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Evaluation of Health Status and Effects of Thermal Power Plant Pollutants on the Population's Health and the Environment around the Plant

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A B S T R A C T

The quality of the soil, air, and water are significantly impacted by coal-fired thermal power plants (TPPs), which negatively affects the surrounding environment and human health. The current study's goals were to detect specific heavy metals in fly ash, air, water, and soil samples, as well as to evaluate the respiratory health of the community living close to the plant. Materials and Procedures In the current cross-sectional study, 3533 adult people from two strata within a 10-kilometer radius of the TPP in the Karnataka state's Udupi district participated. Semi-structured questionnaires, spirometry, environmental air monitoring with a DustTrak aerosol monitor, water samples, and soil samples were used to obtain the data.

Results: The majority of the study's participants were over 45 years old (41.4 percent). There were 70.6 percent females and 0.39 percent transgender people. There were different respiratory issues in 4.3 percent of the population. According to bivariable logistic regression, participants aged 46–65 and >65 respectively had 2.91- and 4.42-times greater risks of respiratory disease than those aged 45 years. The results of multivariable logistic regression revealed a significant correlation between older age groups and subjects who had closed their windows while cooking (P 0.006). While the amounts of iron, manganese, and copper in the ground water samples were overly high, the levels of heavy metals in soil samples and particulate matter 2.5 were well within allowable limits. The results of this study have consequences for the formulation of policies that safeguard the environment and human health.

Keywords:Asthma, particle matter, heavy metals, environmental pollution, and power plants.

1. Introduction

Around 41% of the world's electricity is produced by coal-based thermal power plants (TPP), and demand for electricity has risen as a result of the economy's quickening pace of expansion. Power output has expanded significantly with coal-based facilities, which account for 60% of the electricity produced in our nation, in order to fulfill the demands of India's growing population. Fly ash can have devastating effects on the cardiovascular, nervous, and respiratory systems if it contains heavy metals such nickel, lead, cadmium, chromium, and arsenic. Pneumoconiosis can result from lung injury caused by fine particles. Poisonous gases such sulfur dioxide, sulfur trioxide, carbon monoxide, and nitrous oxide are emitted into the atmosphere, along with other negative health impacts. Air, soil, and water are all impacted by these factors.Previous research has demonstrated how these pollutants affect human health. More than 20 million cases of asthma and 80,000–115,00 premature deaths have been linked to India's exposure to PM10 from coal-fired power plants.

There have been numerous studies conducted in India that have demonstrated the negative effects of environmental abuse on human health, but none that have evaluated the health effects of environmental abuse in the Udupi district and could have aided in the development of more specialized regional policy interventions. In order to test the PM2.5 levels and specific heavy metals in fly ash, air, water, and soil near the thermal power plant and to assess the respiratory health status of the population of villages within a designated geographic area around the plant .[8][9][10][12][13][14]

2.Study Design:

The TPP in Udupi district of the southern Indian state of Karnataka may be a coal-based TPP established in 2008 and is situated in Yellur village and within 7–8 km proximity to Shambavi river. The plant contains a capacity of 1200 MW and have become operational in September 2012. This cross-sectional study was conducted within 10 km radius of the TPP in Padubidri from July 2018 to April 2019. the full villages in and round the TPP were divided into two strata supported proximity (a) 0 to <5 km of radius and (b) >5–10 km from the plant. Five villages were selected randomly for the study. Line listing of households within the two strata was done by collection of the knowledge from the respective panchayaths and from each stratum of villages, about 325 households were selected. the specified number of households from each stratum was proportionately distributed to the chosen villages. There are three villages within 5 km radius of the facility plant and as per the 2011 Census, the population in Yellur, Santhoor, and Palimar were 5453, 2461, and 3319, respectively. Other two villages within the proximity (>5 and <10 km) are Pilar (3221) and Nandicoor (2987). As the information on the present health status wasn't readily available, 3500 individuals were enrolled for the study supported sample size calculation by considering the prevalence rate of respiratory symptoms starting from 6.6% to 26.7% from the previous study. Considering two adults from each household, about 325 households were required to be selected from each village. .[2]

Inclusion and exclusion criteria:

Persons residing since January 2012 within the study areas were included. Exclusion criteria were people who started residing within the study area within the past 6 months, and, known cases of respiratory and neurological disorder before the plant was operational.

