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AMBIENT AIR LEVELS OF CO AND METEOROLOGICAL CONDITIONS NEAR COAL BASED SUPER THERMAL POWER STATION : A CASE STUDY OF KOTA CITY

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ABSTRACT

Air pollution problems due to coal fired thermal power plant are directly related to the combustion of coal ingredients. The chief pollutants generated during coal-combustion are CO, CO_2, SO_2, NOx and flyash. In the present research paper, CO level in ambient air are monitored near Kota Super Thermal Power Station continuously during 2003- 2004. Monitoring is carried out 8 hourly and the 24 hour data are the average of 8 hourly-monitored concentrations. The monthly average concentrations are reported for different sites. Meteorological parameters viz average temperatures, wind velocity, wind direction and relative humidity are continuously measured using automatic weather station during entire period of study. A correlation has been presented between meteorological conditions and CO levels. Ambient air CO is found highest in summer and lowest in rainy season.

INTRODUCTION

Air pollution problems due to coal fired thermal power plants are directly related to the combustion of coal ingredients. During combustion, elements of coal are converted into their oxides. The chief pollutants generated during coal combustion are carbon monoxide, carbon dioxide, sulphur dioxide, nilrogenoxide and flyash. The main elements of coal, carbon and hydrogen are converted into CO_2 and HO_2 respectively during complete combustion but as a result of simultaneous incomplete combustion CO is generated. Bandyopadhyay and Biswas (1995). Increased CO concentration in atmosphere

is dangerous not only due to its well known health impacts, its oxidation reactions are also responsible for enhancing CO_2, a green house gas in the atmosphere Mc Conell. J.C., Mc. Elroy, M.B. and Wofsy. S.C. (1971). In power genetaring plants, CO is lowest or slightly above the stoichiometric Air/ Fuel ratio. At lower than stoichiometrie Air/Fuel ratios, high CO concentrations reflect the relatively low oxygen concentration and the possibility of poor reactant mixing from low turbulence. These two factors can increase CO emissions even though flame temperatures and residence time are high. At higher than stoichiometric Air/Fuel ratios, increased CO emissions result from decreased flame temperatures and shorter residence time. These factors remain predominent even when oxygen concentrations and turbulence increases. In high temperature combustion process, possibility of incomplete combustion is though very little, the presence of CO in the vicinity of power plant is an unavoidable phenomenon.

City Kota is the biggest industrial city of Rajastban. It is well known for its major industrial network in and around the city. The city faces extreme climatic conditions. Temperature varies from 6.0 to 48°C. The average rainfall is about 88°C, humidity anually ranges from 8% to 88%. Summers are full of dust storm. Wind velocity varies from 2-20 km/hr. More than twenty large and small scale industries including a coal based Kota Super Thermal Power Station (KSTPS) are situated within 10 km radius of the city. KSTPS alone uses about 788.25 tonnes coal per day and generate different pollutant gases. The present investigation has been carried out to evaluate the role of KSTPS in enhancing the ambient air CO levels in the city. As meteorological parameters are also responsible for dispersion of pollutants Agarwal (1997), Gujral etal (2000), dependence of ambient CO levels on meterological conditions such as average temperature, wind speed, direction and relative humidity has been looked into.

MATERIAL AND METHODS

The concentration of ambient CO near KSTPS is directly measured using MSA CO aspirator tubes. CO-detector tubes are widely applied in industrial hygiene and are suitable for analysis of highly polluted atomospheric air. (Leichnitz, 1993). The measurement is based on the reaction: $5\ CO+I_2O_5 \rightarrow I_2 + 5CO_2$. The iodine coloured layer in the tube corresponds in length to the CO concentration in the sample. For monitoring of CO emission levels from KSTPS, four sites are selected for sampling work. Three sites are situated within the premises of KSTPS, while fourth one is in the residential colony situated at an arial distance of about 1.5 Km from the main process plant. Sampling stations along wilh their directions have been listed below.

