fly ash reach even the peripheral portion of airways (15) through inhalation. Thus present study investigated the pulmonary function indices of children and adolescent living near coal fired thermal power plant.

In the finding of this study when all of the individuals were compared according to various spirometric parameters, individuals living in village more than 25km from power plant were found to be better respiratory health than individuals living within 5km of thermal power plant. A study in Mexico reported that even a power plant complying with national standard, their emission can still have significant impact on the health of surrounding population (16). Hon'ble Pope stated that every 10 microgram/m^3 increment in concentration of PM10 in air would result with decrement of 2% of the pulmonary function (17). Significantly lower FVC, FEV1, PEFR and FEF25-75% in children and adolescent boys living within 5km around the power plant than villagers living away from power plant were noted. In studies in Turkey, the residence of villages located around coal-fired thermal power plant was found to have low FVC, FEV1 and FEF25-75% (18,19).

Spirometric findings suggest that living within vicinity of a coal power thermal power plant can result in obstructive lung disease as there is significant reduction of FVC, FEV1 and PEFR. Both asthma and COPD involve in obstructing the small airways. FEF 25-75% is utilized noninvasively to detect airway obstruction in asthma in early stages (20). FEF 25-75% is significantly lower ($p,<0.001$) in people living within 5km of thermal power plant than people living more than 25km from power plant. This finding suggests that children and adolescent living near coal-fired thermal power plant have every possibility of an asthma-attack at an early age.

V. Conclusion

Here we conclude that spirometric findings are worse for living within the vicinity of a coal –fired thermal power plant suggesting particularly obstructing small air ways due to asthma. The benefits of reducing ambient air pollution from the power plants are expected to protect the children and adolescent from obstructive pulmonary defects. Early diagnosis of small air way non-functioning is important because in mild to moderate asthmatics, treatment during early stage of the disease may be able to reverse air way remodeling and progression to air way fibrosis effectively. Thus further study with large number of children and adolescent are to be carried out to save their respiratory health. So, Children reside within the locality of coal-fired thermal power plant should undergo immediate lung function test to detect asthma and its management besides ambient air monitoring.

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