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Short Note

Emission of Carbon Monoxide in Atmosphere due to Mine Fire—A Case Study

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Abstract: The emission of carbon monoxide (CO), the silent killer, from coal fire is inevitable. The developed coal pillars are being extracted by opencast mining at Chirimiri due to fire. Though coal faces are quenched by spraying water under high pressure and high walls are blanketed by overburden but even then there is release of carbon monoxide at higher concentration. The paper deals with the estimation of CO concentration at various areas of the mine and its surroundings.

Key Words: CO, fire, coal, open cast.

Introduction

Chirimiri open cast mine owned by South Eastern Coalfield Limited (SECL) is situated in Korea district of Chattisgarh State. The topography is highly undulating with hilly terrain. The government land, forest land and private land area is 213.46 ha, 364.83 ha and 70.82 ha respectively. There are six coal seams in Chirimiri Open Cast Mine block but only seam no I, II and III are being worked at present. Seam III is the thickest with height reaching upto 12.4 m. The coal seam was developed by underground working. The developed coal pillars are being extracted by open cast mining. This mine was opened on 24/12/1978. It is 2400 m along strike, 3400 m along dip and 65 m along depth. Overburden is removed by dragline, shovel and dumper combination.

Provision of Safety due to Fire

As the working face was under fire, the following safety measures were provided in coal and overburden benches (Report, 2005):

1. Spraying of water under pressure at coal face round the clock in all three shifts to control fire
2. Blanketing of high wall

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Carbon Monoxide and Its Impacts

Carbon monoxide is a product of incomplete combustion. Sources include motor vehicle exhaust, heaters, natural gas, mines, anything involving fire, and commercial waxing chemicals (many of which are propane-based). It is called exhaust gas, fuel gas, white damp, coal gas, or just CO.

CO is colourless, odourless and tasteless, making it almost impossible to detect. The symptoms of CO poisoning can be very vague, and they involve many of the body's systems. However, immediate diagnosis is critical (www.safety-council.org).

CO blocks the absorption of oxygen into the bloodstream from the lungs, and poisons the red blood cells; so they cannot carry oxygen. If body tissues do not receive a constant supply of oxygen, they stop functioning. The brain is extremely vulnerable to oxygen deprivation. Most of the early symptoms of CO poisoning are the result of brain malfunction from the lack of oxygen. Physiological effects of CO with different concentration is given in Table 1.

Sources of CO at Chirimiri

The main sources of carbon monoxide at Chirimiri open cast mines are:

- Coal face

Table 1: Physiological effects of carbon monoxide (www.therhondda.co.uk)

% Carbon monoxide in air	*Max. absorption % saturation of blood*	*Effect on man after prolonged breathing*
Below 0.02%	-	No appreciable poisonous symptoms
0.02%	20	Slight giddiness, headache and breathlessness
0.08%	50	The above symptoms
0.08 to 0.20%	50 to 80	still more severe, partial loss of consciousness, especially in exertion, and later collapse and unconsciousness.
0.2%	80	The above symptoms followed by death within one to two hours.
Over 0.2%	-	The greater the percentage the sooner death occurs, especially in exertion.

- Highwall
- Coal stocks
- HEMMS

The concentration of the CO, CO_2 and other noxious gases should be measured at the working face in order to ensure that no person is exposed to high doses of such gases beyond permissible limits.

Instrument Used

Carbon monoxide analyzer of Model 300E manufactured by Teledyne Instruments, Advanced Pollution Instrumentation Division, San Diego, USA was used for measurement of CO in Chirimiri area. Main specifications of the instrument are as follows:

Ranges	User selectable to any full scale range from 0-1 ppm to 0-1000 ppm
Measurement units	ppb, ppm, mg/m^3, micro gram/m^3
Precision	0.5% of reading
Sample flow rate	800 scc/min. + 10%
Temperature range	5–40°C operating
Humidity range	0-95% RH
Lag time	< 10 sec
Dimension (H × W × D)	178 mm × 432 mm × 597 mm
AC Power	220–240 V 50/60 Hz (2.5A)
Environmental conditions	II pollution degree 2
Weight	22.7 kg

For highest accuracy, the voltage of the analog outputs can be manually calibrated. Calibration is done through the instrument software with a voltmeter connected across the output terminals. Adjustments are made using the front panel key by setting the zero point first and then the span point.

Study Sites

Carbon monoxide measurement was carried out at Chirimiri and Kurasia OCP at following locations/zones:

1. Fire zone
2. Non-fire zone in mining area
3. Non-mining zone
4. Coal dumped zone with fire

The instrument used was CO Analyser. It requires 220 V to operate the analyser.

1. Fire Zone

The exploitation was in progress in the III seam, which was already developed and in fire. The face of the coal seam was quenched by spraying water. The blazing fire from the gallery of the high wall was blanketed by overburden.

