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A STUDY ON THE STATUS OF AIR QUALITY OF DHANBAD WITH RESPECT TO THE NEW NATIONAL AMBIENT AIR QUALITY STANDARDS

Sridevi jena *et al.,*

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SRIDEVI JENA[1]*, ATAHAR PERWEZ[1], ASHOK KUMAR DUBEY[1], GURDEEP SINGH[2]
[1]Department of Environmental Science and Engineering, Indian School of Mines, Dhanbad - 826 004, INDIA
[2]Vice Chancellor, VinobaBhave University, Hazaribag, Jharkhand - 825 301, INDIA
e-mail: jena.sridevi@gmail.com

ABSTRACT

The objective of this study was to assess the status of ambient air quality of Dhanbad with respect to the new NAAQS (national ambient air quality standards, 2009). For this assessment, particulate matters (PM_{10} and $PM_{2.5}$), gaseous pollutants (SO_2, NO_X and CO) and heavy metals (Pb and Ni) were monitored at six monitoring locations in Dhanbad during summer, post-monsoon and winter seasons (2014). PM_{10} and $PM_{2.5}$ concentrations were observed exceeding the NAAQS at all stations except ISM Petreleum Department during the whole study period. The concentrations of PM_{10} and $PM_{2.5}$ were observed highest at RSP College (mining area), followed by Bank More (traffic junction). The average seasonal concentrations of PM_{10} were found about 4, 3.34 and 4.3 times higher and the concentrations of $PM_{2.5}$ were examined about 4, 3.8 and 5 times higher than the 24 hourly NAAQS limit during summer, post-monsoon and winter seasons, respectively at RSP College. Higher PM concentrations at this station is attributed to mining and transportation activities. The occurrence of SO_2 (43.2μg/m^3, 39.6 μg/m^{3}and 72μg/m^{3}during summer, post-monsoon and winter, respectively) in higher concentration at this station (RSP College), indicates a substantial influence of mining activities and mine fire. The average concentrations of NO_X and CO (90.4μg/m^3 and 6.5mg/m^3, 85.4 μg/m^3 and 6 mg/m^3, 93.4μg/m^3 and 8.1 mg/m^3 during summer, post-monsoon and winter seasons, respectively) were observed highest at Bank More, which depicts the influence of vehicular emissions. Pb concentrations were detected in the range of 0.024 μg/m^3 to 0.417 μg/m^3 at all monitoring stations which is below the 24 hourly NAAQS limit. While, the concentration levels of Ni were observed in the range of 8 ng/m^3 to 63.2 ng/m^3 and remained higher than the NAAQS at all the stations except Big Bazar during post monsoon and winter seasons.

***Corresponding author**

INTRODUCTION

The degradation in ambient air quality has become a severe threat to human health, climate change, agriculture and the natural ecosystem, especially in developing countries, due to industrialization, urbanization and the concomitant growth in energy use as well as transportation activities. Different energy sources (either fossil fuels or nuclear) are deteriorating to the environment in different ways at different levels (Omer, 2008). Among all the sources, coal is the most abundantly present and the cheapest source of energy (Franco and Diaz, 2009). The increase in usage of coal has created a surge in mining operations. Mining operations create the problem of air pollution directly or indirectly (Baldauf et al., 2001; Collins *et al.*, 2001). The most important emissions during coal mining and coal burning are particulate matters (PM_{10} and $PM_{2.5}$), SO_2, NO_X and heavy metals.

Besides mining, transportation is the major activity deteriorating to air quality, especially in urban areas. It is known to contribute a considerable load of particulate matters (PM_{10} and $PM_{2.5}$) (Chaloulakou et al., 2003; Chan and Yao, 2008; Deshmukh *et al.*, 2010; Katiyar *et al.*, 2002; Vega *et al.*, 2010; Wang *et al.*, 2008), NO_X (Melkonyan and Kuttler, 2012), CO and heavy metals to the atmosphere. The pollution caused by gaseous and particulate trace metals is gaining concerns in urban areas, worldwide (Azad and Kitada, 1998; Salam et al., 2003; Begum *et al.*, 2004 and Cachier *et al.*, 2005). Among the concerned pollutants particulate matters (PM), especially fine particles ($PM_{2.5}$) are most precarious, due to their severe health effects. A strong correlation among elevated concentrations of inhalable particles (PM_{10} and $PM_{2.5}$) and increased mortality as well as morbidity has been established by several epidemiological studies (Perez and Reyes, 2002; Lin and Lee, 2004; Namdeo and Bell, 2005). It also reduces visibility and adversely affect surrounding flora and fauna (Wheeler *et al.*, 2000; NIOSH, 2005). The particulate matters are also known to carry toxic pollutants such as heavy metals (Gunawardana et al., 2011) and toxic organic compounds. Metals associated with these particles, increase lung and cardiopulmonary injuries in humans (Shaheen *et al.*, 2005).

