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Determination of SOx Concentration in Ambient Air and its Dependency on Meteorological Parameters: A Case Study

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Abstract

Present study have been conducted with the objectives of studying the impact of Meteorological parameters on SOx concentration in the campus of Hindustan College of Science and Technology, Farah Mathura. SOx concentration in the study area were determined experimentally for the period from February 2010 to April 2010. Meteorological parameters on SOx concentration the hourly meteorological parameters such as wind speed and direction, temperature, humidity and rainfall were also recorded by automated weather station installed at study site. Air samples were collected as per guidelines of Central Pollution Control Board norms at 24 hours intervals for two days in a week for four consecutive weeks in a month for three months (February, March and April, 2010). 24 Hrs average SOx concentrations determined biweekly on the basis of this experiment indicate that concentrations are higher in winter i.e. in February when temperature were low where as concentration decreases from March onwards when temperature began to rise. However concentration were below the National Ambient Air Quality Standards of Central Pollution Control Board, India i.e. 80µg/m3 for residential and rural area for all the duration of the study. Correlation between 24 Hours average SOX concentration and average daily values of wind speed, temperature and relative humidity were found to be very poor. However the correlation between 24Hrs average SOx concentration and instantaneous values of temperatures at 0.0 Hrs, 18.0 Hrs, 21.0 Hrs and 3.0 Hrs were found to be excellent. Regression equations were derived to predict the 24 Hrs SOx concentration in the study area based on the variables having excellent correlation with SOx concentration. These equations can be used to predict the SOx concentration in the study area when the experiment to determine the SOX concentration is not possible and hourly meteorological parameters are available.

Keywords: Sulphur Dioxide; air pollution; Wind Speed, Temperature, Humidity

1. Introduction

Air pollution is an important environmental issues in different part of world due to its severe health impact. Various contaminants continuously enter the atmosphere through natural and man-made processes and these contaminants interact with the environment to cause disease, toxicity, environmental decay and are labeled as pollutant causing threat to human health in many towns and cities. Particulate emission is mainly responsible for increased death rate and respiratory problems for the urban population. In 1976 the U.S.EPA established a Pollutant Standard Index (PSI) which rated air quality from 0-500, with 100 equal to the National Ambient Air Quality Standards (NAAQS). The PSI is calculated for every pollutant with a NAAQS (Cheng, et. al., 2007). It is a referential parameter describing air pollution levels that provides information to enhance the public awareness of air pollutions (Wang and Lu, 2006). In India also the National Ambient Air Quality Monitoring (NAAQM) Programme has been established by Central Pollution Control Board with the objectives to determine the present air quality status and trends and to control and regulate pollution from industries and other source to meet the air quality standards. Many studies have been conducted till date on the assessment of ambient air quality in India and elsewhere in the world. Sharma et al., (2005) assessed the particulate matter at Kanpur city India. Krochmal et al., (1997) measured nitrogen dioxide and sulphur dioxide concentrations in urban and rural areas of Poland using a passive sampling method. Lahmann et al (1976) compared the sulphur dioxide and nitrogen dioxide measurement in ambient air. Jonnalagadda et al (1990) studied the levels of sulphur dioxide, nitrogen dioxide, ammonia, and hydrogen chloride in ambient air of Harare, Zimbabwe. Chang et al., (1998) determined the water soluble trace gases in ambient Air by condenser-type diffusion denuder coupled ion chromatography. Center for Science and environment in its recent studies (2010) has assessed the level of pollutants in major cities of India.

The concentration of air pollutants depends on various factors including emissions, local and synoptic scale meteorological conditions, atmospheric chemical processes, geographical region, its surrounding emission source areas and the season of the year. Generally, the degree to which air pollutants discharged from various sources, concentrate into a particular area depends on meteorological conditions of the area. Certain meteorological parameters like Wind Speed, Wind

Direction, Temperature, Atmospheric Stability, Mixing Height etc. have profound impact on air pollutant dispersion. Present study have been conducted with the objectives of studing the impact of Meteorological parameters on SOx concentration in the campus of Hindustan College of Science and Technology, Farah Mathura. The main source of SOx concentration in the campus is Mathura refinery along with heavy traffic of NH-2. In this context first the SOx concentration in the study area was determined experimentally for the period from February 2010 to April 2010. In order to find the impact of meteorological parameters on SOx concentration the hourly meteorological parameters such as wind speed and direction, temperature, humidity and rainfall were also recorded by automated weather station installed at study site. Detail methodology is discussed in following section.

