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SPATIO-TEMPORAL MONITORING OF SO_2 IN BURDWAN TOWN, WEST BENGAL, INDIA

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Abstract
SO_2 emission is an undesirable outcome of civilization. SO_2 affect environmental health in different way e.g.-respiratory problem of human being to acid rain formation. So, in present era it is an urgent need to have surveillance over the concentration of SO_2 in any region. In the study of air pollutants season is also important. So apart from spatial monitoring temporal variation of SO_2 are also taken into account. Burdwan town being one of the most important and heritage towns of West Bengal is selected as monitoring place (25 sampling sites) with respect to of SO_2in this study. SO_2 is collected by bubbling the sample in specific absorbing reagents put in impinger and analysed by standard method. This gaseous pollutant (SO_2) shows the average value is 10.156±7.411 µg/m^3 (range: 2.130 to 23.490 µg/m^3), 7.589±5.340 µg/m^3 (range: 0.120 to 21.300 µg/m^3) and 11.845±7.951 µg/m^3 (range: 1.320 to 30.800 µg/m^3) in premonsoon, postmonsoon and winter season respectively. However the present study of SO_2 shows the town is so far quite safe with respect to SO_2 pollution.

Introduction

Today, the ambient air in most large Indian cities is severely polluted and this pollution has a tremendous impact not only on the health of the population but also in the ecosystem. Industrialisation, the growth in the number of vehicles in urban areas has lead to a rapid deterioration of ambient air quality by emitting various kinds of air pollutants. Urban air pollution has grown in cities like Delhi, Mumbai, and Kolkata, across the Indian subcontinent in the last decade in an alarming condition (Agarwal et al., 1999). Sulphur dioxide is one of the toxic gases emitted during burning of fossil fuel. Goyal and Sidhartha (2002) observed that monthly mean SO_2 concentrations had regular seasonal variations with highest concentration in winter and lowest in monsoon in Delhi, India. In a study by Carmichael et al. (2003) involving the measurement of gaseous pollutants at 50 locations in Asia, Africa, South America and Europe, maximum concentration of SO_2 was observed in Agra (India), indicative of its major contributions from anthropogenic emissions like power plants, industrial boilers, heating and cooking. A long-term study of the impact of SO_2 concentration released from the Mathura refinery on the Taj Mahal (the monument which is adjudged as one of the wonders of the world) in Agra, India was studied by Goyal and Singh (1990). This study has been performed because of the suspected toxicity of SO_2 that it may react with oxygen in the presence of water vapour forming sulphuric acid. It has pungent odour and may cause coughing, suffocation and other respiratory disorder. It also reduces the capacity to do work. Thus it affects the children, elderly, asthmatics and other vulnerable populations. As per Yaseen et al., 2014 sulphur di oxide is one of the main products released from the combustion of sulphur compounds in most energy fuels having significant environmental concern.

Health issues related to SO_2

The issues of chronic exposure of the population to air emissions and the generated health hazards are increasingly the focus of debate. Health effects are now known to be associated with much lower levels of SO_2 than previously believed (World Health Organization WHO, 2011). A brief summary on its source and effect are presented below (Table 1).

Table 1: Sources and effects of SO_2

Pollutant	Anthropogenic Sources	Health Effects	Environmental Effects
Sulphur dioxide (SO_2)	Burning of coal and oil, especially high-sulphur coal; industrial processes (paper manufacturing, metal smelting).	Respiratory illness, breathing problems, may cause permanent damage to lungs.	Precursor of acid rain, which can damage trees, lakes and soil; aerosols can reduce visibility. Acid rain also causes buildings, statues, and monuments to deteriorate.