1. Sampling Station 1 Canteen (East - South direction)
2. Sampling Station 2 Temple (West - North direction)
3. Sampling Station 3 Clarifier (East - North direction)
4. Sampling Station 4 Erector Hostel (South - East direction)

Meteorological parameters are monitored using automatic wheather station mounted on main administrative building of KSTPS.

Table 1
Results of CO Monitoring at Site- 1

Months	No. of Obser-vations	CO Min. conc.	CO Max. µg/m³	CO Monthly µg/m³	Std Devi-ation ± SD Avg. /m³
July 03	48	575	975	756.56	138.32
Augu»t03	42	075	850	73.1.57	.19,64
September 03	45	550	1000	771.67	113.39
October 03	15	625	1000	803.23	124.24
November 03	45	625	975	853.11	SI. 70
December 03	48	550	1 075	781.1 1	136.01
January 04	45	500	1200	786.67	204.61
February 04	42	600	925	748.21	64.96
March 04	48	650	950	750.60	60.10
April 04	45	500	1350	876.43	249.98
May 04	45	915	1535	1186.98	163.20
June 04	45	630	1410	1073.60	173.61

Table2
Results of CO Monitoring at Site - 2

Months	No. of Obser-vations	CO Min. conc.	CO Max. µg/m³	CO Monthly µg/m³	Std Devi-ation ± SD Avg. /m³
July 03	48	525	950	757.29	121.27
August 03	36	700	925	830.56	47.48
September 03	45	575	1175	916.67	153.46
October 03	15	750	1175	938.33	108.51
November 03	45	525	950	661.07	101.06
December 03	48	600	1035	852.56	88.50
January 04	45	650	1500	707.78	208.68
February 04	42	700	950	840.48	69.17
March 04	48	675	975	805.36	69.52
April 04	45	500	1500	1014.29	253.34
May 04	45	721	1390	1168.55	163.75
June 04	45	743	1455	1165.43	172.04

RESULTS

CO is monitored continuously from July 03 to June 04 at all four sites. Number of observed values, minimum and maximum concentrations, monthly averages wth standard deviations are given in Tables 1 to 4. Results indicate that CO values are much higher for site 1, it goes as high as 1186.98 µg/m³ in May For site 2 the highest CO value is 1168.55 µg/m³ again in the month of May. For site 3 and 4 highest measured CO is 1148.40 and 1031.43 µg/m³ respectively in summers.

On investigating the impact of meteorological parameters on ambient air CO levels, temperature, relative humidity, wind velocity and wind direction are continuously monitored for entire period of study on half hourly basis. Table 5 gives the monthly average values of temperature (°C) relative humidity (%) and wind velocity.

Table 3
Results of CO monitoring at Site - 3

Months	No. of Observations	CO Min. µg/m³	CO Max. µg/m³	CO Monthly Avg. µg/m³	Std Deviation
July 03	48	575	950	747.40	119.20
August 03	42	600	750	692.86	39.15
September 03	45	555	1060	787.89	142.05
October 03	15	595	1060	848.33	129.82
November 02	45	600	950	832.22	93.48
December 03	48	555	1060	745.07	115.46
January 04	45	425	1050	664.44	162.24
February 04	42	252	900	488.79	120.30
March 04	48	400	850	652.98	139.05
April 04	45	425	1050	684.52	168.65
May 04	45	870	1400	1148.40	147.71
June 04	45	875	1770	1135.60	184.63

Table 4
Results of CO monitoring at Site -4

Months	No. of Observations	CO Min. µg/m³	CO Max. µg/m³	CO Monthly Avg. µg/m³	Std Deviation
July 03	48	575	950	733.85	128.25
August03	42	550	675	613.69	29.84
September 03	45	545	975	714.67	101.88
October 03	15	580	935	734.67	92.66
November 03	45	575	875	654.60	68.13
December 03	48	545	1045	770.00	138.49
January 04	45	450	1025	675.89	150.25
February 04	42	355	650	512.02	59.46
March 04	48	450	775	625.60	91.15
April 04	45	450	1025	812.86	95.57
May 04	45	478	1355	909.69	220.22
June 04	45	870	1395	1031.43	151.71