Dhanbad (Jharia coal-field) is well known for its metallurgical grade coal reserves and production. It accounts for 30% of the total Indian coal production (Ghose and Majee 2001). In addition to the pollution associated with the mining and associated operations, this coal field is also affected by mine fires, spread over an area of approximately 18 km^2 (Pandey *et al.*, 2014). Which has aggravated the scenario of pollution manifold. That is why, the Central Pollution Control Board (CPCB) in consultation with the Ministry of Environment and Forests, Government of India has declared this area (Dhanbad) as a critically polluted area and ranked 13th among 88 industrial areas (Kamyotra, 2009). This severity of pollution in the area, obliges a comprehensive assessment of pollution levels for its proper abatement.

This study was intended to assess the status of ambient air quality of Dhanbad (on the basis of monitored concentration at six monitoring stations) with respect to the new NAAQS (2009). For this, seven major air pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO, Pb and Ni) were taken into account.

Study area

Dhanbad lies between 23°37′3" N to 24°4′ N latitude and between 86°6′30" E to 86°50′ E longitude, having an average elevation of 222 m. The major sources of air pollution in this area are, open-cast coal mines, coal washeries, coke oven plants, mine fires as well as transportation (mining and non-mining) activities. Being situated in the subtropical climatic zone, Dhanbad experiences a cool winter and hot summer season. The temperature varies approximately between 11°C to 22°C during winter and 25°C to 45°C during summer season. This region receives heavy rainfall (approximately 1300 mm) annually.

The ambient air quality monitoring was done at six (6) selected representative monitoring stations as per the siting criteria provided by IS: 5182 Part XIV. The details of monitoring stations are presented in Table 1 and Figure 1. Among the six stations, RSP College represents a mining area and Bank More (traffic junction, dominated by the heavy load of vehicular traffic), Randhir Verma Chowk (traffic junction) and Big Bazar represent traffic routes. Govind Pur represents an industrial area as well as traffic route. While, ISM, Petroleum Department is an institutional area (represents background concentration due to the absence of any polluting sources).

MATERIALS AND METHODS

Sample collection

Total 24 samples were collected from each monitoring station during summer, post-monsoon and winter seasons (eight samples in each season) on twice a week basis. Summer, post-monsoon and winter seasons were represented by May, October and December, respectively. Monitoring was done for PM_{10}, $PM_{2.5}$, SO_2, NO_X, Pb, Ni (24 hourly basis) and CO (1 hourly basis).

Ambient PM_{10} samples were collected using resipirable dust samplers (Envirotech APM 460) (flow rate 1.1 m^3min^{-1}) on Whatman glass fiber filters and $PM_{2.5}$ samples were monitored using fine particulate samplers (Envirotech APM 550 MFC) (flow rate 16.7 LPM) on PTEF filter papers. The filter papers were conditioned in the desiccator, 24 hours before and after sampling. The differences in the weight of the filters before and after sampling (using an electronic microbalance (AND HR-200), with 0.1 mg resolution) were used to calculate PM_{10} and $PM_{2.5}$ concentrations Then Filter papers were stored in the refrigerator for further metal concentration analysis.

