Impact of Coal Ash Surrounding Thermal Power Stations: A Case Study in West Bengal

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Abstract: Coal-fired thermal power plant, which has adverse impact on environmental condition, is one of the major sources of energy. This paper attempts to make a study of the environmental as well as social impact of coal ash emitted out of the project in the neighbouring region of Kolaghat Thermal Power Station under West Bengal Power Development Corporation in India. It has depicted a general overview of the generated thermal power including its emissions in the atmosphere. This empirical study is based on the data available through personal interview to different respondents of three levels-828 project affected families, 137 families in the buffer zone beyond 5 km and 56 selected social representatives - by using stratified sampling technique. It has highlighted the general profile of respondents, pollution caused to its surrounding environment, activities initiated as curative measures as well as for infrastructural development, general welfare, etc.

Key-words: Coal ash, Project Affected Families (PAFs), Families in Buffer Zone (BZFs), Social Representatives (SRs), corporate social responsibility.

1. Introduction

Electricity is the most refined and convenient form of energy. It is an indispensable part of modern daily life and also a prime component of every economic activity like industrialisation, etc. to build up a nation. With rapid urbanization and the advent of Green Revolution, utilization of power has occupied the significant role of all utilities in the society. In view of its sky-scrapping requirement prime attention has now been thrown on generation of electrical energy. For its higher electrical efficiencies, coal fed thermal energy is well accepted all over the world, though it causes a significant amount of pollution. It may be mentioned here that most prominent power producing countries like China and the USA have also appreciated its recognition. Yet again, people all over the world are very much concerned about its environmental effects.

Burning fossil-fuel for energy generation usually results in about 37.8% of all green house gas (GHG) emissions in the atmosphere mostly in the form of carbon-dioxide (CO2) which is the prime source of global warming. During 2013, at least 42% of CO2 emissions in the world have been sourced by power plants only. As per International Energy Agency (IEA),

India is the third energy-related CO2 (5.8%) emitter in 2013. Again, the radiological impact on generation of solid wastes like fly as well as bottom ash along with hot water and emission of poisonous gases are significant. It has the potential to create grave hazards. Emission of gases and dust in air, effluent and leaching of wastes from disposal places pollute and affect the plant surrounding locality. It also adversely affects the river and ecological environment, causes infertility of land and unhealthy living conditions along with terrible human health intricacy, outbursts for dislocation of inhabitants, wild including aquatic animals, etc. in the plant sites. Above all, such emissions are mainly responsible for harmful polluted atmosphere. A serious threat to the ambient environment may be caused if all these have not been disposed of properly. While equipped with the different pollution control devices in these thermal power plants, such dilemma may to some extent be avoided.

While fixing its main outlays, the Government of India has continuously advocated ample preferences since independence (1947). The installed power generation capacity has been elevated to 284303 MW on December 31, 2015 from a mere 1,362 MW in 1947 and coal fired generation has risen to 60.86% of it. To keep the process of holistic development of the state intact, the state owned electricity utilities have today not only proved their worthy position, but are also playing a very commendable role in the power sector. It is to be noted that Indian power sector has contributed nearly 10338 MW during 2011-12 by its West Bengal counterpart and about 89.07% has been shared by Thermal Power Plants (TPPs).

Considering the creditable role of power for encouraging the ever growing dynamic economy, West Bengal Power Development Corporation Limited (WBPDCL), a government of West Bengal undertaking has been incorporated in July, 1985 with an authorised share capital of Rs. 2000 crore. Primarily its objectives were tutored to run the business of generating and supplying the power. Initial power installed capacity was 2900 MW consisting one unit of 210 MW of Kolaghat Thermal Power Station (KTPS). Thereafter, considering the efficient performance in management and control, all of the thermal power plants under West Bengal State Electricity Board (WBSEB) had been handed over to it. During 2014-15, the power installed capacity of WBPDCL has reached to 3860 MW and by increasing 14.8% of previous year; its generation has recorded to 23853.39 MU whereas it was 15109 MU in 2005-06. Indian coal used in thermal power stations is basically of poor quality with high ash content and low volatile matter. Due to an assortment of reasons, the quality of coal has considerably deteriorated over the last three decades. The percentage of ash content has also increased from 30-35% to 40-45% and this has led to processing of larger quantity of ash with appreciably high resistance by the dust collector system. Notable point is that by consuming 18.0559 million ton (mt) of coal, it has produced about 7.2029 mt of fly ash.

By 2001, KTPS has enhanced its capacity by installing another five units of 210 MW each. Presently its power installed capacity has attained 1260 MW. Again during 2014-15, by using 6.1658 mt of coal, it has produced about 2.4845 mt of fly ash. It may be noted here

that it has introduced 750 Mg/Nm3 of Flue Gas Conditioning System in the level of SPM at the outlet of the chimney.

The present study aspires to hedge clippers to the environmental agony stemming from KTPS in Medinipur (East) district, which is a coal-based thermal plant. An attempt has also been made, through this work, to assess the radiological impact of KTPS. It is increasingly becoming important that fly ash has a significant amount of radioactivity which, if not properly disposed, will be, and is becoming so, a serious threat to the ambient environment. The significant point is that bituminous type of coal which produces 55% - 60% ash is available in India (Mishra, 2004). Owing to the combustion of coal, it generates huge quantity of ash and is disposed-off either in dry or slurry form.

