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Assessment of Seasonal Ambient Air Quality under influence of Coal Based Thermal Power Plant Emission around ATPS Chachai, Madhya Pradesh, India

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Abstract

Current research work is aimed for assessment of ambient air quality of Chachai region. The objective of the study is to know the effect of coal based thermal power plant emission on air quality in the vicinity of Amarkantak Thermal Power plant. The monitoring and estimation of Particulate Matter (i.e. PM_{10} and $PM_{2.5}$), SOx and NOx was done in three consecutive seasons. Significant variation was observed in distribution of particulate matter, as the concentration of PM_{10} varied from 66µg/M^3 (min.) to 129µg/M^3 (max.) while $PM_{2.5}$ was record 26µg/M^3 (min) to78µg/M^3 (max.). The higher particulate in summer is the result of enhanced dispersion of fugitive dust appends by coal and ash handling activity and in winter can be attributed to low temperature and low wind speed. The lowest concentration during monsoon season may be attributed to washout by rainfall and also due to higher relative humidity, which reduces re–suspension of dust. The SOx ranged between 38µg/M^3 to 98µg/M^3 and NOx from 33µg/M^3 to 94µg/M^3. Non-functionalizing of water sprinkling system, ESP, Bag filters may also be the active causes for increasing of environmental pollutants in the surrounding area of TPP. After Air samples analysis the results were compared with Maximum permissible limit as per Guidelines provided by Central Pollution Control Board new Delhi (CPCB) for National Ambient Air Quality Standard (NAAQS) 2009. The collected data were statistically analysed with Pearson Correlation Matrix for examining the effects of Environmental Pollutants on Ambient Air Quality at site. The analysis was performed for seasonal alteration and overall annual interactions on different parameters.

Keywords: Ambient Air Quality, Thermal Power Plant, Coal-ash, Emission, Statistical Analysis.

Introduction

Thermal power plants are major sources of Particulate Matter, SO_x and NO_x. Depending upon the type of fuel used emission of one or more of these pollutants may be of environmental significance. Ambient air pollution in several large cities of India is amongst the highest in the world[1]. According to an estimate, dust pollutants comprise around 40% of total air pollution problem in India[2]. A large amount of SPM as fly ash is emitted from coal fired plants, particularly if the ash content of coal is high and a fly ash removal unit, such as, an electrostatic precipitation (ESP) is not used. However Different sources of energy, from fossil fuels to nuclear, pollute the environment in different ways and at different levels[3]. The area is fast is a big source of coal open cast mining and about many green field mega thermal power projects (such as MB Power, GMR Energy, Welspun Power, Reliance CBM Project etc.) are under establishment within 20 km from the study area. Atmospheric deposition of Air pollutants surrounding the industries is a widely recognise important Environmental hazards[4]. Studies related to thermal power plant pollutant and information on effect of air pollution is still very limited, moreover the environmental condition at which the adverse effect of air pollution originates can be given further emphasis. Therefore In order to access Ambient Air quality of Chachai region periodical monitoring and analysis for SO_x, NO_x along with Particulate Matter (i.e. PM_{10} and $PM_{2.5}$) has been done. The selection of 4 nos. of sampling site in different direction focused on ATPS Chachai, as a source of emission for current study.

Material and Methods

The Amarkantak Thermal Power Station in Chachai (M.P.) is a link in Korba-Amarkantak-Satpura power chain and is situated at 23º 10'04" N and 81º39'15" E falling in Survey of India toposheet nos. 64E, 64F&I. It is interconnected to the 220 KV lines Madhya Pradesh grid line and the Rihand system of Uttar Pradesh through 132 KV lines [5]. Air quality of A.T.P.S area was monitored for three consecutive seasons in 2012 at various sites for SO_x, NO_x and Particulate Matter (i.e. PM_{10} and $PM_{2.5}$). Ambient air monitoring is conducted at all grid points for three consecutive seasons (summer, monsoon and winter). The particulate matters were monitored by High Volume Sampler operated continuously for 24 hours. NO_2 (Oxides of Nitrogen) and SO_2 (Oxides of Sulphur) was monitored by scrubbing a known amount of air in 0.1 M Potassium Tetrachloro mercurate and 0.1 NaOH solution $(HgCl_2SO_3)^{2-}$ (West & Gaeke 1956 and Jacob and Hosciser, 1958- CPCB Guidelines) for 8 hours. All the collected Samples for particulate matter (Captured in glass fibre filter paper) were carefully packed in plastic packets and transported to the laboratory for analysis. Absorbed samples of SOx and NOx were transported to the laboratory for analysis in plastic bottles which are being kept cool in the ice box.