3.Methods:

Systematic sampling procedure was adopted for the choice of households from each village. because the risk in each household was uniform within the study area, a sampling with replacement approach was adopted. For the choice of first household, a coin was tossed from the middle of the village to pick out the direction within which the primary house are selected. If the chosen house was locked, then the very next one was included for the study. Data were collected from the pinnacle of the family or a responsible member from the household consented to be a part of the study. Patient consent declaration form was prepared in local language and consent was taken after explaining risk and benefits of the study to the participants. The study protocol was approved by the Institutional committee (soc/sisec/22.1/2017/11 dated 09-10-2017). Information was gathered by using interviewer-administered semi-structured questionnaires. The questionnaire was prepared in English and translated within the local language. The reliability and validity of the questionnaire were tested through a pilot study among 50 participants. It included questions on sociodemographic details, cooking practices, lifestyle factors, and respiratory symptoms. The presence of cough, wheeze, phlegm, chest pain, and shortness of breath were considered as respiratory symptoms. Detailed history of any preexisting condition and examination of respiratory health was done. Medical records for any illness of the residents, if available was scrutinized for verification of morbid conditions. Spirometry tests were performed by trained staff to assess the lung function among a subset (around 20%) of population residing near the TPP. For this, a completely integrated PC-driven Easy On PC spirometer which is approved by the Food and Drug Administration was used.[9][10][11][12][13][14][15]

4.Environmental sample:

Particulate matter with aerodynamic diameter ≤2.5 μm (PM2.5) levels were monitored in neighborhoods located within the downwind direction of the facility plants, while soil and water samples were collected in multiple buffer zones (0–10 km) round the plant. DustTrak aerosol monitor was used for real-time and gravimetric-based PM2.5 mass concentration measurements. Hand driven Auger was accustomed collect soil samples at five locations and at each location, samples were collected from 2 sites (separated by a distance of a minimum of 50 m to take care of representability) at depths between 0–15 cm and 15–30 cm, which were later pooled together to get a composite sample and picked up in airtight bags, labeled, and transported in ice boxes to the central location for analysis. Five samples of surface and groundwater were collected, labeled, and transported in iceboxes to the central location. The samples were later stored in 4°C refrigerator publically Health Foundation of India laboratory until its transfer to Postgraduate Institute of Medical Education and Research Chandigarh for the analysis. The collected data was coded and entered and exported to STATA (16.1), StataCorp,CollegeStation,Texas USA. for analysis. Percentages, Chi-square test, and Fisher's exact test were applied for categorical data. to see the factors related to respiratory illness, binary logistic regression model was performed and $P < 0.2$ were considered for multivariable logistic multivariate analysis. Unadjusted odds ratio (UOR) and adjusted odds ratio (OR) with 95% confidence interval were calculated for bivariate and multivariate logistic regression, respectively. Statistically significant association was considered for variables with $P < 0.005$ within the multivariate logistic regression.[15][16]

5.Results:

Out of 3533 study participants, majority (27%) were from Pilar village followed by Yellur (24.3%), Nandicoor (23.9%). Fourteen transgenders were also interviewed in our study. over forty percent of the study participants were aged <45 years and 37.5% were within the age bracket of 45–65 years. Two-thirds of the participants were females and 0.39% were transgenders, and 64.5% were currently married. Around 98% of study participants were using sanitary latrine facility in their houses. Majority (87.96%) of the participants were literates. The proportion of current smokers was around 3.6% only and 0.8% of the participants were smoking quite 20 cigarettes per day. quite 90% of this smokers accustomed consume tobacco for over 5 years.Almost all the respondents (98.4%) had separate room for cooking purpose but only 18% study subjects gave response that they need chimney or smoke outlet in their houses. Majority (97.1%) of the cooking rooms had windows and 96.7% of them were kept open while cooking. Only 65% were using LPG as fuel for cooking purpose followed by firewood (34.1%).The most common ailments within the study population were hypertension (44.1%) followed by diabetes (14.8%), asthma (4.3%), allergy (3.1%), artery diseases (2.3%), hypothyroidism (1.6%), respectively. Spirometry was done on 848 subjects, among them, 409 (48.23%) had normal spirometry, 52 (6.13%) had moderate obstruction, and 357 (42.09%) had restrictive pulmonary function. There was statistically significant association between age, presence of respiratory symptoms, smoking, and also the respiratory function tests within the present study ($P < 0.001$).The bivariable analysis shows that the proportion of subjects was more in those with cohort 46–65 years and >65 years with disease as compared to no respiratory illness and was statistically significant. The proportion of smokers was more in those with respiratory illness as compared to not with respiratory disorder (5.9% vs. 3.5%) but wasn't statistically significant. The proportion of subjects who have open window during cooking have less respiratory disorder as compared to no respiratory disorder and was statistically significant (92.8% vs. 96.9%, $P = 0.006$).Our study objective was to seek out the association of disease with demographics and other risk factors. In adjusted model, we've reported OR adjusting for all other covariates reported in [Table 3]. We failed to assess the fit of the model reported and therefore the overall model is statistically significant ($\chi 2 = 62.91$, $P < 0.001$). All 3533 observations were employed in the analysis. The likelihood ratio Chi-square is 62.83 with a $P = 0.0001$. The pseudo R2-value was 0.0499. In bivariable logistic regression, analysis showed age and open ventilation were found to be significantly related to disease. the themes with age 46–65 years and >65 years have 2.91 times and 4.42 times higher odds of disease as compared to those with age ≤45 years (UOR, 95% CI: 2.91 [1.85,–4.57]; 4.41 [2.77–7.04]). The multivariable logistic multivariate analysis showed the percentages (95% CI) among subjects with age 46–65 years and >65 years was 2.79 (1.77–4.41) and 4.33 (2.66–7.07) times more, respectively, as compared to the themes having age ≤45 years while adjusting for other variables (area, gender, occupation, ever smoking, open window, chimney, and open ventilation). In people who have open window, the percentages of disease was 0.41 times less (95% CI: 0.21– 0.79) as compared to people who don't have open window.The analysis of environmental samples collected from the 2 zones of the study area. It will be observed that a high concentration of heavy metals, especially aluminum, chromium, manganese, iron, nickel, copper, zinc, arsenic, cadmium, and lead was found within the samples of well water collected from the inner zone in comparison to the outer zone however apart from iron, manganese and copper all other metals concentrations were within the required limits Bureau of Indian Standards.There was high heavy metal concentration in soil samples collected in inner zone in contrast to samples from outer zone aside from mercury levels. However, there aren't any available Indian standards to comment whether these levels are within the permissible limits or not. The heavy metals concentration in air samples collected from both the zones are within the permissible levels given by Central Pollution electrical device (CPCB) standards. the typical PM 2.5 levels within the location which is <5 km is around 20.6 ± 4.6 µg/m3 whereas it's about 17.6 ± 5 µg/m3 within the places which is over 5 km. Although the PM2.5 levels appear to be more within the places which is near the TPP, it's far low when compare with the CPCB and WHO. .[5].[6].[7].[17]

6.Discussion/Future Implications:

This study was conducted with the aim of assessing the health status and impact of pollution from coal-fired TPP (CFTPP) on health of population and environment round the plant. Our study reported that majority of participants are middle aged, women by gender and residential makers which are just like study findings by Adappa et al.[1] this is often probably because of the very fact that the majority of the males select working during daytime and it's difficult to interview them during that point. Although this information may be collected from female members, there would be serious gaps within the data collected as male members whether or not reached wouldn't reveal their lifestyle habits and other important information. this might introduce a bias within the study findings as occupational exposure to environmental pollutants is strongly related to gender during this study setting.Respiratory conditions like asthma (4.3%) and allergy (3.1%) reported in our study was high compared with national figures in population quite 15 years old (INSEARCH) during which the prevalence of asthma was around 2.05%.[15] However, Masud et al.[16] (14%) and Pala et al. (8%)[17] reported inhabitants tormented by allergy, asthma, skin diseases, and other respiratory problems. the explanations is also pollution caused by combustion of coal leading to generation of waste matter like ash which contains not only dust but also hydrocarbons and heavy metals which are known to possess impact on respiratory health status of the residents round the powerhouse.[2],[3],[4],[5],[6],[7],[8],[9],[10] Studies round the world have reported similar findings in those populations who are exposed to environmental pollution resulting from the CFTPP.[17]
A significant difference ($P < 0.05$) was observed with relevance increased symptoms and variables like age, smoking, and proximity to the TPP. There are chances of getting more symptoms in people who are residing near the ability plant. Similar findings were reported by Adappa et al.[1] and by Pala et al.[17] (2012).Bivariable and multivariable analysis shows that older age, occupation, and open ventilation are significantly related to respiratory diseases. This may be because of the subjective responses given by the study participants. In our study, the prevalence of respiratory diseases is extremely minimal. In-depth pulmonary function tests (as it absolutely was wiped out an only a subset of the study population) might throw light on the prevalence of

