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Fugitive emission studies of workplace air of an opencast mining locality to know the overall impacts on ambient air quality - A Case Study

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डम्पर, ट्रक इत्यादि के पहियों द्वारा उत्पन्न धूल, जो कि हवा में उड़ते हैं, 'फ्यूजिटिव' उत्सर्जन कहलाता है क्योंकि यह सीमित प्रवाह के रूप में वायुमंडल में नहीं फैलते। इस संदर्भ में Block-II OCP में वायु की गुणवता पर पड़ने वाले असर का एक अध्ययन किया गया। Oak Ridge Quality Index (ORAQI) कार्यस्थल पर हवा की स्थिति एवं आसपास के वातावरण की गुणवत्ता पर पड़ने वाले समग्र प्रभाव पर प्रकाश डालता है।

ABSTRACT

Dust generated by the wheels of dumper, trucks, etc of granular materials exposed to the air is known as fugitive emission because it is not discharged to the atmosphere in a confined flow stream. Study has been conducted at Block - II OCP for the evaluation of emission due to area source in order to assess its impact over general ambient air quality. Application of Oak Ridge Air Quality Index (ORAQI) highlights about the status of workplace air as well as overall impacts on the quality of its surrounding atmosphere of the region.

Keywords: Fugitive emission, Air quality, Environment, ORAQI

INTRODUCTION

Block-II open cast project of Bharat Coking Coal Limited (BCCL), is located (nearly 10-12 kms from CIMFR) in the Dhanbad district of State Jharkhand (earlier it was in Bihar), where, the study has been conducted in an opencast coal project of a subsidiary of Coal India Limited (CIL), the largest public sector unit of India that deals with coal mining in India. The study was conduced over a period of four days stretching over a full shift. During the period of study one dragline, two drills and one shovel was seen working. During the study period the average production of the mine was 5000 metric tonnes per day and the amount of overburden removal required was 9500 m^3 per day. Loading was taking places at five points and unloading was done at four locations. Between eleven to fourteen dumper with average vehicle load 35 tonnes were engaged for the transport of coal and overburden. Average fuel consumption rates were 0.35 litre per ton of coal extraction and 0.40 litre per cubic meter of coal extraction.

Opencast mining is one of the majors polluting agencies of air environment, which is creating the air pollution problem of the surrounding atmosphere. Starting from overburden removal, drilling, blasting, loading and other operations, huge amounts of pollutants are generated and these pollutants disperse into the surrounding atmosphere within a few seconds. When each activity is studied for their pollution potential, the source of pollution is considered as a point source and the study is called activity wise study. When all the activities distributed over a wide area in a mine are considered as a whole, then the pollution source, i.e.

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mine is considered as an area source and the study is called area wise study.

EQUIPMENT

- High Volume Samplers (HVS) (Envirotech APM 415, India).
- Respirable Dust Samplers (RDS) (Envirotech APM 460, India).

Parameters:

- SPM
- SO_2
- NO_x

Field study

The study was restricted to three prevalent air pollutants i.e., suspended particulate matter, oxides of nitrogen and sulphur dioxide. US-EPA upwind-downwind methodology was followed for this study by using High Volume Samplers (HVS) (Envirotech APM 415, India). One sampler was kept at a distance of 300 metres at the upwind direction of the mine to know its background concentration. That location was giving the pollution status of the area without the influence of the mine. Three high volume samplers were kept in the downwind direction of the mine at a distance of 100 metres, 300 metres and 500 metres away from the mining haul road. These instruments recorded pollution levels which is a combination of background pollution and pollution due to mining activities with gradually increasing distance from the mining haul road. Filter papers were changed after two hours interval i.e., four times due to sufficient dust concentration where as SO_2 and NO_x were once in a shift.

Calculation

$$\text{Concentration of SPM } (\mu g/m^3) = \frac{W}{V} \times 10^6$$

where

$W = W_f - W_i$ Where,

W =Weight of sample (gm)

W_i & W_f = Initial and Final weight of glass micro-fibre filter paper (gm)

$Q = (Q_i + Q_f)/2$, where,

Q = Rate of sampling (m^3/min.)

Q_i & Q_f = Initial and Final sampling rate indicated by the flow meter (m^3/min.)