Results and Discussion

The link between environmental issues and the development is one of the leading issues of the present time. The development progression has customarily been accompanied by rapid increases in energy demand[6]. Presently, energy is largely produced by burning of fossil fuels such as coal[7]. Which is a crucial resource, most abundantly present, and is also the cheapest source of energy[8]. The seasonal variation in Ambient Air Quality around ATPS, Chachai, (MP) is compared along with Maximum permissible limit as per Guidelines provided by Central Pollution Control Board new Delhi (CPCB) for National Ambient Air Quality Standard (NAAQS:2009)[9]. The results of tested parameters are presented in table-2, 3 and 4 along with statistical data analysis in table-5. The different sampling sites geographical location is mapped in table-1 and figure-1 and other ambient air analysis parameters are illustrated in figure-2, 3, 4 and 5 respectively.

Table-1
Study Site and Location of Ambient Air Sample Points around ATPS

S. No.	Area/Location	Sample ID	Distance/Direction	Geographical Position
1	Near ATPS Main Gate	CHA-01	1500 Mtr. (East)	23° 10’03” N and 81°38’41” E
2	Deori	CHA-02	1500 Mtr (North)	23° 10’22” N and 81°37’44” E
3	Vivek Nagar	CHA-03	1500 Mtr. (West)	23° 09’37” N and 81°37’09” E
4	Sakola	CHA-04	1500 Mtr. (South)	23° 09’14” N and 81°37’56” E