2. Literature Review

Study on this particular topic of thermal power plants is very scanty. However some related references have been briefed here.

Pandey (1983) observed that pollutant concentration in the surrounding area of thermal power plant has made the functional changes in plants and soil. Such point source of pollutants causes steady dreadful conditions of biotic and abiotic elements of ecosystem in immediate vicinity of the project. Possible hampering of soil fertility as well as elimination of deciduous plant species, trees, shrubs, herbs and grasses from the environs of thermal power plants have been cautioned. *Ishikawa (1988)* observed that rapid increase in demand of coal for the TPPs causes huge quantities of coal-ash. An inorganic fibre production technology may be developed and coal-ash has been melted in a fusing furnace and processed into fibres. *Dutta (1997)* examined the environmental and health effects due to disposal of coal-ash from thermal power plants. It leads to distraction of fertility, penetration of the fine particles deeply inside ones lungs effecting human health, etc. It has also indicated the measures taken to utilize fly-ash. The study has concentrated only on impact of fly-ash on health and surrounding atmosphere including its utilities. *Hegde et al. (1997)* carried out a study on the activities of corporate social responsibilities (CSR) which had been performed by SAIL, a public-sector company. *Mehra et al. (1998)* examined the consequence on dispersal of various toxic metal contaminated with fly-ash in Delhi region. *Dasgupta (1999)* illustrated the attempts to expose the means to surmount the problems of disposal of huge quantities of ash generated by TPPs by producing different value added products, like bricks, etc. Only most effective use of the solid waste has been observed here, ignoring its social impact. *Mandal and Sengupta (2005)* observed concerning the predictable environmental hazards associated with Kolaghat Thermal Power Station. *Goswami et al. (2006)* analyzed the distribution pattern of different weed species which have grown naturally on fly-ash pond specifically in Bandel Thermal Power Station in West Bengal. It has been observed that such species have grown comparatively higher in the zones nearer to the fly-ash soil border area and thereafter it gradually declines from that place and shifts to the centre of the same. The effect of fly-ash on green species has also been studied

here. *Chinh and Gheewala (2007)* classified the effective method to assess the environmental effects of coal based TPPs. *Kumari (2009)* examined that fly-ash affected the normal respiration and photosynthetic rate including yield of crops, it has only enlightened on the implication of fly-ash on vegetation. *Jadav et al. (2010)* analyzed the impacts of the waste water stored in the underground water quality. Waste water with hazardous substances in ash pond has leached and percolated through the soil layers and reached into the groundwater which becomes vulnerable and interferes with natural conditions of water as well as affects the aquatic life. The underground water quality near the thermal power plant has only been assessed here. *Ansari et al. (2011)* advocated that the solid waste which is produced by the coal fed thermal power plants and causes threats not only for human being but also for environment may be applied for the purpose of garden soil and may be utilized in horticultural cropping. So a bulk quantity of solid waste may productively be used. *Lokeshappa and Dikshit (2011)* investigated the negative impact of industrial wastes including fly-ash in plant surrounding environs. Besides, this disposal of fly-ash and its extensive use in various construction materials have created other problems. *Dasgupta and Paul (2011)* explored the impact of coal-ash on the surrounding land of the TPPs in respect of its change in use and its degradation. Implementation of better technology and afforestation programme in surrounding area has been recommended.

An empirical study on this issue is too much essential in this present scenario. An attempt has been made to bridge the gap.

3. Research Objectives

To determine the social and environmental cost caused due to emission of fly ash from thermal power station, an attempt has been initiated through this work. The corrective measures that have been undertaken by the project authorities for the development in project affected areas (PAAs) have also been enlightened here. The study specifically traces to assess the–

a) social and environmental impact of coal-ash in power plant surrounding regions;

b) social disturbances caused due to different activities in power plant, and

c) implication of different remedial measures carried out by plant authorities.

4. Research Methodology

To study the above, one of the foremost coal based thermal power plants (TPPs) under West Bengal State Power Sector has been selected. The study is empirical and exploratory in nature. It is based upon the primary data which are collected out of personal interview to different respondents of three levels by using stratified random sampling technique surrounding the plant area of KTPS.

The power plant is treated as the centre of the study circle and some concentric circles are taken as strata depending on the pollution intensity of the area surrounding the plant. First, 828 Project Affected Families are selected randomly within 5 km radius of the plant and

interviewed with structured questionnaire to collect primary data. Next, 137 families in the buffer zone beyond 5 km radius of the plant have been taken into account with similar questionnaire. Finally, the opinion of 56 selected social representatives has been taken into consideration using a special type of structured questionnaire. For secondary data, different websites, books, journals and dailies are consulted.

The SPSS package is used for statistical analysis of data. Descriptive statistical methods, correlation, testing of hypothesis, analysis of variance have been taken into consideration for data analysis. For qualitative data analysis, 5 point Likert's Summated Scale has been applied.