The samples of SO_2, NO_X were collected by thermo-electrically cooled gaseous samplers (Envirotech APM 411 TE) attached with resipirable dust samplers (Envirotech APM 460). The SO_2 concentration present in the ambient air was determined by West and Gaeke method (IS 5182 Part 2). SO_2 gas was absorbed (flow rate 0.4 LPM) through a solution of 0.04 M potassium tetrachloromercurate (K_2HgCl_4) to form non-volatile dichlorosulfitomercurate ($HgCl_2SO_3$) and the formed colour complex was measured spectrophotometrically at 560 nm. The NO_X concentration in ambient air was determined by Jacob and Hochheiser method (IS 5182 Part 6). NOx was absorbed (flow rate 0.5 LPM) in a solution of 0.4% sodium hydroxide (NaOH) and 0.1% sodium arsenite ($NaAsO_2^-$) to form sodium nitrite ($NaNO_2$) which is stable for 48h and measured spectrophotometrically at 550 nm.The concentration of CO was determined by portable CO sampler (KIMO, AQ 200, France) with a one minute interval for one hour.

Extraction of heavy metals

The concentration of Heavy Metals were analyzed by using Atomic absorption spectrophotometer (GBC Avanta PM). The detection limits of the instrument for Pb and Ni are 0.01 ppm and 0.009 ppm, respectively. Heavy Metals were extracted from the exposed filter papers by the acid digestion method. Acid digestion was done in Teflon bombs by following these steps: (1) Filter papers were cut into pieces and dissolved in nitric acid and perchloric acid (20:2), (2) digestates were completed till white fumes arose and reduced to 5 mL, (3) filtered through a Whatman Filter 42 and the final volume was adjusted to 5 mL by double distilled water.

The observed concentration levels of the pollutants under consideration were compared with the NAAQS (2009) which is presented in Table 2.

RESULTS AND DISCUSSION

The average seasonal variation in PM_{10} and $PM_{2.5}$ concentrations at the selected monitoring stations is depicted in Table 3. From the table, the seasonal variation in particulate concentrations is quite evident. The concentrations of PM_{10} and $PM_{2.5}$ were observed highest during the winter season, followed by summer and post-monsoon seasons. The average concentrations of PM_{10} and $PM_{2.5}$ were observed 240 $\mu g/m^3$, 224 $\mu g/m^3$, 181 $\mu g/m^3$ and 160 $\mu g/m^3$, 123 $\mu g/m^3$, 116 $\mu g/m^3$ during summer, post-monsoon and winter seasons, respectively. Higher concentration during winter is attributed to the prevalence of anti-cyclonic conditions, characterized by calm or light winds and limited mixing depth due to a stable or inversion of atmospheric lapse rate (Chaulya, 2004).

From the observations, the spatial variation in particulate matter

Table 1: Details of monitoring stations in the study area

Monitoring Stations	Geographical Location		Dominating Activities
	N	E	
Big Bazar	23°49.230′	86°.28.192′	Vehicular movement, Commercial activities, Shopping mall
Bank More	23°47.302′	86°.25.165′	Busiest marketing center, Heavy traffic density
Govind Pur	23°50.673′	86°.28.999′	Industrial area, Coke oven plants, Vehicular movement
ISM Petroleum Dept.	23°48.890′	86°.26.590′	Green belt area, Free from pollution sources
Randhir Verma Chowk	23°47.892′	86°26.226′	Traffic junction, Commercial activities
RSP College	23p 45.193′	86p 24.740′	Rigorous vehicular movement (mining and non-mining), Mining activities and Coal washeries

Table 2: National ambient air quality standards (2009)

Pollutants	Duration	Concentration in Ambient Air (Industrial, Residential, Rural and other Areas)
Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual	50
	24 hours	80
Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual	40
	24 hours	80
Particulate Matter (PM_{10}), $\mu g/m^3$	Annual	60
	24 hours	100
Particulate Matter ($PM_{2.5}$), $\mu g/m^3$	Annual	40
	24 hours	60
Lead, $\mu g/m^3$	Annual	0.5
	24 hours	1
Carbon Monoxide, mg/m^3	8 hourss	2
	1 hour	4
Nickel, ng/m^3	Annual	2

(Source: CPCB, 2009)

Table 3: Spatial variation in PM_{10} and $PM_{2.5}$ concentrations during summer, post-monsoon and winter seasons