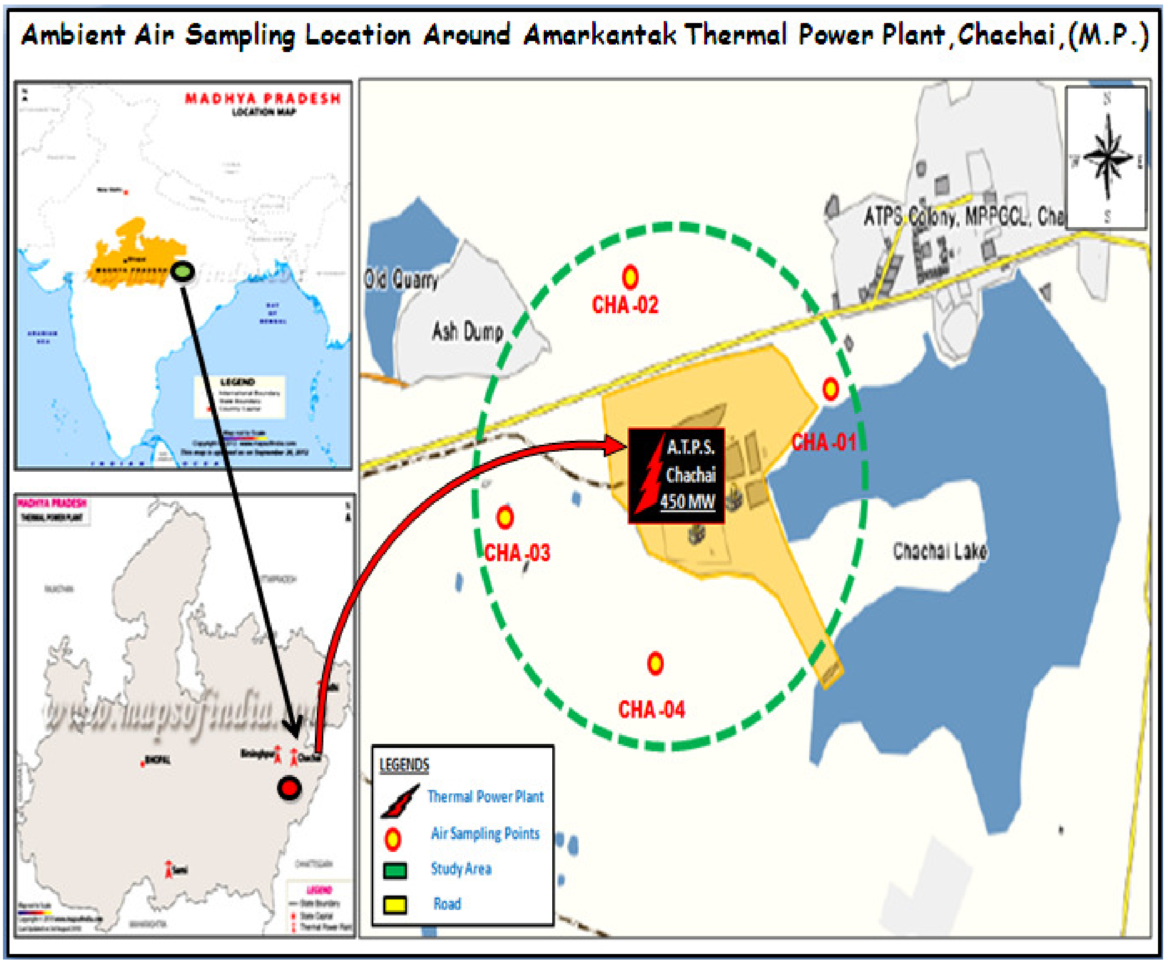

Figure -1
Key map of study area along with identified Ambient Air Sampling Location

Effect of Thermal power Plant Emission on Particular Matter (PM_{10}): A large amount of Particulate matter as fly ash is emitted from coal fired power plants, particularly if the ash content of coal is high (<35%) and due to improper functioning of a fly ash removal/collecting unit such as, electrostatic precipitation (ESP) used. In the current study PM_{10} showed significant variation site wise and season wise accordingly demonstrated in Figure-2. Monitoring site CHA-01 was found in the range of 129µg/M^3 in summer, 117µg/M^3 in winter and 82µg/M^3 in monsoon. Similar trends were observed for CHA-02 114µg/M^3 (S), 74µg/M^3 (M), 109µg/M^3 (W) and for CHA-03 119µg/M^3 (S), 85µg/M^3 (M), 108µg/M^3 (W) respectively. However PM $_{10}$ was at site CHA-04 was reported 84µg/M^3 in summer, 87µg/M^3 in winter and 66µg/M^3 in monsoon, which is lower from the permissible limit (<100 µg/M^3) in all respects. The deviation range of CHA-01, CHA-02 and CHA-03 found to be higher (>100µg/M^3) as per given guidelines of CPCB-NAAQS: 2009 in summer and winter. During summer season, particulate matter concentrations were found to be higher due to enhanced dispersion of fugitive dust append by coal and ash handling activity. Higher concentrations of particulate matter during winter can be attributed to low temperature and low wind speed, which lead to lower mixing height and poor dispersion conditions [10]. The lowest concentration was observed during monsoon season, which may be attributed to washout by rainfall and also due to higher relative humidity, which reduces re–suspension of dust.

Table-2
Ambient Air Quality Analysis around ATPS, Chachai in summer season

S. No.		Parameters	Unit	NAAQC-2009	CHA-01	CHA-02	CHA-03	CHA-04
Ambient Air Analysis	1	PM $_{10}$	µg/M3/24 Hrs.	100	129	114	119	84
	2	PM $_{2.5}$	µg/M3/24 Hrs.	60	43	78	62	46
	3	SOx	µg/M3/24 Hrs.	80	98	86	87	59
	4	NOx	µg/M3/24 Hrs.	80	94	86	85	54