5. Data Analysis and Findings

The detailed analysis of the data has been outlined here from different perspectives viz. general profile of the respondents, Socio-economic status, environmental condition including effect of fly-ash, remedial measures and association of different variables with distance from TPPs. All these are presented below under several subsections.

a) Basic information about Kolaghat Thermal Power Station

Kolaghat Thermal Power Station (KTPS) is located near Mecheda Railway Station along with the main line of South Eastern Railways and at a distance of 59 km from Howrah station. It is on the west bank of River Rupnarayana and is placed in the adjunct area of Sahid Matangini Block and Kolaghat Community Development (C.D.) Block of Medinipur (East) district in West Bengal. It is one of the leading largest thermal power generating stations in India with highest daily energy generation capacity under WBPDCL. Since its inception during 6th plan period (1980-85), it has been contributing major share to the state power sector. Yet again, outburst of local people on different social and environmental aspects since the beginning of this century has enthused to select this issue.

b) Study Area

Out of thirteen and ten Gram Panchayats (G.P.) under Panskura-II (Kolaghat C.D) Block and Sahid Matangini (Tamluk-II) Block respectively, the survey has been conducted in most of its project affected villages in five and two respective G.P.s located within a distance of five kilometer from the power station. Again some villages which are situated beyond a distance of five kilometer i.e. in Buffer Zone (BZ) from the project have also been studied. Details of the studied Project Affected Families (PAFs) and persons (PAPs), Families in Buffer Zone (BZFs) and Persons (BZPs) and Social Representatives (SRs) in KTPS surrounding areas have been summarized in Table-1.

c) General Profile of Respondents

The study considers 828 PAFs within 5 km in KTPS surrounding areas comprising of 28.2%, 37.1%, 14.3%, 14.3% and 1.4% of 1 km, 2km, 3km, 4km and 5 km respectively. Whereas for 137 BZFs, it is 2.2%, 31.4%, 8.8%, 13.9%, and 43.8% of 6 km, 7 km, 8 km, 9 km, and

Table-1: Summary of Surveyed Families and Persons in KTPS Area

Name of the Blocks	Within 5 Km (PAAs)		Beyond 5 Km (BZ)		Total		SRs
	PAFs	PAPs	BZFs	BZPs	Families	Persons	
Panskura – II (Kolaghat C.D.)	605	3337	69	317	674	3654	35
Sahid Matangini (Tamluk- II)	223	1206	68	364	291	1570	21
Total	**828**	**4543**	**137**	**681**	**965**	**5224**	**56**

10 km respectively. Again, a sample of 56 SRs is selected within a distance of 5 km. Direction-wise distributions of the same are 16.2%, 22.8%, 33.9% and 27.1% from east, west, north and south respectively. The studied PAFs consist of 4543 PAPs in the plant's surrounding areas comprising of 52% male and 47.8% female, whereas for BZFs, it is 681 BZPs comprising of 52.6% male and 47.4% female. Most of the PAPs belong to the age of 20 to 60 years comprising of 20.6%, 16.8% and 21.9% in 20-30, 30-40 and 40-60 years respectively. Again, 72% and 95.7% of the sample are Nuclear and Hindu families respectively. The study shows that only 45.0% of sample PAPs have an education of secondary level whereas it is 38.9% for BZPs. It reveals that service (12.2%) is the most important occupation in this belt than others and almost 88% PAFs have monthly income up to Rs. 10000. So, most of them belong to very low income group.

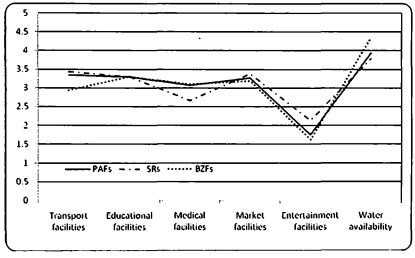
d) Socio-Economic Status of Respondents

Most of the surveyed families live in their own houses (97%) of which 70.3% are *pacca*. With regard to holding of agricultural land by the sample PAFs, the study exposes that though it is an agricultural based rural area still, they argued that due to acquisition of their cultivable land by the project authority, only 39.4% have the same. A very few PAFs have used the modern sophisticated amenities like refrigerator (3.6%), connection of gas (32.0%), computer with internet facilities (1.9%), etc. On the contrary, most of them (90%) have common utilities like bicycle, television, etc. Hence majority of them are in meagre financial stipulation.

In respect of transport and communication facilities, the survey reveals that 33.5% PAFs and 30.4% SRs have expressed that average facilities are available in their locality, whereas about 28.9% and 48.2% respectively are fully dissatisfied with it. Again about 26.1% and 48.2% respectively have expressed their dissatisfaction about the available educational facilities in their area. Significant point is that most of them have expressed their dissatisfaction as there is no college in their zone. Unavailability of library facilities in the areas is also an important point. Majority of the PAFs (68.3%) along with SRs (8.2%) have expressed their reasonable

contentment with existing medical facilities. However, it shows that about 11% PAFs have no medical facility. However, a very few selected BZFs (5.1%) are dissatisfied on the issue.