TABLE 1: Results of SPM, SO2 and NOX at up wind and down wind locations

1st Day (All figures are in µg/m³)						
Locations	**SPM**				**SO_2**	**NO_x**
U300	263				42	50
D100	2148	1015	830	760	68	90
D300	694	729	692	589	58	76
D500	493	460	502	417	43	52
2nd Day						
U300	239				40	46
D100	1154	848	679	750	72	87
D300	916	548	607	683	51	70
D500	468	419	408	452	46	51
3rd Day						
U300	242				44	52
D100	1114	1627	921	352	78	104
D300	815	600	839	410	60	83
D500	444	359	492	409	51	55
4th Day						
U300	354				41	48
D100	1281	868	918	692	63	80
D300	867	768	653	601	53	69
D500	439	477	462	439	50	68

V=Q x T , where,
V= Volume of air sampled at time T (m^3)
T= Duration of sampling (hr)

DISCUSSION

1st Day

Location (down wind directions) at distance 100 metres away from the source we found SPM concentrations very much higher than the permissible limit (500µg/m^3) during daytime at 8 a.m.-10a.m. but drastically reduced SPM concentrations in next two hours sample. We found SO_2 and NO_x concentrations were well within the permissible limit (120µg/m^3).

Location (down wind directions) at distance 300 metres away from the source we found SPM concentrations slightly higher than the permissible limit (500µg/m3) during daytime 8 a.m. - 10 a.m. but up and down variations were there in next two hours. We found SO_2 and NO_x concentrations were well within the permissible limit (120µg/m^3).

Location (down wind directions) at distance 500 metres away from the source we found SPM concentrations within the permissible limit (500µg/m^3) during daytime 8 a.m.-10 a.m. but slightly variations were there in next two hours. SO_2 and NO_x concentrations were found well within the permissible limit (120µg/m^3).

Fig. 1-4; 5-8 and 9-12 respectively visualize different day's variations of Concentrations of parameters SPM, SO_2, and NO_x in the emission studies of Block -II OCP

Application of Oak Ridge Air Quality Index (ORAQI) Equation

$$ORAQI=9.61(SPM/P_1SPM+NO_X/P_1NO_X+SO_2/P_1SO_2)1.37$$

Where, P_1 = Permissible limit

TABLE 2: Results of various parameters at up wind and down wind locations

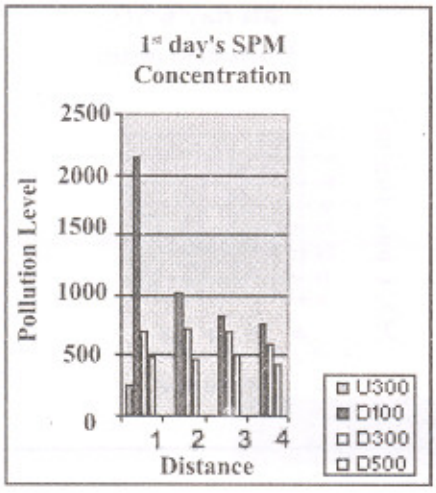
Days/ Locations	Average SPM	SO_2	NO_x	Wind Speed M/min	Temp.(°C)/ RH (%)
1st Day		(µg/m^3)			
U300	263	42	50	140	29/69
D100	1188.25	68	90	116	30/75
D300	676	58	76	138	29/68
D500	468	43	52	160	28/70
2nd Day					
U300	239	40	46	148	29/70
D100	857.75	72	87	120	29/72
D300	688.5	51	70	130	28/70
D500	436.75	46	51	140	29/72
3rd Day					
U300	242	44	52	158	29/62
D100	1003.5	78	104	105	29/66
D300	666	60	83	117	30/72
D500	426	51	55	135	29/71
4th Day					
U300	354	41	48	93	25/77
D100	939	63	80	70	26/73
D300	722.25	53	69	115	26/76
D500	454.25	50	68	147	24/76