Table-3
Ambient Air Quality Analysis around ATPS, Chachai in monsoon season

S. No.		Parameters	Unit	NAAQC-2009	CHA-01	CHA-02	CHA-03	CHA-04
Ambient Air Analysis	1	PM $_{10}$	µg/M3/24 Hrs.	100	82	74	85	66
	2	PM $_{2.5}$	µg/M3/24 Hrs.	60	27	36	48	26
	3	SOx	µg/M3/24 Hrs.	80	58	66	42	38
	4	NOx	µg/M3/24 Hrs.	80	33	64	40	37

Table-4
Ambient Air Quality Analysis around ATPS, Chachai in winter season

S. No.		Parameters	Unit	NAAQC-2009	CHA-01	CHA-02	CHA-03	CHA-04
Ambient Air Analysis	1	PM $_{10}$	µg/M3/24 Hrs.	100	117	109	108	87
	2	PM $_{2.5}$	µg/M3/24 Hrs.	60	34	69	56	33
	3	SOx	µg/M3/24 Hrs.	80	84	74	76	57
	4	NOx	µg/M3/24 Hrs.	80	89	84	83	61

Table-5
Pearson Correlation Matrix for Different Ambient Air Quality Parameters

	PM_{10}	$PM_{2.5}$	SO_X	NO_X	NO_X	SO_X	$PM_{2.5}$	PM_{10}	PM_{10}	$PM_{2.5}$	SO_X	NO_X	NO_X	SO_X	$PM_{2.5}$	PM_{10}
PM_{10}	1							1	1							1
$PM_{2.5}$	0.157	1					1	0.609	0.298	1					1	0.580
SO_X	0.952	-0.137	1			1	-0.009	0.011	0.453	0.087	1			1	0.404	0.901
NO_X	0.988	0.282	0.895	1	1	0.833	0.275	-0.197	0.938	-0.046	0.493	1	1	0.908	0.585	0.893
Summer					Monsoon				Winter				Annual Correlation Matrix			