Figure-1: Assessment of Socio-Economic Status from PAFs, SRs and BZFs



Overall assessment of all respondents on social-economic status of the respondents has been depicted in Figure-1 which exhibits almost similarity among all.

e) Environmental Impact

Various emissions from thermal power plants quietly pollute its neighbouring atmosphere. Even though, way of social life in project's surrounding residents changes hurriedly. So, basing upon the responses of nearby PAFs, the implication of TPP specifically coal-ash on different environmental issues has been exemplified here.

Table-2: Coal Ash Dumped in the Locality

Coal Ash Dumped	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Yes	64.0	58.9	21.9
No	36.0	41.1	78.1
Total	**100.0**	**100.0**	**100.0**

Not less than 64.0% of PAFs and 58.9% SRs have burst out their displeasure as coal ash has been dumped all over the place in their locality. In comparison with distant place it is only 21.9%.

Table-3: Geological Change Due to Dumping Coal Ash in the Locality

Geological Change	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Uniquely	52.9	39.3	21.2
Completely	15.8	17.9	18.2
Partially	10.9	19.6	0
Very little	11.5	23.2	8.0
Not at all	8.9	0	52.6
Total	**100.0**	**100.0**	**100.0**
Mean	3.92	3.73	2.47
S.D.	1.38	1.21	1.72
Skewness	-0.95	-0.28	0.48
Kurtosis	-0.52	-1.51	-1.61

With respect to major geological alteration (Table-3) caused by coal-ash dumped in their locality, there is too much similarity between the opinions of PAFs and SRs. The table displays that 68.7% selected PAFs and also 57.2% selected SRs in KTPS surrounding areas are awfully worried on this aspect. In contrast, most of the BZFs (60.6%) have conversely replied on this issue.

Table-4: Presence of Dust in House

Presence of Dust	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Very high	55.4	60.7	1.5
High	38.9	25.0	10.2
Average	3.7	12.5	26.3
Low	1.6	1.8	12.4
Very low	0.4	0	49.6
Total	**100.0**	**100.0**	**100.0**
Mean	4.47	4.45	2.01
S.D.	0.68	0.78	1.14
Skewness	-1.5	-1.22	0.63
Kurtosis	3.38	0.59	-0.9

At least 94.3% have expressed horribly about not only high but also very high level presence of fly-ash in air as well as on houses. The descriptive statistics for PAFs furnishes the mean value as 4.47 in 5 point scale.

Table-5: Air Pollution Caused by TPP

Air Pollution	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Very high	46.4	89.3	6.6
High	48.3	7.1	3.6
Average	4.8	0	32.8
Low	0.5	3.6	10.9
Very low	0	0	46.0
Total	**100.0**	**100.0**	**100.0**
Mean	4.41	4.82	2.14
S.D.	0.61	0.61	1.23
Skewness	-0.62	-3.96	0.71
Kurtosis	0.14	16.10	-0.42

Almost every PAFs (94.7%) and SRs (96.4%) have expressed that high or very high level of air pollution has been caused by TPP owing to emission of gases and fly-ash. Table-5 also discloses that in all cases the mean value is more than 3. Conversely only 10.2% of the selected BZFs have expressed similar views.

Table-6: Impact of Air Pollution on Trees and Agricultural Land

Impact of Air Pollution	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Very high	28.9	53.6	9.5
High	17.8	28.6	10.9
Tolerable	46.4	14.3	21.2
Low	6.2	3.6	21.9
Very low	0.8	0	36.5
Total	**100.0**	**100.0**	**100.0**
Mean	3.68	4.32	2.35
S.D.	0.99	0.86	1.33
Skewness	0.08	-1.04	0.62
Kurtosis	-0.97	0.21	-0.77

As per the perception of respondents on impact of air pollution on agricultural land and trees in PAAs, it is observed from the Table-6 that the majority of PAFs (46.7%) and SRs (82.2%) have well-expressed the high or very high terrifying impact. Views differing with this have been uttered by BZFs. The descriptive statistics have also similar indication.

Table-7: Discolouring Effect on Trees and Plants

Discolouring Effect	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Highly decreasing	0	0	3.6
Decreasing	0.2	1.8	65.7
Static day by day	2.3	1.8	19.7
Increasing	3.4	5.4	10.9
Highly increasing	94.1	91.1	0
Total	**100.0**	**100.0**	**100.0**
Mean	1.09	1.14	3.62
S.D.	0.37	0.52	0.73
Skewness	4.71	4.23	-1.01
Kurtosis	23.00	19.1	0.40

Nearly each one of the PAFs has been living in the particular PAAs for a long period of time; most of them are the resident before the incorporation of the project. They have observed that intensity of green colour of trees and plants closest to the project has been disappearing very fast. At least 97.5% PAFs and 96.5% SRs have observed such phenomenon. On the contrary the largest parts of BZFs have not agreed with the same.