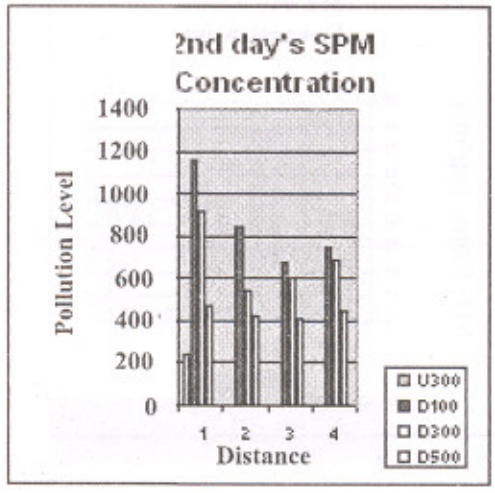
TABLE 3: Classification of Oak Ridge Air Quality Index

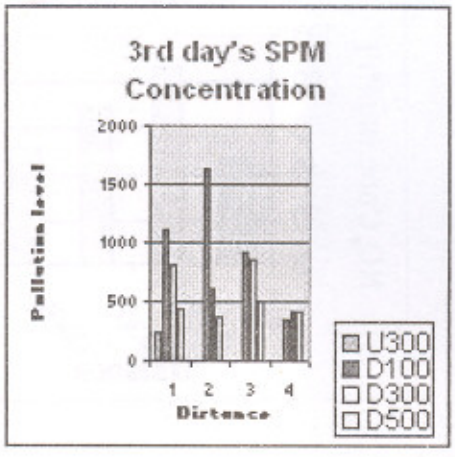
Sl. No.	ORAQI value	Atmospheric condition
1.	< 20	Excellent
2.	20-39	Good
3.	40-59	Fair
4.	60-79	Poor
5.	80-99	Bad
6.	100	Dangerous

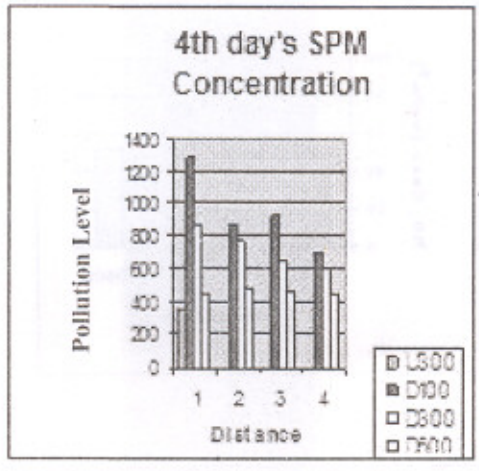
Table 4: Air Quality as per ORAQI

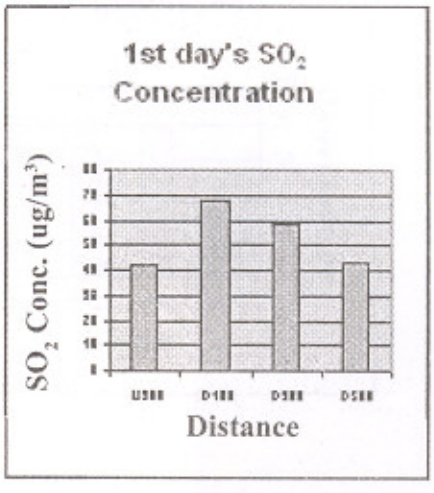
Sampling Days/ locations	ORAQI Value	Air Quality of Surrounding Atmosphere
1st Day		
U300	13.66	Excellent
D100	57.55	Fair
D300	33.14	Good
D500	20	Excellent
2nd Day		
U300	12	Excellent
D100	44	Fair
D300	31.62	Good
D500	19.59	Excellent
3rd Day		
U300	13.54	Excellent
D100	53.96	Fair
D300	34.16	Good
D500	20.45	Good
4th Day		
U300	15.90	Excellent
D100	44.7	Fair
D300	33	Good
D500	23.02	Good

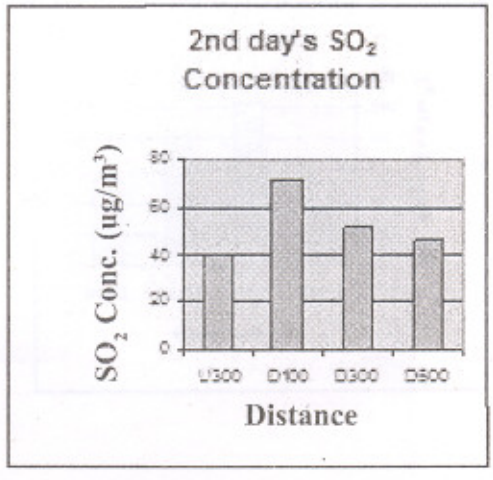

1st day's SPM Concentration
Pollution Level
2500
2000
1500
1000
500
0
1 2 3 4
Distance
U300
D100
D300
D500