Methods

Study area**:** Burdwan is located at 23°.12′ - 23°.15′'N, 87°.48′ - 87°.53′E. It has an average elevation of 40 metres (131 ft). The city is situated 1100 km from New Delhi and a little less than 100 km north-west of Kolkata on the Grand Trunk Road (NH-2) and Eastern Railway. The chief rivers are the Damodar and Banka. Burdwan Municipality area is divided into 35 no of wards having a total area of 25.29 square kilometers (sq km). The main land use of the municipality is dominated by residential area (36.88 %). Though it is a municipality area, but agriculture is still practiced in few wards. However crop land became dominated land use in those wards. Rice mill is the major industry of this municipality. Overall 2.51 % and 2.59 % area of Burdwan municipality (Table 2) is covered by rice mill cluster and mixed urban with mill areas. Overall 2.95 % and 2.70 % area of this municipality is covered by commercial areas and mixed urban with commercial areas respectively which seems that more commercialization is necessary for future development related to residential area (Gupta and Roy, 2012). Table 3, 4 and 5 represent the details of sampling sites and NAAQS standard.

Table 2: Land use/land cover of Burdwan Municipality area

Land Use/Land Cover Classes	Area (sq m)	% of Area
Evergreen Vegetation Surrounding the forest area	504737.45	2.00
Spar evergreen Vegetation Along with Residential area	2990965.69	11.83
Crop Land	2111009.03	8.35
Residential area	9327609.73	36.88
Commercial area	746664.20	2.95
Mixed urban with commercial area	682345.40	2.70
Ephemeral Ponds	64287.35	0.25
Barren land	499139.04	1.97
Nonforested Wet land	181319.25	0.72
Mixed Forest	260609.08	1.03
Streams & Canals	296275.35	1.17
Perennial Fishing ponds	1537423.73	6.08
Sandy area other than beaches	260797.79	1.03
Perennial Nonfishing ponds	156724.00	0.62
Rice mill clusters	634821.83	2.51
Mixed urban with mill areas	654919.49	2.59
Herbaceous Range Land	1131224.57	4.47
Play Ground	113981.09	0.45
Institutions	72370.44	0.29
Hospital	10253.27	0.04
Services Area	47240.51	0.19
Nurseries	7202.45	0.03
Dense Evergreen Vegetation Along with residential area	2997318.94	11.85
Total Area	**25289239.67**	**100.00**

Source: Gupta and Roy, 2012

Table 3.: Details characteristics about the sampling sites

Sampling Sites	Description
R11, R12, R13, R15, R6, R7	Residential area with high traffic density
R3, R4, R5, R8, R14	Residential area with moderate traffic density
R1, R2, R10	Residential area with low traffic density
R9	Residential area influenced by industrial emission
I1 and I2	Industrial area with high traffic density
I4	Industrial area with moderate traffic density
I3	Industrial area with low traffic density

S2, S5, S6	Sensitive area with high traffic density
S1	Sensitive area with moderate traffic density
S3	Sensitive area with moderate traffic density and highly influenced by industrial emission
S4	Sensitive area with high traffic and highly influenced by industrial emission