Due to excess of water spraying, the haulage road in the vicinity of the face was full of slush. The electrical connection of 220 V was made in shovel to carry out the CO measurement close to the face. The CO observations were taken by standing over the shovel, in all directions. Owing to restricted movement and unavailable electrical connection facility in the field it was not feasible to carry out the measurements along the haulage road. The measurement was also done in the chamber behind the operator’s cabin.

2. Non-fire Zone in Mining Area

The measurement was done at the edge of the mine. The location was selected for measurement considering the following factors:

1. Availability of electrical connection (220 V)
2. Maximum movement of the mine workers (work allocation site)

The site was 600 m away from the fire zone. No CO concentration was found in this zone. The observations were taken at varying wind directions.

3. Non-Mining Zone

The site was selected at the residential area, near Guest House . It was 1450 m away from the fire zone. No CO concentration was observed.

4. Coal Dumped Zone with Fire

There was outcrop of fire in the coal dumped area. Carbon monoxide monitoring was done all around the fire at the interval of 5 m upto a distance where no CO concentration was observed. The CO concentration was more than 1000 ppm at the outcrop of fire. The concentration drastically falls down laterally (Figure 1)

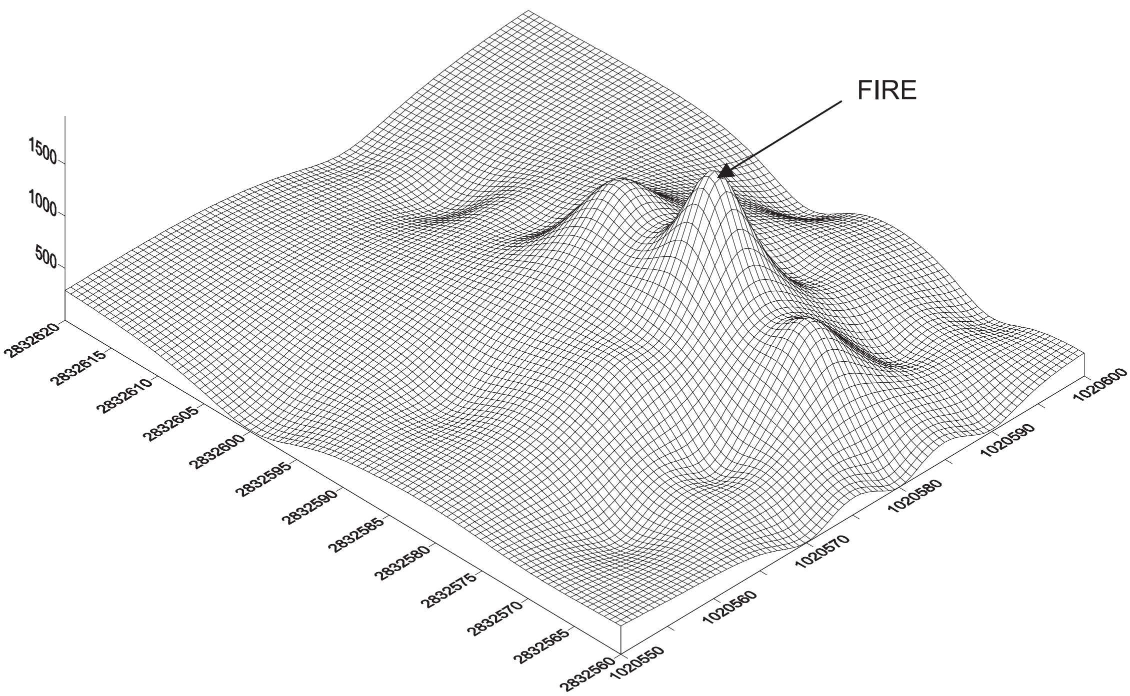

Figure 1: Surface profile of carbon monoxide concentration.

Discussion and Interpretation

Several data were taken at different orientations in the vicinity of the working face at the fire zone. Lots of fluctuations in the CO concentration were found when observations were taken at the same direction. The probable cause was time-to-time change in the wind direction. The maximum CO concentration observed was 246.49 ppm when the gas inlet pipe of CO analyzer was facing the blazing high wall whereas the minimum concentration was 9.981 ppm (Table 2). The concentration of CO in the chamber of shovel located behind the operator's cabin, which was very hot due to the operation of machines, was very high which varied from 107.82 ppm to 182.34 ppm as given in Table 3. It has also been observed that inside the cars the CO concentration is above 100 ppm in traffic-congested areas (Karakas, 2003), (www.coheadquarters.com). The maximum CO concentration around the coal dumped area was more than 1000 ppm. The CO concentration varied with the change in wind direction and hence maximum value of the CO concentration has been noted at each point. The peak concentration was at the fire point, the surface profile of which is shown in Figure 1. The contour of the CO as given in Figure 2, covers an area of 75 m × 50 m.

