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Original Research

Health effects and environmental issues in residents around coal-fired thermal power plant, Padubidri: A cross-sectional study

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ABSTRACT

Background: Coal-based thermal power plants have been found to deteriorate human health and environment by its releases. It can cause an impact on air, water, and soil. Thus, the present study was undertaken to assess the health status of the residents and environmental conditions in the area in the vicinity of thermal power plant. **Materials and Methods:** The present cross-sectional study included 408 residents in a 5 km radius around Padubidri thermal power plant. The information was gathered using interviewer-administered semi-structured questionnaire, measurement of peak expiratory flow rate (PEFR) using peak flow meter, and environmental air monitoring using the DustTrak monitor. **Results:** It can be observed that majority of the participants were in the age group ≥45 years (50.7%) with the mean age of the participants being 43.08 ± 12.05 years. 82.8% were females and 17.2% were males. In a total of 408 study participants, 26.7% had cough, 16.7% had phlegm, 4.2% had wheeze, 6.6% had shortness of breath, and 1.5% had chest pain. 9.8% had allergic symptoms such as sneezing, eye irritation, and skin itching. Although the mean observed PEFR was lower in females, smokers, those residing very near to the plant, and those with respiratory and allergic symptom, the difference was statistically non-significant ($P > 0.05$). **Conclusion:** The present study highlights the presence of health problems, particularly respiratory and allergic symptoms among the residents in the vicinity of thermal power plant.

KEY WORDS: Coal-based thermal power plants, environmental pollution, chronic bronchitis, particulate matter

INTRODUCTION

Electricity is the basic necessity of the modern era, and globally 41% of them are generated by coal-based thermal plants. Aspiration for rapid economic growth due to rapid industrialization has led to increased demand for generation of electricity. In India, coal-based thermal power plants (CFTPPs) are a major source for generation of electricity which accounts for 60% of generation [1]. In China and India, coal is the favorite fuel used for electricity generation as it available in abundance and it is economic compared to other fuels.

The coal used in power generation in India has a very high ash content of around 30-40% compared to other developed countries and India stands fourth in the production of coal ash as the waste byproduct. As the use of coal in these plants has increased drastically in years [2,3], the disposal and proper management of fly ash has become a major environmental and health issue.

Fine particles present in the fly ash can reach the alveolar region of the lungs and cause damage and other heavy metals such as nickel, cadmium, lead [Pb], arsenic [As], and chromium [Cr] present in the combusted coal can cause toxicity of major bodily system on the long run [2]. Other releases from these plants include sulfur oxides, nitrogen oxides, suspended particulate matter (SPM), and respirable SPM which can disperse over surrounding of the power plant where people reside.

CFTPPs have been found to deteriorate human health and environment by its releases. It can cause an impact on air,

water, and soil [4-8]. Globally, it is also established that emissions released from these plants significantly increase respiratory illness and premature deaths. A recent study showed 80,000-115,000 premature deaths and more than 20 million asthma cases due to exposure to PM_{10} caused by emissions released from Indian coal plants. It also estimated that the cost on health-care expenditure as a result of these impacts was approximately 16,000-23,000 crores/year [9].

Padubidri thermal power plant is located in Yellur, Udupi district. It is located in the western coastal region of Karnataka where four villages, namely, Yellur, Santhuru, Bada, and Tenka are situated around the thermal power plant. It is a coal-fired thermal power plant of 1200 MW capacity, and it imports 4000 million tons/annum of coal mostly from Indonesia. In the vicinity of the plant, around 120 houses with a total population of 500-700 are residing within 5 km radius. The fly ash and other pollutants released from the plant are taken away by wind to these villages, and the residents are exposed to these pollutants. Thus, the present study was undertaken to assess the health status of the residents and environmental conditions in the area in the vicinity of thermal power plant.

MATERIALS AND METHODS

The present cross-sectional study was done in a 5 km radius around Padubidri thermal power plant. Study area included 120 houses within 5 km radius around the thermal plant. It consisted of approximate population of 500 participants. Complete enumeration technique was adopted in the study. A total of 408 residents of the area participated in the study. The study was carried out during February-July 2015. The inclusion criteria were the residents aged 15-60 years of the selected area residing since January 2012, i.e., after the day of starting of thermal power plant, whereas the exclusion criteria were participants residing within the past 6 months, women who have come to their parent's home, migrant workers, known case of respiratory and neurological disease before the plant was operational, and people on treatment for any respiratory or neurological disease.

The information was gathered using interviewer-administered semi-structured questionnaire which was prepared with the help of literature review. The questionnaire was prepared in English language and administered to the participants in local language by the researcher. The reliability and validity of the questionnaire was tested through a pilot study among 50 participants. It included questions on sociodemographic details, lifestyle factors, respiratory symptoms, allergic symptoms, and neurological symptoms. A detailed history of any preexisting condition and examination of respiratory and neurological systems were done.