respiratory diseases in association with various confounding factors.In our study, there was significant association between abnormalities in pulmonary function tests and increasing age, smoking, and people living within the vicinity of the plant. people who live near the plant had higher abnormal lung function test compared to people who are residing far. Our findings were according to findings by Pala et al.[17] and Hill and Baum.[16] Although higher abnormal spirometric test was observed in females and people residing concerning the facility plant than males and people who are residing off from the plant, respectively, the difference wasn't statistically significant. This finding was per study by Adappa et al.[1]Analyses of air, water, and soil samples in two different zones was performed to seek out out the concentration of heavy metals and particulate levels in air. Twenty four hour concentration of heavy metals and PM2.5 levels in air in both the inner and outer zones were well within the standards given by CPCB. However, Tiwari et al.[10] reported high levels of PM2.5 levels starting from 27 to 79 μg/m3 in study done around TPPs in Chhattisgarh.
Similar findings were reported by studies drained India.[15],[16]

Soil sample analysis showed high concentration of mercury levels in outer zone when put next to inner zone. Huang et al.[8] reported similar findings in China. However, Sengupta et al.[10] reported higher concentration of Pb, Cd, and As within the soil vicinity to the TPP. Özkul[12] reported heavy contamination by As, Hg, and Ni within the soil around TPP. Whereas da Silva Júnior et al.[11] reported soil contamination by Mn. These variations could be because of various factors like topography, local source on the subject of the positioning of monitoring which could influence the metal concentrations within the soil.Heavy metal concentrations (except iron and copper) in water samples of both the zones are well within the boundaries prescribed by the standards. Kanchan et al.[17] reported high levels of lead (0.04 mg/l) and cadmium (0.004 mg/l) in comparison to our study but it absolutely was within the permissible limits. However, Bhardwaj et al.[8] reported high concentration of Pb and Cd but only As levels were exceeding the permissible limits. Verma et al.[9] reported levels of Pb, Ni, Fe, Cr, and Mn in groundwater which were in way over WHO permissible limits. the explanation for variations in these studies might be because of the factors like pH, physiochemical nature of water, and bonding between ash and therefore the element and its chemical properties.[10]

7.Conclusion:

The present study highlights environmental pollution with a special emphasis on respiratory health status of the population around TPP. However, continuous monitoring of the environmental samples for the presence of pollutants will aid in taking on risk reduction measures. The cross-sectional nature of the study meant that environmental sampling that accounts for temporal variation across seasons couldn't be captured. The sampling was all done during the summer months. a bigger study with more detailed health assessments for other effects in addition as collection of environmental samples across seasons may provide additional insights regarding the impact of CFTPP on health and environment in these vulnerable populations. Additional efforts to gather information on the working male population during this area may provide important differences on attributable risk of living and dealing within the vicinity of the coal-fired TPPs. The study results may be used for framing evidence-based operational guidelines for CFTPP. to reduce the pollution caused by ash activities like recycling and its usage as material in industries like bricks manufacturing, cement, ceramics, and building may be done. Although our study attempted to incorporate the specified sample size, there have been differences in gender ratio as most males couldn't be contacted during the survey period. Another important limitation may be recall bias because of self-reported illness and behavior, but literature has shown high agreement between medical and self-report. As ours was a community-based study and that we had the advantage of getting more accurate results through cooperation from the study population.

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