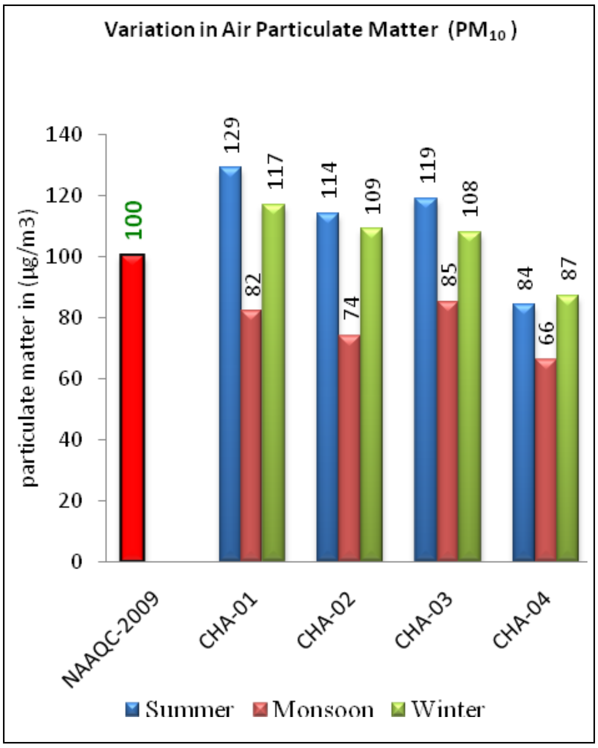

Figure-2
Distribution of Ambient Air PM $_{10}$

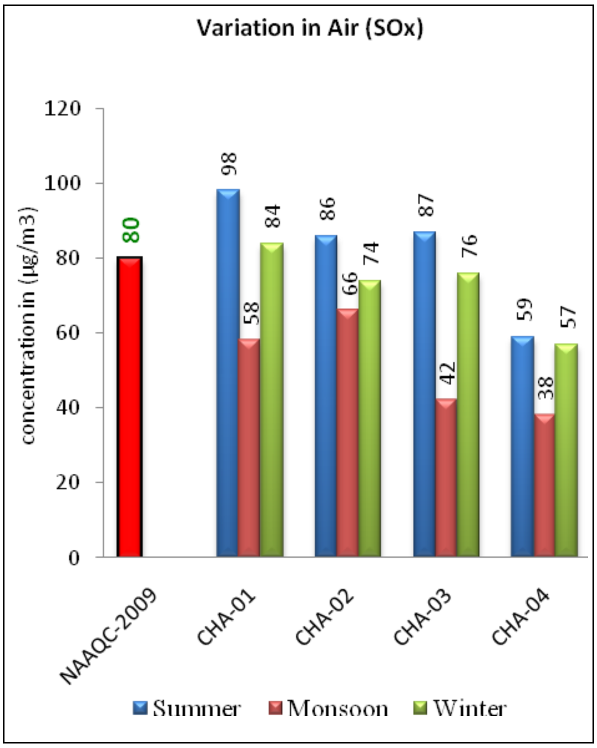

Figure-4
Distribution of Ambient Air SO_x

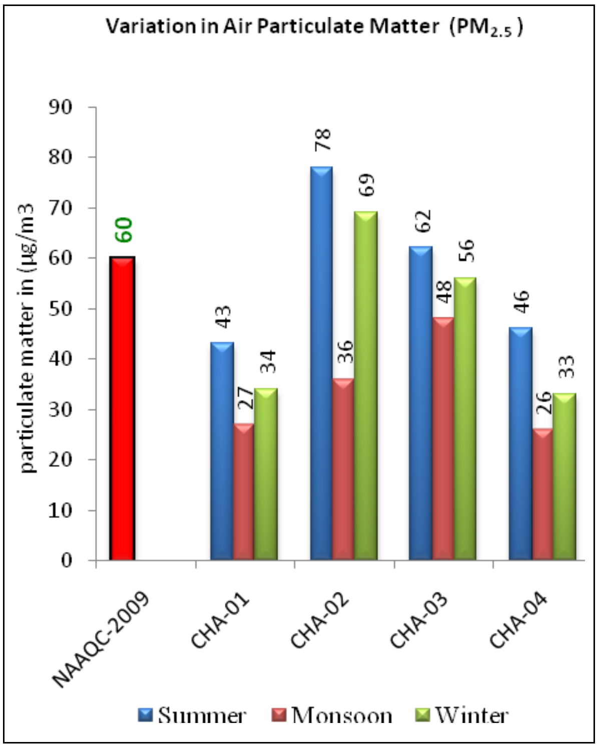

Figure-3
Distribution of Ambient Air PM $_{2.5}$

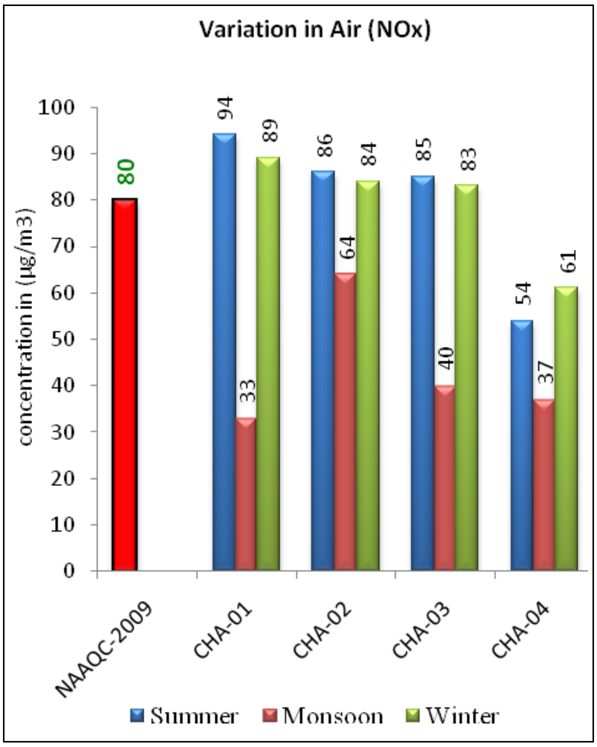

Figure-5
Distribution of Ambient Air NO_x

Effect of Thermal power Plant Emission on Particular Matter ($PM_{2.5}$): Fine and ultrafine particles are formed by chemical reaction; nucleation, condensation, coagulation, evaporation of fog and cloud droplets, in which gases also dissolve and react [11]. Combustion of coal including coal and ash handling activity is a major source in generation of $PM_{2.5}$ at all the four monitoring sites around ATPS, Chachai. Except Site CHA-02, all the study sites showing Lower concentration of particulates than the prescribed limit (< 60µg/M^3) of NAAQS: 2009. Although concentration of $PM_{2.5}$ for CHA-03 (62µg/M^3) is very close to maximum permissible limit in summer, but reported below in winter and monsoon seasons. The discrepancy in $PM_{2.5}$ concentration at study site CHA-02 during summer (78µg/M^3) and winter (69µg/M^3) season (Fig.-3) might be the result of uniform distribution of emitted particulates and low relative humidity of Air. Non-functionalizing of water sprinkling system, ESP, Bag filters may also be the active causes.

Effect of Thermal power Plant Emission on Oxides of Sulphur (SO_x): SO_2 emissions from coal combustion mainly depends on the sulphur content in the coal unlike the emissions of CO_2 and NO which depends on the operating conditions and the design of the plant. Sulphur content in Indian coal (<0.5%) is much lower compared to the foreign coal (>1%) in the United States[12]. Power plant combustors operate at temperatures usually around 1200 K. These temperatures are above the thermal decomposition temperature of calcium sulphate, it does not serve as a sulphur retaining agent. The concentration of SO_2 at CHA-01 (98 µg/M^3), CHA-02 (86 µg/M^3) and CHA-03 (87 µg/M^3) exceeded the prescribed limit of NAAQS India (80 µg/M^3) during summer. It is predictable that arid atmosphere and higher temperature clutch the gases more frequently as compare to humid atmosphere. The coal dust emission from coal yard, stock pile, crusher house and mining