Table-8: Yield of Different Crops

Yield of Crops	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Not Applicable	60.6	21.4	43.1
Applicable	39.4	78.6	56.9
Total	**100.0**	**100.0**	**100.0**
Highly increasing	0	0	12.8
Increasing	0	0	67.9
Static day by day	6.1	6.8	15.4
Decreasing	21.2	72.7	3.8
Highly decreasing	72.7	20.5	0
Total (Applicable)	**100.0**	**100.0**	**100.0**
Mean	1.33	1.86	3.90
S.D.	0.59	0.51	0.66
Skewness	1.58	-0.24	-0.74
Kurtosis	1.43	0.74	1.53

The applicable section of the Table-8 includes the percentage of respondents of each class who have the cultivated land at present in the TPS surrounding areas. It reveals that almost 93.9% PAFs of applicable section and 93.2% SRs of the same have expressed their frustration that yield of crops has been considerably diminishing. In each case, the mean score remains below point 3 which also signifies the same. But reverse views have been observed for BZFs.

Table-9: Water Pollution

Water Pollution	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Very high	8.0	28.6	0.7
High	7.0	8.9	8.8
Tolerable	80.0	51.8	65.7
Low	4.0	3.6	12.4
Very low	1.1	7.1	12.4
Total	**100.0**	**100.0**	**100.0**
Mean	3.17	3.48	2.73
S.D.	0.67	1.16	0.82
Skewness	1.19	-0.17	-0.77
Kurtosis	3.35	-0.39	0.63

Table-9 shows that about 15.0% PAFs and 37.5% SRs have expressed high level of water pollution. Again, BZFs have also expressed dissimilar views.

Table-10: Quality of Available Water

Quality of Water	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Very good	2.7	0	3.6
Good	3.9	8.9	19.7
Tolerable	87.8	80.4	70.1
Bad	4.3	10.7	0.7
Very bad	1.3	0	5.8
Total	**100.0**	**100.0**	**100.0**
Mean	3.02	2.98	3.15
S.D.	0.49	0.45	0.75
Skewness	0.73	-0.09	-0.56
Kurtosis	9.31	2.40	2.79

The perception of respondents on quality of the available water has been presented in Table-10. It reveals that almost everyone in TPS surrounding regions have expressed their satisfaction about the quality of available water in their locality.

Table-11: Regeneration of Fish

Regeneration of Fish	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Not Applicable	63.2	61.4	52.6
Applicable	36.8	38.6	47.4
Total	**100.0**	**100.0**	**100.0**
Highly increasing	0	0	7.7
Increasing	0.7	6.4	20.0
Static day by day	11.8	12.6	72.3
Decreasing	14.1	32.9	0
Highly decreasing	73.4	58.1	0
Total (Applicable)	**100.0**	**100.0**	**100.0**
Mean	1.40	1.16	3.35
S.D.	0.72	0.63	0.62
Skewness	1.60	1.30	1.58
Kurtosis	1.26	1.34	1.37

The applicable row of the Table-11 points toward the percentage of respondents of studied families who have wet land at the moment in the TPS regions. It discloses that about 90.0% PAF and SRs of the above applicable line have articulated their aggravation that fish culture has been degenerating continuously. The mean score of both of them remain lower than point 3 which is also a sign of the same. However opposite opinion has been observed for BZFs.

Table-12: Impact of Pollution on Livestock

Impact on Livestock	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Not Applicable	73.6	30.4	73.7
Applicable	26.4	69.6	26.3
Total	**100.0**	**100.0**	**100.0**
Highly increasing	44.7	0	0
Increasing	19.6	25.6	0
Static day by day	34.7	43.6	38.9
Decreasing	0.9	17.9	16.7
Highly decreasing	0	12.8	44.4
Total (Applicable)	**100.0**	**100.0**	**100.0**
Mean	4.08	2.82	1.94
S.D.	0.91	0.97	0.92
Skewness	-0.24	-0.53	0.11
Kurtosis	-1.59	-0.55	-1.87

The applicable portion of Table-12 narrates the percentage of respondents who have livestock at this time. It reveals that it is applicable for almost 26.4% PAFs and 69.6% SRs. They have uttered their displeasure that effects of pollution on livestock have steadily been intensifying. It causes gradual or highly declining in number of them. In contrast BZFs are not much worried on this issue.

Table-13: Reason for Decline in Number of Livestock

Reason for Decline of Livestock	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Not Applicable	73.6	30.4	73.7
Applicable	26.4	69.6	26.3
Total	100	100	100
Pollution	93.6	100	100
Others	6.4	0	0
Total (Applicable)	**100.0**	**100.0**	**100.0**

The Table-13 expresses that nearly every one of the applicable surveyed families who have livestock together with SRs believe that pollution due to establishment of TPS is the basic cause of such declination.

Table-14: General Health Condition of Family Members

General Health	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Very good	0.7	0	2.2
Good	2.1	3.6	4.4
Average	94.9	92.9	89.1
Poor	1.9	3.6	4.4
Very poor	0.4	0	0
Total	**100.0**	**100.0**	**100.0**
Mean	3.01	3.00	3.04
S.D.	0.29	0.27	0.42
Skewness	1.17	0	2.14
Kurtosis	27.90	12.20	11.10

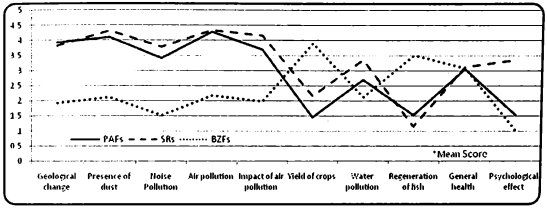
Table-14 shows that general health of most of the surveyed families is at moderate level. Merely about 2.3% PAFs are in poor and very poor level. SRs and BZFs have also viewed similarly.