This was followed by measurement of peak expiratory flow rate (PEFR) using peak flow meter made by Medicare Equipments India Private Limited for all the participants who were included. The person was asked to take a deep breath and exhale forcefully into the instrument. Three readings were taken, and average of the three reading was taken for each individual.

Environmental air monitoring was done using the DustTrak monitor. Eight sample areas were randomly selected according to the wind direction. Two samples per directions were taken. The reading was taken for 1 h duration each during morning hours and early noon hours from 9 am to 2 pm. Mass concentration for each of these reading was noted.

For analyzing the presence of symptoms according to study variables, the symptoms were categorized into three groups, namely, respiratory, allergic, and neurological symptoms. The participants who had anyone of the symptoms such as cough, phlegm, wheeze, shortness of breath, and chest pain were considered as having respiratory symptoms. Similarly, the presence of any one of the symptoms such as headache, numbness, and fatigue was considered as having neurological symptoms, whereas the presence of either of the symptoms such as sneezing, eye irritation, and skin itching was considered as having allergic symptoms. For categorizing the distance of house from thermal power plant, arbitrarily, people residing at <1 km were considered as residing very near, those residing at 1-3 km as near the plant, and those residing at 3-5 km were considered as residing far from the plant. The statistical analysis was done by SPSS software version 15.0 and included calculation of proportion and percentages.

RESULTS

Table 1 shows the basic demographic and socioeconomic characteristics of the study population. It can be observed that majority of the participants were in the age group of ≥45 years (50.7%) with the mean age of the participants being 43.08 ± 12.05 years. 82.8% were females and 17.2% were males. Most of the participants had education up to primary school level (43.9%). Household income had a median of Rs. 50,000 with interquartile range of Rs.38,000-60,000. Information about personal habits suggested that 94.9% had mixed diet, 97.1% were non-smokers, 82.1% were non-tobacco chewers, and 97.1% were non-alcoholics.

Table 2 shows the distribution of symptoms according to the study variables. In a total of 408 study participants, 26.7% had cough, 16.7% had phlegm, 4.2% had wheeze, 6.6% had shortness of breath, and 1.5% had chest pain. 9.8% had allergic symptoms such as sneezing, eye irritation, and skin itching. The common neurological symptoms reported were headache (17.6%), numbness in limbs (10.5%), and easy fatigability (13.5%). According to the standard clinical definition of chronic bronchitis, 11 (2.7%) participants were found to have chronic bronchitis.

Table 3 depicts the mean observed PEFR according to the study variables. The overall mean observed PEFR was 173.63 ± 70.75 l. There was a declining trend observed in the mean PEFR according to increasing age. Although the mean observed PEFR was lower in females, smokers, those residing very near to the plant, and those with respiratory and allergic symptom, the difference was statistically non-significant ($P > 0.05$).

Table 1: Distribution of study participants according to sociodemographic characteristics

Sociodemographic characteristics	Frequency (%)
Age (in years)	
15-24	30 (7.4)
25-34	73 (17.9)
35-44	98 (24.0)
≥45	207 (50.7)
Sex	
Male	70 (17.2)
Female	338 (82.8)
Education	
Illiterate	54 (13.2)
Primary school	179 (43.9)
High school	103 (25.2)
Graduate and above	72 (17.7)
Occupation	
Housewife/Beedi worker/retired	287 (70.3)
White collar	30 (7.4)
Non-white collar	71 (17.4)
Student	20 (4.9)
Marital status	
Single	39 (9.6)
Married	305 (74.8)
Divorce/widow	64 (15.7)
Number of family members	
2	29 (7.1)
3	70 (17.2)
4	71 (17.4)
>4	238 (58.3)
Number of children	
0	58 (12.7)
1	72 (19.1)
2	142 (34.8)
3	82 (20.1)
≥4	54 (13.2)
Type of family	
Nuclear	176 (43.1)
Joint	232 (56.9)
Median household income (IQR)	50,000 (38,000-60,000)

The ambient air monitoring revealed that the dust levels were within the permissible levels suggested by American Conference of Governmental Industrial Hygienists. However, different dust fraction could not be measured.

DISCUSSION

The present study was carried out to assess the effect of environmental pollution among the residents in the vicinity of coal-fired thermal power plant. The higher prevalence of respiratory symptoms and allergic symptoms reported in the study could be due to the environmental pollution caused by the hazardous waste generated from the combustion of coal, particularly the fly ash. Fly ash contains nuisance dust, heavy metals, and hydrocarbons. All are known to affect the respiratory system of the exposed individual [1,8]. Other studies have also reported these health problems in those exposed to environmental pollution from thermal power plants [5,10]. In addition, study also reported that coal fly ash impairs airway antimicrobial peptides and increases bacterial growth [11].