Monitoring Stations	PM_{10} Mean ± SD			$PM_{2.5}$ Mean ± SD			$PM_{2.5}/PM_{10}$		
	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter
Big Bazar	225±9	166±49	249±30	140±15	113±22	143±29	0.62	0.68	0.57
GovindPur	217±16	177±28	211±21	94±8	96±20	119±8	0.43	0.54	0.56
RSP College	401±42	334±30	432±16	244±11	226±13	308±37	0.61	0.68	0.71
Bank More	251±16	188±51	287±23	122±9	130±21	227±11	0.49	0.69	0.79
Randhir Verma Chowk	154±18	130±10	163±21	93±10	82±6	110±7	0.61	0.63	0.67
ISM Petroleum Dept.	95±10	92±8	98±10	42±9	48±7	54±9	0.44	0.52	0.55

Table 4: Spatial variation in SO_2, NO_x and CO concentrations during summer, post-monsoon and winter seasons

Monitoring Stations	SO_2 Mean ± SD			NO_x Mean ± SD			CO Mean ± SD		
	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter
Big Bazar	18.9±6.8	14.1±6.8	20.5±7.2	24.4±8.2	13.2±5.8	26.2±10.0	1.4±0.8	1.6±0.2	2.3±0.9
GovindPur	39.2±9.2	24.1±6.3	41.8±11.1	34.8±6.1	27.4±7.6	46.7±4.8	0.5±0.3	1.0±0.1	1.0±0.3
RSP College	43.2±18.5	39.6±12.2	72.0±11.1	53.6±8.7	34.8±7.9	61.4±9.5	1.1±0.3	0.8±0.4	2.0±0.6
Bank More	25.0±8.6	23.0±8.9	26.9±7.3	90.4±9.9	85.4±7.9	93.4±8.0	7.4±1.5	6.8±1.1	9.2±1.5
Randhir Verma Chowk	18.8±4.9	10.0±4.5	20.0±5.5	39.4±6.7	31.3±7.2	57.7±6.7	0.6±0.3	0.6±0.3	1.3±0.6
ISM Petroleum Dept.	9.9±6.5	10.2±4.0	12.6±5.4	8.5±4.4	5.5±4.2	10.3±4.2	ND	ND	ND

*ND - Not Detected

concentrations is also apparent. The average seasonal concentrations of PM were observed highest at RSP College, Jharia (mining area), followed by Bank More (traffic junction). The highest concentrations of both PM_{10} and $PM_{2.5}$ at RSP College is due to the impact of mining activities in nearby locations as well as due to vehicular emissions (tail pipe and resuspension). Mining operations and resuspension generally contribute coarse sized particles (PM_{10}) whereas, vehicular emissions (tail pipe) contribute fine particles (PM_{10}). At RSP College, the PM_{10} and $PM_{2.5}$ concentrations were observed as 401 $\mu g/m^3$ and 244 $\mu g/m^3$ during summer, 334 $\mu g/m^3$ and 226 $\mu g/m^3$ during post-monsoon and 432 $\mu g/m^3$ and 308 $\mu g/m^3$ during winter season. Whereas, at Bank More, the PM_{10} and $PM_{2.5}$ concentrations were observed as 251 $\mu g/m^3$, 188 $\mu g/m^3$, 287 $\mu g/m^3$ and 122 $\mu g/m^3$, 130 $\mu g/m^3$, 227 $\mu g/m^3$ during summer, post-monsoon and winter seasons, respectively. The concentration levels of PM at Bank More is solely emanated from transportation activities (both tail pipe and resuspension). The lowest concentration of PM_{10} and $PM_{2.5}$ (95 $\mu g/m^3$, 92 $\mu g/m^3$, 98 $\mu g/m^3$ and 42$\mu g/m^3$, 48 $\mu g/m^3$, 54 $\mu g/m^3$ during post-monsoon, winter and summer seasons, respectively) were observed at the ISM Petroleum Department. The lowest concentration at this station is attributed to the absence of any pollution sources. The seasonal average concentrations of PM_{10} and $PM_{2.5}$ were found higher than the 24 hourly NAAQS (national ambient air quality standards, 2009) limit at all the locations except ISM Petroleum Department.