2. Materials and Methods

2.1. The Study Area

Hindustan College of Science and Technology campus is located near Farah town in Mathura district of Uttar Pradesh, India which is 27 km from Mathura City on Delhi-Agra Highway i.e. NH2. Area is spread across 34 acres land, The campus has a total built up area of 6,00,000 sq. ft. It is bordered by three cities namely Agra, Mathura, Bharatpur and it location is at 27°17'47"N 77°47'11"E. The main source of SOx concentration in HCST campus is Mathura Refinery. Another reason for concentration of sulphur dioxide is due to transport present in nearby Mathura-Delhi Highway.

2.2. Determination of SOX Concentration

2.2.1. The Experiment

Air samples were collected as per guidelines of Central Pollution Control Board norms at 24 hours intervals for two days in a week for four consecutive weeks in a month for all the four months (i.e. January, February, March and April, 2010) of Winter Season. 'ENVIROTECH High Volume Respirable Dust Sampler, APM 460' together with gaseous attachment APM 411 capable of drawing air at a flow rate of 1 to 1.3 m^3/ min, with very little pressure drop was used for collection of samples. The instruments were installed on the terraces over a three storage building (about 10 meter above ground) without any obstruction around the instrument. The sampler was placed at a distance of at least 100 m from highways/ roads to avoid inclusion of traffic related emissions. Glass micro-fibre filter papers (GFA sheets, Whatman or equivalent) were used for the collection of RPM and the SPM was collected in a Teflon cup, placed at the base of cyclone separator. Sulphur dioxide from air is absorbed in a solution of potassium tetrachloro-mercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable of strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution is stored for some time prior to analysis. The complex is made to react with pararosaniline and formaldehyde to form the intensely colored pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable double beam spectrophotometer. Special grades of Glass Microfibre filters like Whatman EPM2000 which have a controlled and a low known concentration of metals like Iron, Zinc, Cadmium, Lead, Arsenic, Nickel, etc. were used to collect the sample.

2.2.2. Calculations of SOx Concentration

Conversion of the volume of air sampled to the volume at the reference conditions of 25 ^{0}C and 760mm:

$$Vr = V\ (P/760)\ [298/\ (t+273)]$$

Where:

Vr – Volume of air at 25°C and 760 mm Hg, litres

V – Volume of air sampled, litres

P – Barometric pressure, mm Hg

t – Temperature of air sampled, °C

When sulphite solutions are used to prepare calibration curves, the concentration of sulphur dioxide, C, in micrograms per cubic meter, in the sample were computed as follows:

$$C = (A\text{-}A_0)\ (10^3)\ (B)\ (D)/Vr$$

Where:

A – Sample Absorbance

A_0 – Reagent blank absorbance

10^3 - Conversion of litres to cubic meters

Vr – Volume of air corrected to 25°C and 760 mm Hg, litres

B – Calibration factor, µg/absorbance unit

D – Dilution factor

$$C\ (SO2\ \mu g/m^3) = (A\text{-}A_0) \times 10^3 \times B/V$$

Where:

A – Sample absorbance

A_0 – Reagent blank absorbance

10^3 – Conversion litres to cubic meters

B – Calibration factor, µg/absorbance

V – Volume of air sampled in litres

If desired, the concentration of sulphur dioxide may be calculated as parts per million of sulphur dioxide at reference conditions as follows:

$$ppm\ SO_2 = \mu g\ SO_2/m^3 \times 3.82 \times 10^{-4}$$

2.3. Meteorological Observations

Hourly recording of Wind speed, Wind direction, temperature, humidity and rainfall were made by the automatic weather station installed in the campus for the duration of the study period.

2.4. Assessing the Dependency of SOX Concentration on Meteorological Parameters.

24 Hrs average daily meteorological parameters were calculated by taking the average of hourly recorded values. Correlation coefficients were calculated between 24 Hrs average SOx concentration and (i) average daily meteorological parameters namely wind speed, temperature and relative humidity on the same day (i) average meteorological parameters one day before the SOx measurement and (iii) two day before the SOx measurement. In addition correlation was also calculated between daily SOX concentration and instantaneous meteorological parameters at every three hour intervals beginning at 0.0 Hrs. The regression equations were fitted between SOx concentration and those meteorological parameters either average or instantaneous having excellent correlations with SOX. Our findings on this aspects is discussed in the following section.