Table 4: Locational details of sampling sites at a glance

Local name of the sites	site label	Lat/Long
Goda	R1	23° 15'06.73" N. 87 °50'22.17" E
Tarabag	R2	23° 15'05.38" N. 87 °50'44.79" E
Jagatber	R3	23° 13'16.49" N. 87 °51'51.58" E
Jilpibagan	R4	23° 13'14.60" N. 87 °51'37.13" E
Bermore	R5	23° 13'23.31" N. 87 °51'35.69" E
Bhangakuti	R6	23 °15'22.78" N. 87 °51'08.22" E
Policeline1	R7	23 ° 13'23.13" N. 87 ° 52'39.57" E
Ichlabad	R8	23 ° 14'02.36 "N. 87 ° 52'04.69" E
Bhatchala1	R9	23° 13'45.94" N. 87 °51'29.94" E
Bhatchala2	R10	23° 14'04.87" N. 87 °51'16.12" E
Tinkonia	R 11	23° 14'58.06" N. 87 °52'06.26" E
Curzongate	R12	23° 14'25.48" N. 87 °52'03.57" E
Barabazar	R13	23 ° 14'24.04N ". 87 ° 51'23.53" E
Kanchannagar	R14	23 ° 14'14.39" N.87 ° 49'41.95" E
Golapbagmore	R15	23° 15'27.42" N. 87 °50'59.15" E
Tejganj1	I1	23° 13'29.61" N. 87 °50'48.05" E
Tejganj 2	I2	23° 13'32.38" N. 87 °50'57.75" E
Alamganj1	I3	23° 13'55.76" N. 87 °50'53.54" E
Alamganj2	I4	23° 14'06.98" N. 87 °50'57.72" E
Rajcollege	S1	23° 14'43.95" N. 87 °51'26.42" E
Vidyarthi School	S2	23° 14'00.26" N. 87 °51'55.75" E
Kalpataru children park	S3	23° 14'09.51" N. 87 °50'48.84" E
Alamganj primary school	S4	23 °13'54.41"N. 87 ° 50'57.01"E
SadhanpurPolytechnique college	S5	23° 15'00.32" N. 87 °52'53.27" E
Department of Environmental Science	S6	23° 15'25.28" N. 87 °50'55.87" E

Table 5: National Ambient Air Quality Standards

All Pollutants («g/m^3) Only CO in mg/m^3	Time weighted	Concentration in ambient air in average		
		Sensitive	Industrial	Residential and others
Sulphur dioxide (SO_2)	24h	30	120	80

Source: Central pollution control board, Delhi, 1994

Sampling procedure: Sampling was carried out in three seasons for twenty-four (24) hours at each site. The seasonal classification was followed as per specification laid by Indian meteorological department (Murty, 2004). March, April and May months were considered as premonsoon season and June, July, August and September were considered as postmonsoon season and January and February were considered as winter. Envirotech APM 460BL was used for monitoring of SO_2. Air

was allowed to pass through impinger having specific 50 ml absorbing reagent for SO_2. The average flow rate through the impinger was taken for the calculation of gaseous samples. After the sampling the impinger sample were kept in iceboxes and transferred to a freeze until the analysis was done. Potassium tetrachloromercurate was used as absorbing reagents for SO_2 to arrest SO_2 in the form of dichlorosulfitomercurate complex measured spectrophotometrically at 560 nm. For analysis of SO_2 by spectrophotometeric method, was followed by popular methods of West and Gaeke, 1956.

Results and discussions

The average value of SO_2 in the study area is 10.156±7.411 µg/m^3, 7.589±5.340 µg/m^3 and 11.845±7.951 µg/m^3 in premonsoon, postmonsoon and winter season respectively (Table 6).

Among industrial, residential and sensitive sites maximum SO_2 level is observed in (site I2) industrial site where SO_2 is found as 23.490 µg/m^3, 21.300 µg/m^3 and 30.800 µg/m^3 during premonsoon, postmonsoon and winter season respectively. This might be possibly due to emission from industrial boiler, heating and cooking sources. The finding of the study area is similar to the findings by Gupta et al. (2008). It is generally found that all the sites have high winter concentration of SO_2 than premonsoon and low value in postmonsoon season. Precipitation driven wash out may lower down the postmonsoon value of SO_2. Reddy and Ruj (2003) also found the value of SO_2 were high in winter followed by summer and monsoon. Sometimes a few sites viz. R1, R3, R6 and I3 have higher level of SO_2 concentration during postmonsoon like in comparison to other season. Burning of coal by local people may be responsible factor for the elevated concentration of SO_2. This type of observation is also reported by Valeroso and Monteverde (1992) in Manila where monsoonal value of SO_2 sometimes become higher negating the effect of rain.