activity of nearby areas can be treated as contributing factor. The lowest concentration of SO_2 for all study sites varied from 38µg/M^3 to 66µg/M^3 in rainy season may be attributed to washout by rainfall. Moderately higher SOx (84µg/M^3) in winter season at CHA-01 sites might be influenced by stumpy air flow and temperature, which lead to lower amalgamation and dispersion of gaseous compound around ATPS. Because of the easy availability of coal as the cheapest energy source and its frequent use for domestic purposes is also be one of the reason of high SO_2 concentration in the area.

Effect of Thermal power Plant Emission on Oxides of Nitrogen (NOx): Nitrogen oxides are important chemical species in the atmosphere since they contribute to its acidity; they also act as precursor gases for the formation of tropospheric ozone. The formation of NO is influenced by the concentration of oxygen (which depends on the excess air for Combustion) in the thermal power plants and the flame temperature. In reality the gas temperature in the boiler varies from 1000 K to 2500 K and the reaction also occurs in several phases. In the present study NO_2 concentration recorded higher for CHA-01 (94 µg/M^3), CHA-02 (86 µg/M^3) and CHA-03 (85 µg/M^3) in summer. However in monsoon season NO_2 ranged in between 33µg/M^3 to 64µg/M^3, which is below from the permissible limit (< 80 µg/M^3) of CPCB-NAAQS: 2009. In absence of sunlight, NO_2 has a longer existence in the atmosphere[13], which explains the reason of higher NO_2 during winter season recorded for CHA-01(89 µg/M^3), CHA-02 (84 µg/M^3) and CHA-03 (83 µg/M^3) respectively. There is considerably less mixing in the lower air boundary during winter, which leads to elevated levels of NO_2 during this season [14]. Higher concentrations of NO_2 around ATPS area are also attributed to presence of higher emission rate, high load of vehicular movement for coal transport and other mining activities of adjacent opencast mines. Almost all NO_x emissions are in the form of NO, which has no known adverse health effects in the concentrations found in atmosphere. However, NO can be oxidized to NO_2 in the atmosphere, which in turn may give rise to secondary pollutants, which are injurious. NO_2 may also lead to formation of HNO_3, which is washed out of the atmosphere as acid rain.