No CO concentration was observed in the non-fire zone of the mining area as well as in the residential area. The probable causes for no CO concentration are:

1. Rapid dilution of CO in the atmosphere
2. Irregular movement of the air
3. Upward movement of CO owing to its lighter weight

Table 2: Concentration of CO in the vicinity of coal face with fire

Sl no.	*CO (ppm)*	*Sl no.*	*CO (ppm)*
1	72.317	23	44.012
2	21.425	24	19.337
3	14.016	25	26.123
4	11.912	26	31.779
5	22.8	27	48.006
6	57.012	28	15.113
7	125.01	29	19.913
8	80.781	30	82.017
9	63.663	31	15.016
10	11.423	32	23.231
11	130.96	33	19.47
12	141.83	34	27.014
13	33.156	35	14.886
14	40.216	36	23.415
15	12.854	37	11.917
16	31.171	38	39.712
17	52.555	39	42.444
18	9.006	40	19.913
19	82.017	41	246.49
20	15.016	42	9.981
21	23.231	43	15.905
22	11.379	44	40.68

Table 3: Concentration of CO inside the shovel at the coal face

Sl no.	*CO (ppm)*
1	175.34
2	119.47
3	132.39
4	145.63
5	142.13
6	122.03
7	156.09
8	145.17
9	124.99
10	107.82
11	133.12
12	167.71
13	119.11
14	132.29
15	172.77
16	117.72
17	155.43
18	124.27
19	166.54
20	122.59
21	124.88
22	154.75
23	132.17
24	182.34

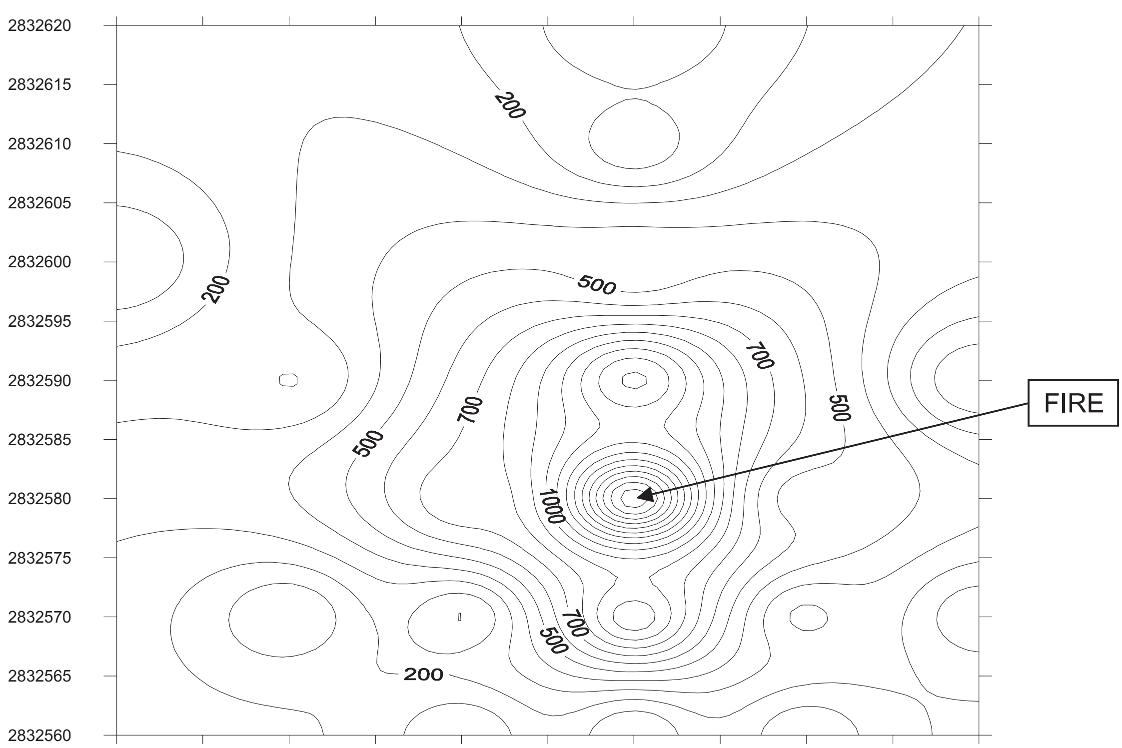

Figure 2: Contour of carbon monoxide concentration around the coal dumped fire source.

Conclusion

Emission of carbon monoxide is a snow-balling problem in mine fire areas. Lots of fluctuations in the CO concentration were found when observations were taken at the same direction due to time-to-time change in the wind flow at the face of the working. The concentration of CO in the chamber of shovel located behind the operator's cabin was above 100 ppm due to less space available for dilution.

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