No significant increase in symptoms was observed when analyzed according to the study variables, namely, age, sex, smoking habit, tobacco chewing habit, and alcohol drinking habit. However, the symptoms increased as the distance from plant is reduced, the closer the residence to the plant, the more the symptoms. This finding was similar to findings in other studies [10]. This is due to high concentration of pollutants in the immediate vicinity of thermal power plants and gradual dilution and dispersion of these pollutants as the distance increases.

Table 2: Distribution of study participants according to presence of respiratory, allergic and neurological symptoms

Study variables	*n*	Symptoms *n* (%)		
		Respiratory	Allergic	Neurological
Age				
15-24	30	10 (35.7)	1 (3.6)	11 (39.3)
25-34	73	20 (27.4)	8 (11.0)	18 (24.7)
35-44	98	32 (32.7)	10 (10.2)	32 (32.7)
≥45	207	59 (28.5)	21 (10.1)	63 (30.4)
Gender				
Male	70	26 (37.1)	8 (11.4)	16 (22.9)
Female	338	95 (28.1)	32 (9.5)	108 (32)
Occupation				
Housewife/beedi worker/retired	287	83 (28.9)	26 (9.1)	96 (33.4)
White collar	30	7 (23.3)	4 (13.3)	7 (23.3)
Blue collar	71	25 (35.2)	10 (14.1)	15 (21.1)
Student	20	6 (30)	-	6 (30)
Smoking				
Smoker	12	4 (33.3)	1 (8.3)	3 (25)
Non-smoker	396	117 (29.5)	39 (9.8)	121 (30.6)
Tobacco chewing				
Chewer	73	20 (27.4)	3 (4.1)	24 (32.9)
Non-chewer	335	101 (30.1)	37 (11)	100 (29.9)
Alcohol intake				
Alcoholic	12	4 (33.3)	2 (16.7)	1 (8.3)
Non-alcoholic	396	117 (29.5)	38 (9.6)	123 (31.1)
Distance from TPP				
Very near (<1 km)	160	51 (31.9)	18 (11.2)	46 (28.8)
Near (1-3 km)	176	51 (29)	20 (11.4)	51 (29)
Far (3-5 km)	72	19 (26.4)	2 (2.8)	27 (37.5)

The residents residing very near and near the plant complained of poor soil quality, poor yielding of crops, rusting of utensils, rusting of vehicles, and poor quality of water used for consumption. Similar results of poor yielding of crops and effect on soil and water were seen in some studies; it was due to fly ash which has high contents of heavy metals [12-18].

As the fly ash is considered as nuisance dust and it causes irritation of respiratory tract, thereby causing the obstructive type of pulmonary function impairment, the peak expiratory flow was measured. When PEFR was analyzed according to the study variable, a statistically significant decline was observed according to the increasing age of the participant. The smokers, females, chewers, and those residing near the thermal power plant had lower PEF as compared to non-smokers, males, non-chewers, and those residing far from the thermal power plants, respectively. However, the difference was statistically non-significant.

Although this is the first attempt to assess the effect of environmental pollution caused by coal-fired thermal plant,

Table 3: Distribution of mean observed PEFR and SD with variables

Variables	*n*=263	Mean observed PEFR (l/s) (Mean±SD)	*P*
Age			
15-24	22	214.09±78.24	0.008
25-34	59	184.53±79.93	
35-44	67	170.60±70.43	
≥45	115	162.08±61.15	
Sex			
Males	44	175.34±59.54	0.862
Females	219	173.29±72.92	
Smoking habit			
Smoker	7	143.33±59.03	0.251
Non smoker	256	174.47±70.97	
Distance from the plant			
Very near	92	167.55±62.90	0.95
Near	123	183.37±73.44	
Far	48	160.34±75.81	
Respiratory symptoms			
Yes	68	167.43±74.76	0.402
No	195	175.80±69.37	
Allergic symptoms			
Yes	32	166.89±71.04	0.566
No	231	174.57±70.82	

PEFR: Peak expiratory flow rate, SD: Standard deviation

the present study also has some limitations. First, this being a cross-sectional study has a limitation in establishing causal effect relationship. All efforts were taken to gather information and analyze the potential confounders. Second, the environmental monitoring was carried out only from the total particulate matter. The measurement of each fraction such as PM_{10}, PM_5, $PM_{2.5,}$ and PM_1 would have resulted in much more specific information from prevention and control perspective. However, due to the limitation of resources, this could not be done.

Thus, to conclude the present study highlights the presence of health problems among the residents in the vicinity of thermal power plants. Poor quality of water used for consumption, poor quality of soil, poor yielding of crops, and rusting of vehicles were also seen as a result of improper disposal of fly ash. There is a need for regular and more meticulous monitoring of ambient air for presence of pollutants released from the coal thermal power plant. Recent judgment of honorable supreme court also indicates toward this. As the principal cause for the contamination of environment is improper disposal of fly ash waste, efforts should be taken to dispose of fly ash waste more safely such as recycling and using for manufacturing cement, making bricks, development of ceramics, fertilizer, and use in road construction should be done [9,19,20].

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