Statistical Analysis of Data by Pearson Correlation Coefficient (r): Obtained data were statistically analysed with Pearson Correlation Matrix for examining the effects of Environmental Pollutants on Ambient Air at site. The analysis was performed for seasonal alteration and overall annual interactions on different parameters. In the present study the Correlation coefficient (r) between every pair of parameters is computed by taking the values as shown in table. Correlation coefficient (r) between any two parameters, X-axis & Y-axis is calculated for total 04 parameters such as, ultra fine Particulate Matter ($PM_{2.5}$), Fine Particulate Matter (PM_{10}), Oxides of Sulphur (SO_x) and Oxides of Nitrogen (NO_x) around ATPS, Chachai, (M.P.). The degree of line association between any two of the Seasonal parameters measured by Pearson correlation coefficient (r) is presented in form of 4 x 4 correlation matrix. Total 40 correlations were calculated for three different seasons along with annual correlation coefficient, which help us to know the cumulative effect of Emission pollutants on Ambient Air Quality. Out of 24 correlations tabulated for 4 parameters, 20 were recorded significantly positive while other 4 was shown negative (inverse) correlations.

Pearson correlation coefficient of PM_{10} with other variants: The study of correlation coefficient (r) in summer season suggests that PM_{10} shows positive correlation with other three parameters such as $PM_{2.5}$(r=0.157), SO_x (r=0.952) and NO_x (r=0.988). While in monsoon it bears positive correlation with $PM_{2.5}$(r=0.609), SO_x (r=0.011) and significant negative correlation for NO_x (r= -0.197). Similarly the coefficient (r) is positive with $PM_{2.5}$ (r=0.298), So_x (r=0.453) and NO_x (r=0.938) in winter season. But cumulative effect of PM_{10} reflects significant positive correlation with $PM_{2.5}$ (r=0.580), So_x (r=0.901) and NO_x (r=0.893) for annual correlation among various parameter of ambient Air Quality around ATPS, Chachai.

Pearson correlation coefficient of $PM_{2.5}$ with other variants: The correlation study of Fine particulate Matter ($PM_{2.5}$) confirms positive correlation with NO_x in summer and winter (i.e. r=0.285 & r=275), while significant negative correlation with SO_x (i.e. r= -0.137 and r= -0.009) respectively. Correlation coefficient of $PM_{2.5}$ bears positive correlation with So_x (r=0.087) and negative with NO_x (r= -0.046) in winter season. However annual correlation matrix implies significant positive correlation with$PM_{2.5}$ (r=0.580) So_x (r=0.404) and NO_x (r=0.585) respectively.

Pearson correlation coefficient of SO_x with other variants: The correlation coefficient (r) study for oxides of sulphur (SO_x) indicates strong positive correlation with NO_x in summer, monsoon and winter (r=0.895, r=0.833 & r=0.493), PM_{10} (r= 0.952, r=0.011 & r=0.453). However with $PM_{2.5}$ coefficient shows positive correlation (r= 0.087) in winter but significant negative correlation in summer and monsoon (r= -0.137, r= -0.009) respectively. Similar to other variants the oxides of sulphur also admitted significant positive correlation in annual correlation matrix with NO_x (r=0.908), $PM_{2.5}$ (r= 0.404) and PM_{10} (r=0.901).

Pearson correlation coefficient of NO_x with other variants: The present study reveals that oxides of nitrogen have positive correlation with PM_{10} in summer and winter (r=0.998 &r=0.938), but significant negative in monsoon (r= -0.197). The correlation of NO_x with $PM_{2.5}$ is positive in summer and monsoon (r=0.282 & r=0.275), while negative has been observed (r= -0.046) in winter season. Oxides of nitrogen have a significant positive correlation with SO_x in summer (r=0.895), monsoon (r=0.833) and winter (r=0.493). Though Pearson correlation coefficient (r) showing mix interpersonal effect of NO_x in different seasons, but the cumulative effect of NO_x introduced significant positive correlation with PM_{10} (r=0.893), $PM_{2.5}$ (r=0.585)and SO_x (r=0.908).