Table-15: Causes of Suffering from Chronic Diseases

Causes of Suffering from Chronic Diseases	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Not suffering	47.2	37.2	57.7
Suffering	52.8	62.8	42.3
Total	**100.0**	**100.0**	**100.0**
Hereditary	2.7	2.9	6.9
Pollution	92.2	94.9	81.0
Other	5.0	2.2	12.1
Total	**100.0**	**100.0**	**100.0**

Table-15 has illustrated that at least 52.8% and 62.8% of sample PAFs and SRs respectively have been marked in the list of families; those are suffering from different types of chronic diseases. These are relatively higher than that of BZFs. Most of the respondents (almost 93%) where members in the same have been suffering from chronic diseases have a vigorous credence that pollution caused by TPS is the critical source of it.

Figure - 2: Overall Environmental Impact Assessment* from PAFs, SRs and BZFs



The above diagram (Figure-2) assesses the overall environmental impact in projects surrounding regions as per opinions of PAFs, SRs and BZFs. It has been observed that BZFs have mostly differed from that of others who have most horrible experience with these issues.

f) Environmental Awareness

Awareness of project surrounding people regarding the intensity of pollution caused by TPS particularly emission of solid waste in the air has been studied at this stage.

Table-16: Idea about Coal Ash Removed from TPP

Coal Ash Removal	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Uniquely	1.2	73.2	100
Completely	1.3	23.2	0
Partially	4.2	3.6	0
Very little	7.2	0	0
Not at all	86.0	0	0
Total	**100.0**	**100.0**	**100.0**
Mean	1.25	4.70	5.00
S.D.	0.70	0.54	0
Skewness	3.36	-1.59	0
Kurtosis	11.8	1.71	0

The above Table-16 presents that the most of the PAFs (86.0%) have confessed their lack of awareness on this aspect. The descriptive statistics indicates the same. A negligible percentage (2.5%) is conscious on this issue. But most of the SRs (96.4%) are very much concerned on this issue.

Table-17: Awareness on Recycling of Coal Ash

Awareness on Recycling	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Uniquely	0	0	0
Completely	3.5	0	0
Somewhat	3.1	7.1	0
Very little	2.2	8.9	3.6
Not at all	91.2	83.9	96.4
Total	**100.0**	**100.0**	**100.0**
Mean	1.19	1.23	1.04
S.D.	0.65	0.57	0.19
Skewness	3.48	2.40	5.00
Kurtosis	11.0	4.60	23.30

The above Table-17 shows that a negligible proportion of studied families are conscious about recycling of coal-ash.

Table-18: Awareness of Pollution Caused by TPPs

Awareness on Pollution	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Uniquely	88.5	87.5	0
Completely	3.6	7.1	2.2
Partially	5.0	3.6	1.5
Very little	1.8	1.8	12.4
Not at all	1.1	0	83.9
Total	**100.0**	**100.0**	**100.0**
Mean	4.77	4.80	1.22
S.D.	0.72	0.59	0.58
Skewness	-3.35	-3.34	3.20
Kurtosis	11.10	11.50	11.1

From the Table-18, it is clear that about 88.5% PAFs and 87.5% SRs are exclusively aware about the environmental pollution caused by TPS. Conversely, opposite picture is being described by BZFs.

Table-19: Level of Pollution over Last Five Years

Pollution Level	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Highly increasing	79.2	12.5	5.8
Increasing	11.6	64.3	11.7
Indifferent	4.7	17.9	44.5
Decreasing	4.5	5.4	38.0
Highly decreasing	0	0	0
Total	**100.0**	**100.0**	**100.0**
Mean	4.66	3.84	2.85
S.D.	0.77	0.71	0.84
Skewness	-2.34	-0.72	0.88
Kourtosis	4.58	1.03	0.33

Table-19 reveals that almost 90.8% PAFs along with 76.8% SRs have exceptionally frustrated with the intensity of pollution which, they feel, has been increasing or highly increasing in their region over last five years. On the contrary, somewhat small proportion of BZFs (17.5%) has uttered their displeasure on this issue.

g) Investigation of Social Disturbances

Relating to the immoral activities in plant surrounding area, the study has investigated the followings.

Table-20: Immoral Activities Related to Thermal Power Plant

Immoral Activities	Study Area of KTPS		
	PAFs (%)	SRs (%)	BZFs (%)
Not Applicable	80.2	60.7	89.8
Applicable	19.8	39.3	10.2
Total	**100.0**	**100.0**	**100.0**
Highly increasing	12.8	0	0
Increasing	51.8	68.2	0
Indifferent	27.4	18.2	71.4
Decreasing	3.0	4.5	7.1
Highly decreasing	4.9	9.1	21.4
Total (Applicable)	**100.0**	**100.0**	**100.0**
Mean	3.65	3.45	2.50
S.D.	0.92	0.96	0.85
Skewness	-1.02	-1.80	-1.29
Kurtosis	1.50	2.32	-0.20

Table-20 exposes that 19.8% PAFs and 39.3% SRs are great concerned about the social disturbances in their locality. According to them, establishment of TPS is its primary source. Nevertheless, among those respondents, who expressed dissatisfaction, 64.6% PAFs and 68.2% SRs respectively have affirmed that immoral activities are gradually increasing, while BZFs have opposite views.

h) Remedial Measures

Various restorative facilities which have positive effect by improving agriculture as well as rural economy in project surrounding region and are undertaken by the project authorities have been highlighted here. Implementation of such positive and appropriate measures in the places may to some extent relief the project affected communities as well as improve economical condition of the affected people.