Comparison with measurements of other urban areas and cities

The overall average value of SO_2 in Dhaka is 48 µg/m^3 (Salam et al., 2008). But the highest concentration of SO_2 is found in commercial and heavy traffic zone (76.8µg/m^3) in Dhaka by Salam et al. (2008). Verma et al. (2003) found the concentration of SO_2 as 41.92 µg/m^3 at Lucknow. The concentration of sulphur dioxide was found in Pakistan in the range 0.02-0.007 ppm (Ali and Athar, 2008). In Haryana SO_2 ranged from 9.85 µg/m^3 to 37.0 µg/m^3 (Kaushik et al., 2006). The daily average of SO_2 in Kolkata is 12.3±9.2 µg/m^3 in residential site, 21.3±15.7 µg/m^3 in industrial and 8 h value of SO_2 was 15.5±11.9 µg/m^3 (Gupta et al., 2008). Among these findings Kolkata's scenario with respect to SO_2 is mostly similar to our study area. In recent Yaseen et al., 2014 found SO_2 concentration of average value of 21 µg/m^3 near Parichha, India. The Cpcb report 2016 showed SO_2 concentration as 22 to 36 µg/m^{3}during deepawali in Delhi.

Comparison with National ambient air quality standard (NAAQS) standard

The concentration of SO_2 is comparatively lower in all the seasons than the prescribed standard of NAAQS in all the monitoring sites. Similar kind of SO_2 status was also high lighted by other research workers such as Reddy and Ruj (2003), Ali and Athar (2008) and Gupta et al. (2008). Reddy and Ruj (2003) had reported that the all the monitoring sites in their study field i.e. Raniganj-Asansol area are below the standard of SO_2. Jain and Saxena (2002) in Dhanbad and Jharia also observe the SO_2 concentration to be below the prescribed standards. Apart from NAAQS standard the average value of SO_2 is much more below the World Health Organization's (WHO) guide line (WHO, 2000: 50 µg/m^3) and for the European Union. Again as per Revised National Ambient Air Quality Standards (NAAQS)[NAAQS Notification dated 18th November, 2009] for Industrial,Residential, Rural and otherAreas EcologicallySensitive Area(notified byCentralGovernment) the limit value of Sulphur Dioxide (24 Hours)is 80 µg/m^3.Still the town's SO_2 level is below that standard.

Table 6: Spatial and temporal variation of SO_2 in the study area

Site	Premonsoon	Postmonsoon	Winter
	SO_2 (µg/m^3)	**SO_2 (µg/m^3)**	**SO_2 (µg/m^3)**
R1	3.670	7.060	5.100
R2	2.280	1.470	2.880
R3	2.130	4.240	2.290
R4	10.340	7.960	10.600
R5	2.210	8.480	16.950
R6	4.470	12.530	3.180
R7	13.200	12.720	19.110
R8	3.940	6.800	12.720
R9	20.340	3.180	20.400
R10	16.950	4.370	12.130

R11	6.930	3.410	5.450
R12	3.210	19.090	5.600
R13	22.850	2.006	1.320
R14	4.550	9.750	6.360
R15	14.300	2.700	16.490
I1	20.340	5.060	22.800
I2	23.490	21.300	30.800
I3	4.000	10.600	10.000
I4	7.510	12.720	18.200
S1	2.680	0.120	20.250
S2	14.320	7.300	3.640
S3	14.940	12.850	12.010
S4	21.960	6.360	22.790
S5	5.800	3.180	9.750
S6	7.500	4.480	5.300
Minimum	**2.130**	**0.120**	**1.320**
Maximum	**23.490**	**21.300**	**30.800**
Average	**10.156**	**7.589**	**11.845**
Standard deviation	**7.411**	**5.340**	**7.951**

Conclusion

All the monitoring sites are observed to have high winter value of SO_2 than premonsoon and low value in postmonsoon season. Precipitation driven wash out may lower down the postmonsoon value of SO_2. The concentration of SO_2 was comparatively lower in all the seasons than the prescribed standard of NAAQS in all the monitoring sites. So, this scenario is quite safe so far to this town.

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