Conclusion

Current study investigates the fact that thermal power plant emission attributes for alteration in ambient air quality. The composition of natural Air is directly influenced by emission either from unidirectional or homogeneous distribution of fine (PM_{10}) and ultrafine ($PM_{2.5}$) particulate matter materializes by combustion of coal from power plants. Analytical data of the ambient air stats that particulate matter was found higher specifically for CHA-01, CHA-02 and CHA-03 in summer may be result of enhanced dispersion of fugitive dust append by coal and ash handling activity and during winter can be attributed to low temperature and low wind speed, which lead to lower mixing height and poor dispersion conditions. However SO_x and NO_x were also recorded higher but in monsoon attributed to washout by rainfall and also due to higher relative humidity, which reduces re–suspension of dust. Statistical analysis also reveals that the pollutants have significant correlation. The emission is also a potential cause for destruction of soil and water natural component due to precipitation of suspended dust of coal and ash in the vicinity of thermal power plant. Long term effect of deposition results the leaching of metal ions in to soil and after that aquatic system. The increase in energy demand will lead to increase in environmental pollution but can be controlled by adapting modern equipments and technology such as desulphurization of flue gas, automated water sprinkling system at Coal handling plants, high efficiency ESP, Bag filter and wet disposal of fly-ash and finally development of green cover around the thermal power plant.

References

1. Agarwal M, Effects of air pollution on agriculture: An issue of national concern, *Natl. Acad. Sci., Lett.,* **28(3&4),** 93-105**(2005)**
2. Chauhan A Sanjeev, Impact of dust pollution on photosynthetic pigments of some selected trees grown at nearby of stone crushers, *Environment Conservation Journal*, **9(3)**, 11-13, **(2008)**
3. Omer A.M., Energy, environment and sustainable development. *Renewable & Sustainable Energy Reviews* **12**, 2265–2300, **(2008)**
4. Nayak R., Biswal D. and Sett R., Biochemical changes in some deciduous tree species around Talcher Thermal Power Station, Odisha India, *J. Env. Biol.,* **34**, 521-528 **(2013)**
5. Banerjee S.K., Kashyap M.K., Journal of Environmental Studies and Policy **2(2)**, 117-124 **(1999)**
6. Kaygusuz K., Energy for sustainable development: A case of developing countries. *Renewable & Sustainable Energy Reviews* **16**, 1116–1126, **(2012)**
7. Veziroglu T.N. and Sahin S., 21st Century's energy: Hydrogen energy system. *Energy Conversion and Management* **49**, 1820–1831, **(2008)**
8. Franco A. and Diaz A.R., The future challenges for "clean coal technologies" Joining efficiency increase and pollutant emission control. *Energy* **34**, 348–354, **(2009)**
9. CPCB (Central Pollution Control Board), National Ambient Air Quality Standards (NAAQS), under Gazette Notification B-29016/20/90/PCI-1, New Delhi, **(2009)**
10. Pandey Bhanu, Madhoolika Agrawal and Siddharth Singh, Assessment of air pollution around coal mining area: Emphasizing on spatial distributions, seasonal variations and heavy metals, using cluster and principal component analysis, *Atmospheric Pollution Research* **5,** 79-86, **(2014)**
11. Wilson W.E. and Suh H.H., Fine particles and coarse particles: Concentration relationships relevant to epidemiologic studies, *Journal of the Air and Waste*

Management Association **47**, 1238-249, **(1997)**

12. Visuvasam D., Selvaraj P. and Sekar S., "Influence of Coal Properties on Particulate emission control in Thermal Power Plants in India". Proceedings in Second International Conference on Clean Coal Technologies for our Future *(CCT 2005)*, Sardinia, Italy, **(2005)**

13. Li S.P., Matthews J. and Sinha A., Atmospheric hydroxyl radical production from electronically excited NO_2 and H_2O, *Science,* **319**, 1657–1660, **(2008)**

14. Atkins D.H.F. and Lee D.S., Spatial and temporal variation of rural nitrogen dioxide concentrations across the United Kingdom, *Atmospheric Environment,* **29**, 223-39, **(1995)**