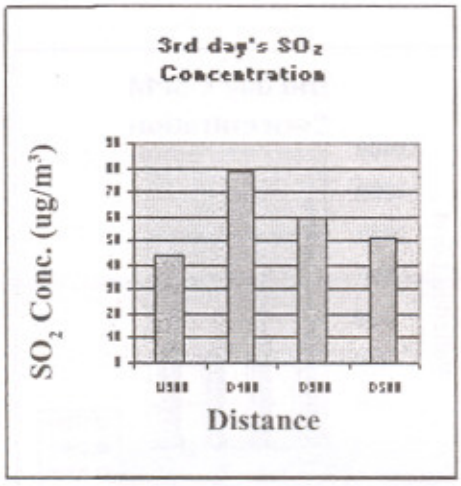

2nd day's SPM Concentration
Pollution Level
1400
1200
1000
800
600
400
200
0
1 2 3 4
Distance
U300
D100
D300
D500

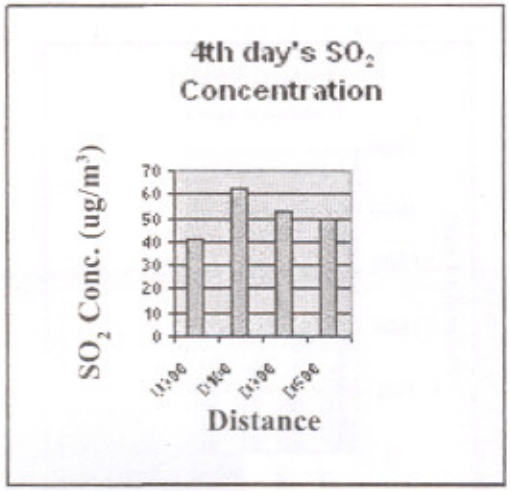

3rd day's SPM Concentration
2000
1500
1000
500
0
1 2 3 4
U300
D100
D300
D500

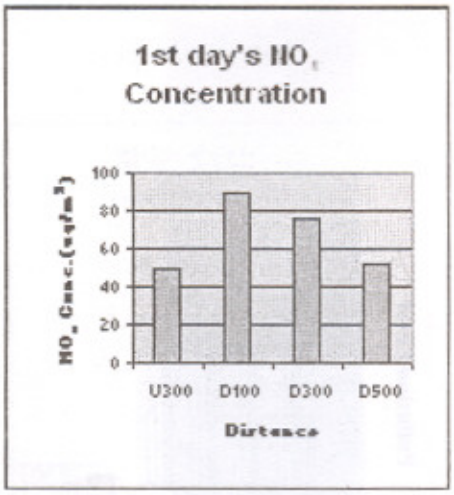

4th day's SPM Concentration
Pollution Level
1400
1200
1000
800
600
400
200
0
1 2 3 4
Distance

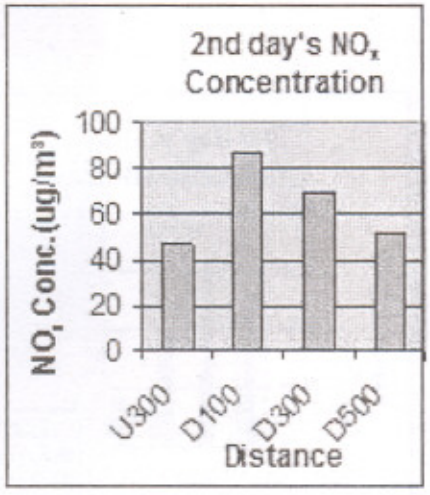

1st day's SO_2 Concentration
SO_2 Conc. (ug/m^3)
Distance

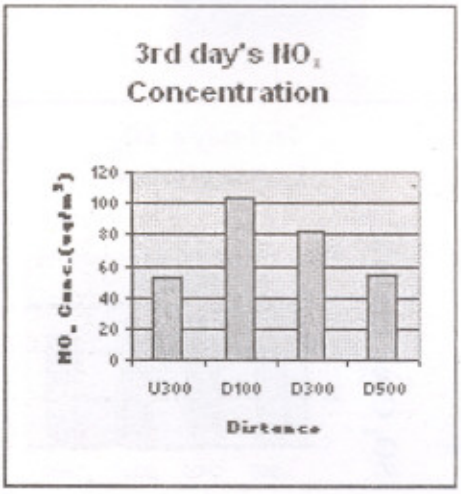

2nd day's SO_2 Concentration
SO_2 Conc. (ug/m^3)
80
60
40
20
0
U300
D100
D300
D500
Distance