Table 5
Monthly average values of temperature, relative humidity and wind velocity during study period

Months	Average Temperature (⁰C)	Average relative Humidity (%)	Average wind velocity (m/sec.)
July 03	35	72	2.3
August 03	33	75	2.1
September 03	36	62	1.9
October 03	32	35	1.6
November 03	28	45	1.1
Decemeber 03	20	48	1.3
January 04	16	37	1.2
February 04	23	45	2.4
March 04	25	38	1.8
April 04	32	16	2.0
May 04	38	10	2.5
June 04	44	13	3.0

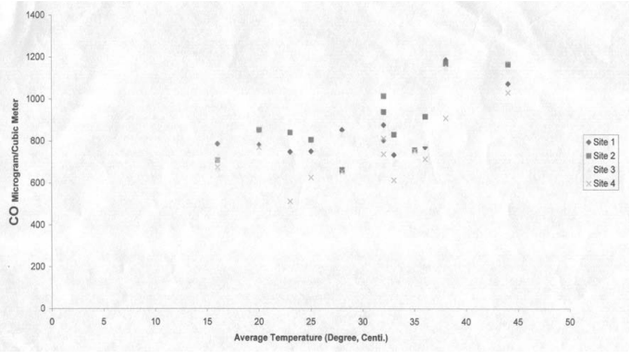

Fig. 1 Relationship between CO levels and average temperature near KSTPS, Kota

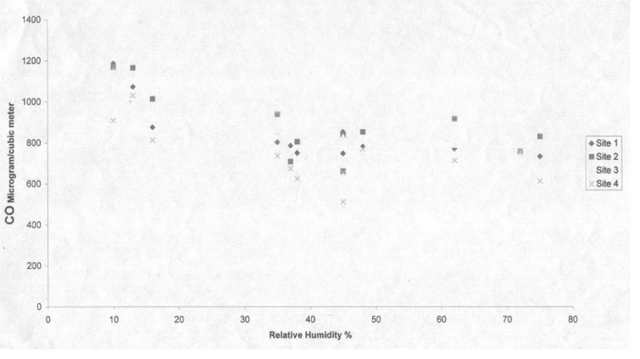

Fig. 2 Relationship between CO levels and humidity near KSTPS, Kota

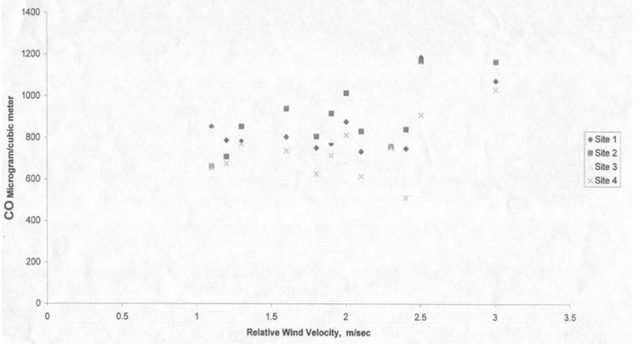

Fig. 3 Relationship between CO levels and relative wind velocity near KSTPS, Kota

The maximum value of wind velocity is found 20 km/hr. in June 2004, during day time. Maximum average temperature recorded is 44°C in June 04 and minimum is 16°C in January 04. Maximum average relative humidity is