The ratios of $PM_{2.5}$ and PM_{10} ($PM_{2.5}/PM_{10}$) calculated at all monitoring stations (Table 3) illustrates a significant contribution of $PM_{2.5}$ to the total PM_{10} concentrations except Govind Pur and ISM Petroleum Department. The highest ratio (0.79) was observed at Bank More during winter season. High $PM_{2.5}$ to PM_{10} ratio (greater than 0.5) represents significance influence of vehicular emissions (especially, tail pipe emissions), while low ratio (less than 0.5) depicts the influence of fugitive emission as well as resuspension of settled dusts.

The concentration of gaseous pollutants also exhibits significant spatial variation (Table 4). The concentrations of SO_2 were observed highest at RSP College (43$\mu g/m^3$, 40 $\mu g/$

Table 5: Spatial variation in Ni and Pb concentrations during summer, post-monsoon and winter seasons

Monitoring Stations	Ni Mean ± SD(ng/m3)			Pb Mean ± SD(μg/m3)		
	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter
Big Bazar	15.43	13.78	16.95	0.19	0.20	0.40
GovindPur	41.68	51.00	34.21	0.09	0.20	0.20
RSP College	18.42	41.00	53.10	0.14	0.17	0.26
Bank More	16.81	33.13	58.25	0.42	0.33	0.42
Randheer Verma Chowk	35.50	53.83	63.16	0.19	0.17	0.24
ISM Petroleum Dept.	7.99	28.11	33.80	0.02	0.03	0.03

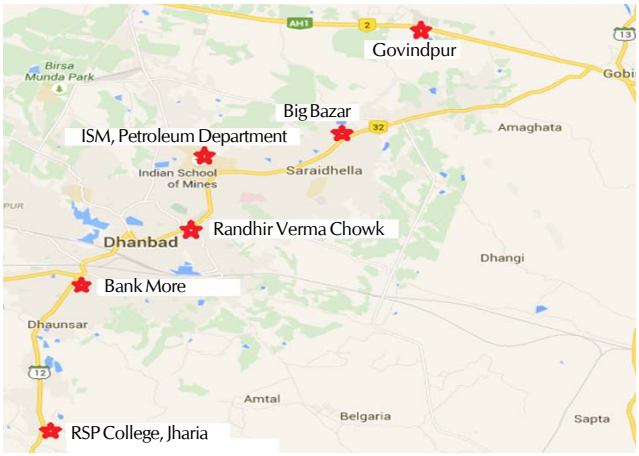

Figure 1: Map of study area depicting monitoring stations

$m^3$and 70 $\mu g/m^3$during summer, post-monsoon and winter seasons, respectively), followed by Govind Pur (40 $\mu g/m^3$, 24 $\mu g/m^3$ and 42 $\mu g/m^3$ during summer, post-monsoon and winter seasons, respectively). The sources of SO_2 at RSP College are mine fire and coal burning, while at Govind Pur the sources are coke oven plants. NOx concentrations were found highest at Bank More (90 $\mu g/m^3$, 85 $\mu g/m^3$ and 93 $\mu g/m^3$ during summer, post-monsoon and winter seasons, respectively), followed by RSP College, Bank More and Govind Pur. At Bank More, the concentrations of NO_X were exceeded the NAAQS during all seasons. High concentration of NO_X at this station represents strong influence of vehicular activity, which is also evidenced by the occurrence of higher levels of CO (6.5 mg/m^3, 6 mg/m^3 and 8 mg/m^3 during summer, post-monsoon and winter seasons, respectively) during all seasons.

Heavy Metals

The concentration levels of heavy metals (Pb and Ni) are depicted in Table 5. The range of average Pb concentrations were detected between 0.024 $\mu g/m^3$ to 0.417 $\mu g/m^3$ at all monitoring stations during this study, which is below the 24 hourly NAAQS limit. The low concentration of Pb even along the traffic routes may be attributed to the complete phase out of leaded diesel and petrol owing to the implication of stringent fuel standards. While, the range of average Ni concentrations were observed between 8 ng/m^3 (at ISM Petroleum department, during summer season) to 63.2 ng/m^3 (at Randhir Verma Chowk, during winter season). Ni concentrations were observed higher than the NAAQS at all monitoring stations except Big Bazar during both post monsoon and winter seasons. The increased concentrations of Ni in this area indicates the influence of transportation activities on the ambient air quality. During both the seasons, the concentration at Randhir Verma Chowk was observed highest, which may be attributed to vehicular emission and coal burning.

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