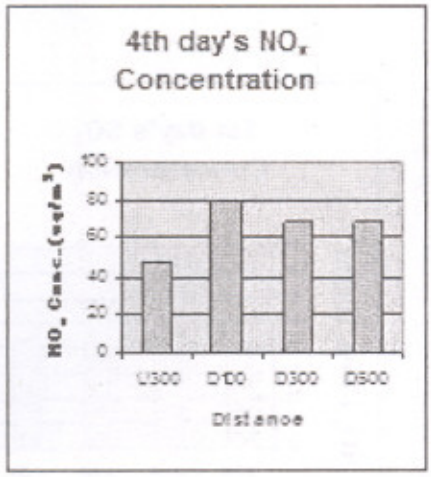

3rd day's SO_2 Concentration
SO_2 Conc. (ug/m^3)
Distance

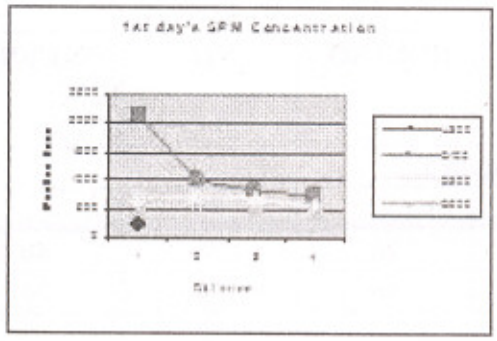

4th day's SO_2 Concentration
SO_2 Conc. (ug/m^3)
70
60
50
40
30
20
10
0
Distance

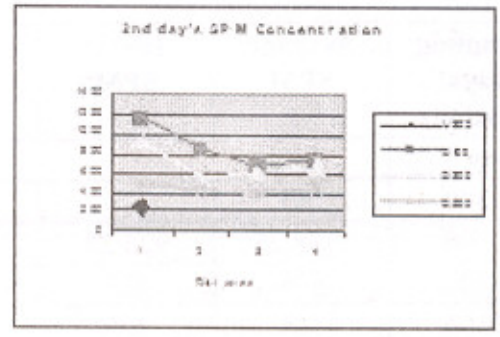

1st day's NO_x Concentration
100
80
60
40
20
0
U300
D100
D300
D500
Distance

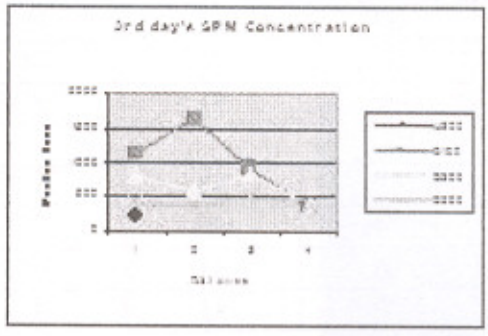

2nd day's NO_x Concentration
NO_x Conc.(ug/m^3)
100
80
60
40
20
0
U300
D100
D300
D500
Distance