Table 6
Percentage of air blow in μ four directions

		North-East	East - South	South - West	West - North
July,2003	Total % of blow	22.2	5.5	34.8	34.8
	Maximum %	8.5	2.1	14.8	10.4
	Minimum %	3.0	0.3	3.1	7.3
Aug., 2003	Total % of blow	15.0	7.5	50.8	28.5
	Maximum %	6.1	5.5	24.0	13.0
	Minimum %	2.2	1.1	5.4	5.5
Sept., 2003	Total % of blow	13.1	4.0	48.0	38.2
	Maximum %	4.1	2.2	20.6	13.0
	Minimum %	2.0	0.2	3.0	5.5
Oct., 2003	Total % of blow	30.4	12.0	38.4	38.2
	Maximum %	12.0	4.4	12.5	12.6
	Minimum %	5.1	0.7	5.0	7.4
Nov., 2003	Total % of blow	41.1	10.0	25.0	20.9
	Maximum %	13.4	5.0	8.7	6.1
	Minimum %	5.1	2.0	2.2	3.4
Dec., 2003	Total % of blow	12.0	23.0	7.0	8.6
	Maximum %	4.8	8.8	2.4	4.0
	Minimum %	1.5	2.5	1.5	0.5
Jan., 2004	Total % of blow	14.1	13.5	6.5	7.5
	Maximum %	8.6	10.5	2.5	3.1
	Minimum %	3.4	0.7	0.8	0.8
Feb., 2004	Total % of blow	18.2	9.4	8.2	7.5
	Maximum %	14.2	1.5	3.4	3.1
	Minimum %	2.4	1.6	0.7	0.8
March, 2004	Total % of blow	38.4	14.0	17.1	8.8
	Maximum %	15.0	4.2	8.6	3.4
	Minimum %	6.3	2.5	1.7	0.7
April, 2004	Total % of blow	30.0	8.0	10.7	15.0
	Maximum %	8.0	4.1	8.2	21.1
	Minimum %	4.0	0.5	2.5	6.0
May, 2004	Total % of blow	10.9	2.5	20.0	48.0
	Maximum %	7.5	1.5	13.0	13.9
	Minimum %	4.5	0.3	2.1	9.5
June, 2004	Total % of blow	2.7	12.8	35.6	35.0
	Maximum %	8.0	4.5	22.1	12.1
	Minimum %	3.5	1.0	1.5	5.1

75% in August 03 and minimum is 10% in May 04. Similarly maximum average wind velocity is found 3.0 m/sec in June 04 and minimum is 1.1 m/sec in Nov. 03. Relationship between average CO values and average temperatures of all four sites are given in Fig. l. To study the effect of relative humidity on CO concentration the monthly average values of CO at all 4 sites are plotted against monthly averages of relative humidy in Fig.2. Plot of monthly average values of CO and wind velocities for all sites may be seen in Fig. 3. Table 6 gives the monthly total maximum and minimum percentage air blow in all 4 directions.

DISCUSSION AND CONCLUSION

All available findings and facts depict that KSTPS is utilizing its coal with full efficiency most of the times but during summers, the CO levels in the vicinity of the power plant is higher than the ambient air quality standard. [Industrial area - 5000μg/m^3, Residential area - 2000 μg/m^3 and Sensitive area - 1000 μg/m^3]. All the 4 sites are situated within 2 km radius of the main processed plant. Three sampling station are situated within the premises of KSTPS. while fourth one is in a residential colony about 1.5 Km away. Results indicate that concentration of CO not only velocity depends on distance from the main processed plant but also on meteorological factors.

In summer, as wind - speed is very high and % air blow is more in the south-west and west-north direction sampling station. 2 is having higher % of CO than rest of the three. In summer CO concentrations are found higher than in rainy season. In winter, as it is comparatively calm, precipitation of CO in lower atmosphere is more and levels of CO in the ambient air are found higher. However, the highest ambient CO are received during summers. Due to high humidity, gaseous CO is found less in rainy season. The study reports that gaseous CO near power plants gets affected by relative humidity of the atmosphere. Thus, it is desired that in an impact assessment study and to develop mathematical dispersion models, relative humidity factors should also be taken into consideration in dispersion calculations besides other meteorological factors. It is recommended that to minimise CO emissions from power generating plants, utilizing coal as fuel, combustion units should be designed to have high turbulence, sufficient residence time, high temperature and near stoichiometric Air/Fuel ratios. The CO generation in powerplant is controlled by combustor design while its dispersion by meteorological conditions.

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