Table-21: Rehabilitation of PAFs

Rehabilitation	Study Area of KTPS	
	PAFs (%)	SRs (%)
Not Applicable	78.0	69.6
Applicable	22.0	30.4
Total	**100.0**	**100.0**
Uniquely	0	0
Totally	0	0
Partially	5.5	0
A little	1.1	0
Not at all	93.4	100.0
Total (Applicable)	**100.0**	**100.0**
Mean	1.12	1.00
S.D.	0.47	0
Skewness	3.72	0
Kurtosis	12.20	0

Table-21 significantly depicts that almost 22.0% selected PAFs have lost their land and houses due to land acquisition by project authority. Again not less than 30.4% SRs have viewed the same for their belts. But it has also been observed that not less than 93.4% PAFs of the land / livelihood losers have not yet been rehabilitated.

Table-22: Employment of PAFs in the Project

Employment in the Project	Study Area of KTPS	
	PAFs (%)	SRs (%)
Not Applicable	78.0	69.6
Applicable	22.0	30.4
Total	**100.0**	**100.0**
Yes	29.7	0
No	70.3	100
Total (Applicable)	**100.0**	**100.0**

It has also been studied that most of the selected PAFs including land losers (70.3%) are not yet employed in the project. According to SRs, it is none.

Table-23: Infrastructural Development

Infrastructural Development	Study Area of KTPS	
	PAFs (%)	SRs (%)
Roads	65.5	35.7
Bridges	8.2	7.1
Culverts	9.1	14.3
School	24.5	41.1
Buildings	0.2	0
Libraries	0.8	0
Drainage	9.9	17.9
Drinking water	26.2	42.9
Rural electrification	85.5	76.8
Earth filling	0.4	0
Irrigation	2.3	0
Direct power supply to PAA	0	0
None	0.8	5.4

Opinion of sample PAFs as well as SRs in surveyed PAAs on the improvement of some selected infrastructural facilities has been depicted in the Table 23. It reveals that most of the respondents have expressed their satisfaction in respect of improvement of some infrastructural issues.

Table-24: General Welfare Scheme

General Welfare	Study Area of KTPS	
	PAFs (%)	SRs (%)
Tree plantation	14.1	28.6
Health camps	11.5	16.1
Sanitations	4.0	23.2
Family welfare camp	0.4	0
Adult education centre	0.8	7.1
Dispensary	0.1	0
Street light	4.8	3.6
None	74.0	48.2

Opinion of randomly selected PAFs and SRs on various general welfare activities like tree plantation, organising health camps, street light programme, etc. undertaken by the project authorities have been exposed in Table 23. Among the others, the study communicates that only 14.1% PAFs together with 28.6% SRs have contented on the adequate tree plantation programme carried out by the TPS authorities in PAAs. Only a few proportion of respondents are pleased with other welfare activities noted in the Table 24.

Table-25: Pollution Control Measures Taken by TPPs

Pollution Control Measures Taken	Study Area of KTPS	
	PAFs (%)	SRs (%)
Very quickly	0	0
Quickly	0.4	0
Slowly	2.9	7.1
Very slowly	7.2	10.7
Not at all	89.5	82.1
Total	**100.0**	**100.0**
Mean	1.14	1.25
S.D.	0.45	0.58
Skewness	3.49	2.25
Kurtosis	12.60	3.93

It is very disappointing to note from the Table 25 that around 90% of the respondents believe that the project authorities are reluctant to launch any appropriate pollution control measures.

Mostly they are utterly indifferent concerning the environment pollution caused by it. It is regrettable to note from the views of respondents that the project authority has not made any special provision on electricity facilities for the PAFs.

i) Association of Different Variables with Distance from TPPs

Table 26 exhibits the Pearson correlation coefficient along with their significance of some environmental issues with distance from the project to analyze the impact of the same.