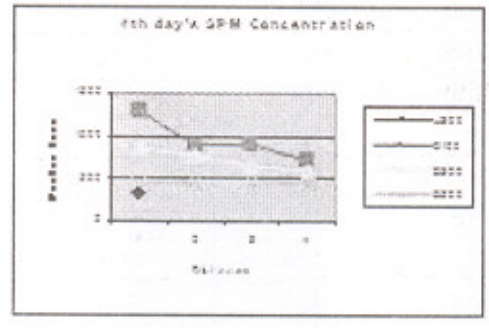

3rd day's NO_x Concentration
120
100
80
60
40
20
0
U300
D100
D300
D500
Distance

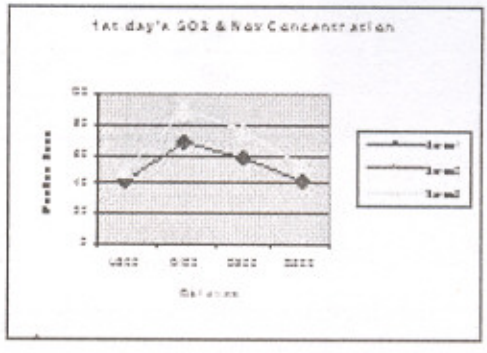

4th day's NO_x Concentration
100
80
60
40
20
0
U300
D100
D300
D500
Distance

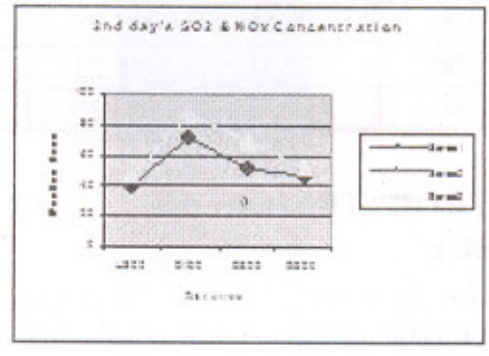


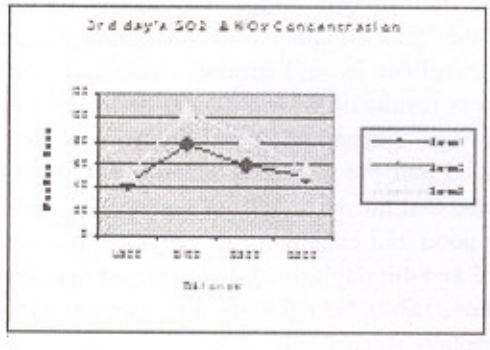












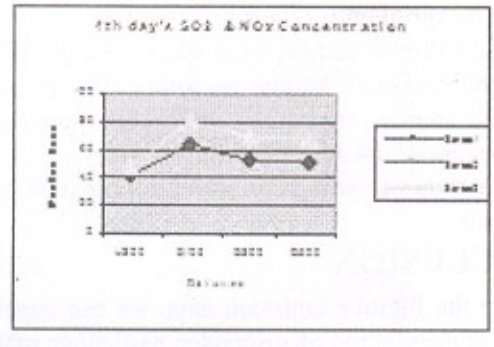


Table 5: Results of various parameters at up and down wind locations after (D-U)

Sampling Days/ locations	Average SPM	(D-U) SPM	SO_2	(D-U) SO_2	NO_x	(D-U) NO_x
1st Day	($\mu g/m^3$)					
U300	263		42		50	
D100	1188.25	925.25	68	26	90	40
D300	676	413	58	16	76	26
D500	468	205	43	1	52	2
2nd Day						
U300	239		40		46	
D100	857.75	618.75	72	32	87	41
D300	688.5	449.5	51	11	70	24
D500	436.75	197.75	46	6	51	5
3rd Day						
U300	242		44		52	
D100	1003.5	761.5	78	34	104	52
D300	666	424	60	16	83	31
D500	426	184	51	7	55	3
4th Day						
U300	354		41		48	
D100	939	585.75	63	22	80	32
D300	722.25	368.25	53	12	69	21
D500	454.25	100.25	50	9	68	20

CONTROL TECHNIQUE : AT SOURCE

- There should be semi-circular water sprinkling system at an alternate position on both the sides of a haul road. The most common and least expansive method is temporary dust control method i.e., water sprinkling.
- Reduction of surface wind speed with the help of windbreaker or source enclosure. Windbreakers and source enclosures are often impractical because of the size of the dust sources.
- Clean up of spillage on paved or unpaved travel roads.

CONCLUSION

From the fugitive emission data, we can conclude that the concentration of suspended particulate matters found in the air quality of the surrounding atmosphere was below the permissible limit of 500g/m3 at a distance from 500 meters from the activity areas.

In the light of Oak Ridge Air Quality Index we can conclude that air quality of surrounding atmosphere was excellent in and around location U300 meters whereas results of location D100 depicted that the Air Quality of Surrounding Atmosphere was fair. It also revealed that the results of locations D300 and D500 inferred that the air quality of surrounding atmosphere were good and excellent respectively. But in the light of 3rd and 4th day's results, it depicted that in both the locations D300 and D500 the air quality of surrounding atmosphere were good.

Table 6: Air Quality as per ORAQI

Sampling Days/ locations	ORAQI Value	Air Quality of Surrounding Atmosphere	ORAQI Value (DW-UW)	Air Quality of Surrounding Atmosphere
	Without subtraction		Subtraction from DW to UW	
1st Day				
U300	13.66	Excellent	13.66	Excellent
D100	57.55	Fair	31.5	Good
D300	33.14	Good	12	Excellent
D500	20	Excellent	3.07	Excellent
2nd Day				
U300	12	Excellent	12	Excellent
D100	44	Fair	22.25	Good
D300	31.62	Good	12.2	Excellent
D500	19.59	Excellent	3.6	Excellent
3rd Day				
U300	13.54	Excellent	13.54	Excellent
D100	53.96	Fair	29	Good
D300	34.16	Good	12.9	Excellent
D500	20.45	Good	3.23	Excellent
4th Day				
U300	15.90	Excellent	15.90	Excellent
D100	44.7	Fair	18.63	Excellent
D300	33	Good	9.76	Excellent
D500	23.02	Good	3.14	Excellent

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REFERENCES

1. *Colls, J., "Airborne particles and their measurement", Air Pollution: An introduction, 1997, p.147-163, E & FN Spon, an imprint of Chapman & Hall: London.*
2. *IS:5182 Indian Standard Methods for Measurement of Air Pollution*

   Part – II: 1969: Sulphur dioxide

   Part – IV: 1973: Suspended matter

   Part – V: 1975: Sampling of gasious pollutants

   Part – VI: 1975: Nitrogen oxide

   Part – XIV: Guidelines for planning of sampling of atmosphere

   Part – XV: 1974 Mass concentration of particulate matter in the atmosphere

   Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi-110001.
3. *Anon (1998) 40 Code of Federal Regulations, Pan 58, in Federal Register , United States Environmental Protection Agency. 63, 236.*
4. *Babcock L.R. (1970) Combined Pollution Index for Measurement of Total Air Pollution. Journal of Air Pollution Control Association, 20 (10), 653 - 659.*

5. *Babcock, L.R. Nagda (1972) Indices of Air Quality, In Indicators of Environment Quality (Ed) W. A. Thomas, Plenum Press. New York .*

6. *Hamekoski. K. (1998) Use of a Simple Air* Quality Index in the Helsinki Area , Finland , *Environmental Management, 22. (4), 517 - 520.*

7. *Ott, WR. and Thons, GC (1976), Oak Ridge Air Quality Index: Air Pollution Indices, A Compendium and Assessment of Indices used in the United States and Canada, Ann Arbor Science, 43-46.*

8. *Sengupta S., Patil R. S. and Venkatachalu P. (1996) Assessment of Population Exposure and Risk Zone due to Air Pollution using the Geographical Information System. Camputers Environment and Urban Systems, 20 (3), 191 - 199.*

9. *Trozzi C., Vaccaro R. and Crocetti S. (1999) Air Quality Index and its use in Italy's Management Plan, The Science of the Total Environment, 235 (1 - 3), 387 - 389.*

10. *Kaku, L.C.,"DGMS Circulars", 1994, Lovely Prakashan: Dhanbad.*

11. *Indian Standard "Methods for measurement of air pollution", IS 5182 (Part IV) -1973, Indian Standards Institution, New Delhi .*

12. *Rao, M.N. and Rao, H.V.N.," Sampling Procedure", Air Pollution, 1995, p.83 -102, Tata McGraw-Hill Publishing Company Limited:New Delhi.*

13. *Singh, T.N.,"Geo-environment of Indian Coalfields", 1997, p.131-135, Sharada Prakashan: Dhanbad.*

14. *Mondal, S. K., Tewary, B. K., & Sinha, Amalendu, 2009 (29th - 31st October), "Applications of Oak Ridge Air Quality Index to know the Status of workplace air of Block - II OCP as well as overall impacts on its ambient air quality - A Case Study", ", 1st International Seminar and Exhibition for Explosive Atmospheres on Design, Development, Testing & Certification of Ex-equipment (DTEX-2009) Organised by Central Institute of Mining and Fuel Research, Dhanbad, Vol pp335-344.*

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