Table-26: Association of Some Variables with Distance from TPP

Variables	r	Value	Significant
Significant geological change	r_{dv}	-.358**	With the increase in distance, geological change has been declining for all TPP surroundings.
	p	.000	
Awareness of pollution caused by TPS	r_{dv}	-.183**	Awareness among PAP has gradually been moving negatively with increasing distance.
	p	.000	
Presence of dust in house	r_{dv}	-.301**	As distance is being increasing, presence of dust on residence has been decreasing.
	p	.000	
Air pollution	r_{dv}	-.353**	Like noise pollution, air pollution has also the similar effect.
	p	.000	
Impact of air pollution on trees and agricultural land in locality	r_{dv}	-.246**	As distance has been changing, impact of air pollution on trees and agricultural land in locality has been varying negatively.
	p	.000	
Yield of different crops	r_{dv}	.065	Yield of different crops is positively correlated with distance from respective TPP.
	p	.061	
Quality of available water	r_{dv}	.033	Better quality of water is available as distance from TPS has been increasing.
	p	.349	
Greenery/plantation in locality	r_{dv}	.246**	With the increase in distance, the greenery plantation in locality has been increasing. Hence positively correlated.
	p	.000	
Idea about coal-ash removed from TPP	r_{dv}	-0.024	Idea on such removal is negatively related with change in distance
	p	0.491	

Table-26: Association of Some Variables with Distance from TPP (*Contd.*)

Variables	r	Value	Significant
Dumping of coal-ash nearer to house	r_{dv}	-0.374**	Coal-ash dumping nearer to house has reversely been changed with distance.
	p	0.000	
Level of pollution over last 5 years	r_{dv}	-.057	Opinion on effect of pollution during last 5 years is negatively correlated with the distance.
	p	.101	

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Here 'r_{dv}' denotes Pearson Correlation coefficient between distance from TPS (d) and observed variable (v) and 'p' denotes the significant (2-tailed) level.

j) Variation of Environmental Condition with Distance and Direction from Plants

To study the impact of its adjoining areas, ANNOVA has been applied to verify the variation of environmental conditions with distance from a plant as well as direction to a plant.

Table-27: Variation of Environmental Condition with Distance and Direction

KTPS	With Distance			With Direction		
	F-Value	p -value	Conclusion	F-Value	p -value	Conclusion
Environmental Condition	4.8870	.000	highly varying with distance	21.9077	.000	highly varying with direction

Table-27 shows that the overall environmental condition is highly varying in relation to the distance from KTPS (F-value = 4.887, p-value =.000). Again the table also exposes that the same has high level of variation towards different directions of KTPS (F-value = 21.9077, p-value = .000).

Again to check the Dependency of Environmental Condition with Distance and Direction of surrounding areas, Chi-square Test has been applied. The hypotheses whether different environmental issues are dependent on distance as well as on direction are tested here. The Chi-square value (= 756.227) and p value (= 0.000) signifies the high level of dependence of the attributes of environmental condition and distance from the plant. Also the same is highly dependent on the direction of the affected area to plant [Chi-square value = 456.849 and p value = 0.000].

6. Conclusion

Considering some of the social and environmental issues, this study reveals the social impacts of thermal power plants, particularly its fly-ash, in project surrounding region based on the opinion of PAFs and SRs. It discloses that the cultivated land of major PAFs has been acquired by the plant authority. Again most of them have not yet been rehabilitated, compensated or employed in the project. Inadequate living condition and food availability imply their socio-economic backwardness. Most of them belong to low income group (below Rs. 10000 per month). Majority of them have an education only up to higher secondary level (around 75% of PAPs). It presents that the general education facilities are moderate, higher education facilities are exceptionally poor as there is no college in this region. Overall, infrastructural facilities including transport and communication in PAAs are up to their satisfaction level. Most of the families are aware of coal ash which pollutes the environment dangerously and well concerned about its removal from the KTPS. A large number have boldly expressed their displeasure about coal ash which being discarded in their surrounding area. They are also much aware of its adverse environmental effects on the geological change in their areas. Presence of fly-ash from power plant in the atmosphere at its extreme level also makes the surrounding residents much concerned as well as highly dissatisfied with it. The surrounding inhabitants have strongly asserted that houses, crops and other plants in areas are fully wrapped with emitted fly-ash. Again the expression on rapid declination of greeneries and the negative impact of air pollution on agricultural land and trees in PAAs have also been observed from the study. Significant decline in yield of crops and regeneration of fish has been opined by all respondents. Most of the PAFs believe that pollution caused by TPS is the prime reason of such declination. It is observed that rate of suffering from various forms of chronic diseases by PAPs is relatively higher than that of BZPs. Most of them have a vigorous credence that pollution caused by TPS is the critical source of it. Again most of the PAFs as well as SRs are highly frustrated with the increasing intensity of pollution during last five years. They have also viewed that different social disturbance including immoral activities have been sourced by the TPS particularly its coal-ash counterpart.

However, most of the PAFs and SRs have expressed their satisfaction with respect to some infrastructural improvement but only a certain percentage of them have expressed their pleasure with different welfare activities undertaken by the project authority. It is recommended that the initiation should be taken by TPS for coal ash to implement different measures to mitigate social and environmental degradation caused by it. Again, coming forward with different CSR activities, the TPS authority may reprimand the different annihilation caused by it. It is also advocated for the proper arrangement of rehabilitation to the dispossessed people on priority basis and it should be executed eventually by consulting with the government. It should be obligatory for the project authority to implement the afforestation programme within the plant areas along with its adjoining areas. The plant authority should instigate various activities to improve the economic condition in the nearby part of TPS. The plant authority should strictly

put into practice various legal provisions like compulsion for allocation of fund (2% of profit) as per CSR Rules under Companies Act, 2013, etc. to maintain a social and environmental balance in the locality.

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