3. Results and Discussions

3.1. Assessment of SOx Concentration

24 Hrs average SOx concentrations determined biweekly on the basis of experiment performed and calculations as discussed in previous section for the period from February 2010 to April 2010 are shown in Figure 1. Results indicate that concentrations are higher in winter i.e. in February when temperature were low where as concentration decreases from March onwards when temperature began to rise. However concentration were below the National Ambient Air Quality Standards of Central Pollution Control Board, India i.e. 80µg/m3 for residential and rural area.

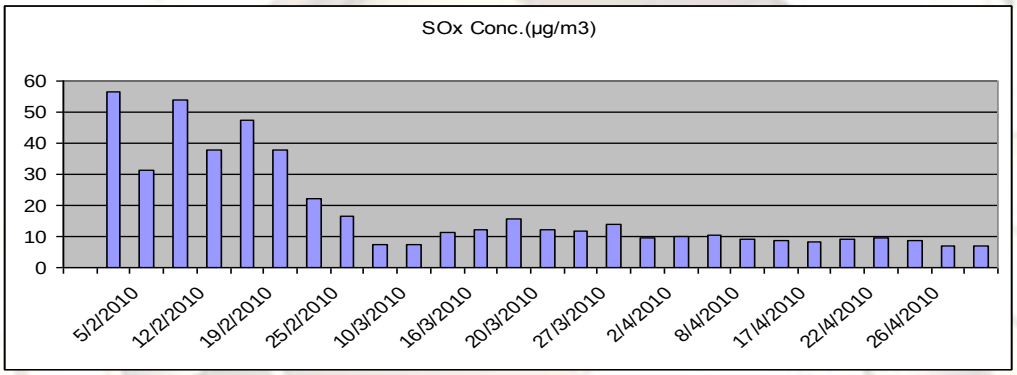

Figure 1: Variation in SOx concentration in the study area

The main source of SOx concentration in HCST campus is Mathura Refinery. Another reason for concentration of Sulphur dioxide is due to transport present in nearby Mathura-Delhi Highway. High transport emitting various pollutants which also containing SO_2 at causing dispersion in the atmosphere. This leads to high concentration of SO_2 in atmosphere of college campus.

3.2. Assessing Dependency of SOx Concentration on Meteorological Parameters

Correlations between 24 Hrs average SOx concentration and average daily wind speed on the same day, one day before and two day before the SOx measurement were found to be very poor (less than 0.1) and therefore not considered further for the study. Same was the case with average daily temperature on the same day, one day before and two day before the SOx measurement where correlation were also very less (i.e. less than 0.3). A better correlation were obtained with the average daily humidity and the values were 0.60, 0.59 and 0.64 for same day, one day before and two day before the SOx measurement respectively. However non of these average daily meteorological parameters show a significant correlation with the measured SOx concentration in order to be considered as a predictor variable of SOx concentration.

Correlation between 24Hrs average SOx concentration and instantaneous values of wind speed and relative humidity beginning at 0.0 Hrs were also found insignificant (Table 1) and were not considered further as predictor variables. However correlations with instantaneous temperature and 24 Hrs average SOx concentration were found to be excellent (Table 1). Though all the values of correlation coefficients are found as good as to be considered as predictor variable but those which have shown excellent correlations are further considered for deriving a regression equation to predict the SOx concentration. These are temperature values at 0.0 Hrs, 18.0 Hrs, 21.0 Hrs and 3.0 Hrs (Table 1). Therefore these values were used as predictor variables individually and regression equation were derived to predict the 24 Hrs SOx concentration in the study area which is shown in Figure 2. Any of the regression equation (particularly the one at 0.0 Hrs and other at 18.00 Hrs) shown in figure 2 can be used to predict the SOx concentration in the study area when the experiment to determine the SOX concentration is not possible and hourly meteorological parameters are available.

Table 1: Correlation Coefficient between Instantaneous Temperature and 24 Hrs Average SOx Concentration in the Study Area.

	Time of Weather Record							
	0.0 Hrs	3.0 Hrs	6.0 Hrs	9.0 Hrs	12.0 Hrs	15.0 Hrs	18.0 Hrs	21.0 Hrs
Correlation Between 24 Hrs average SOx Concentration and Instantaneous Wind Speed	-.178	-0.0491	-.1959	-.1129	0.0991	0.0672	0.0492	-0.105
Correlation Between 24 Hrs average SOx Concentration and Instantaneous Temperature	-.826	-0.7822	-.6494	-.7066	-0.7192	-0.7516	-0.8018	-0.7903
Correlation Between 24 Hrs average SOx Concentration and Instantaneous Relative Humidity	0.601	0.6464	0.4292	0.6264	0.6026	0.6939	0.7187	0.7905

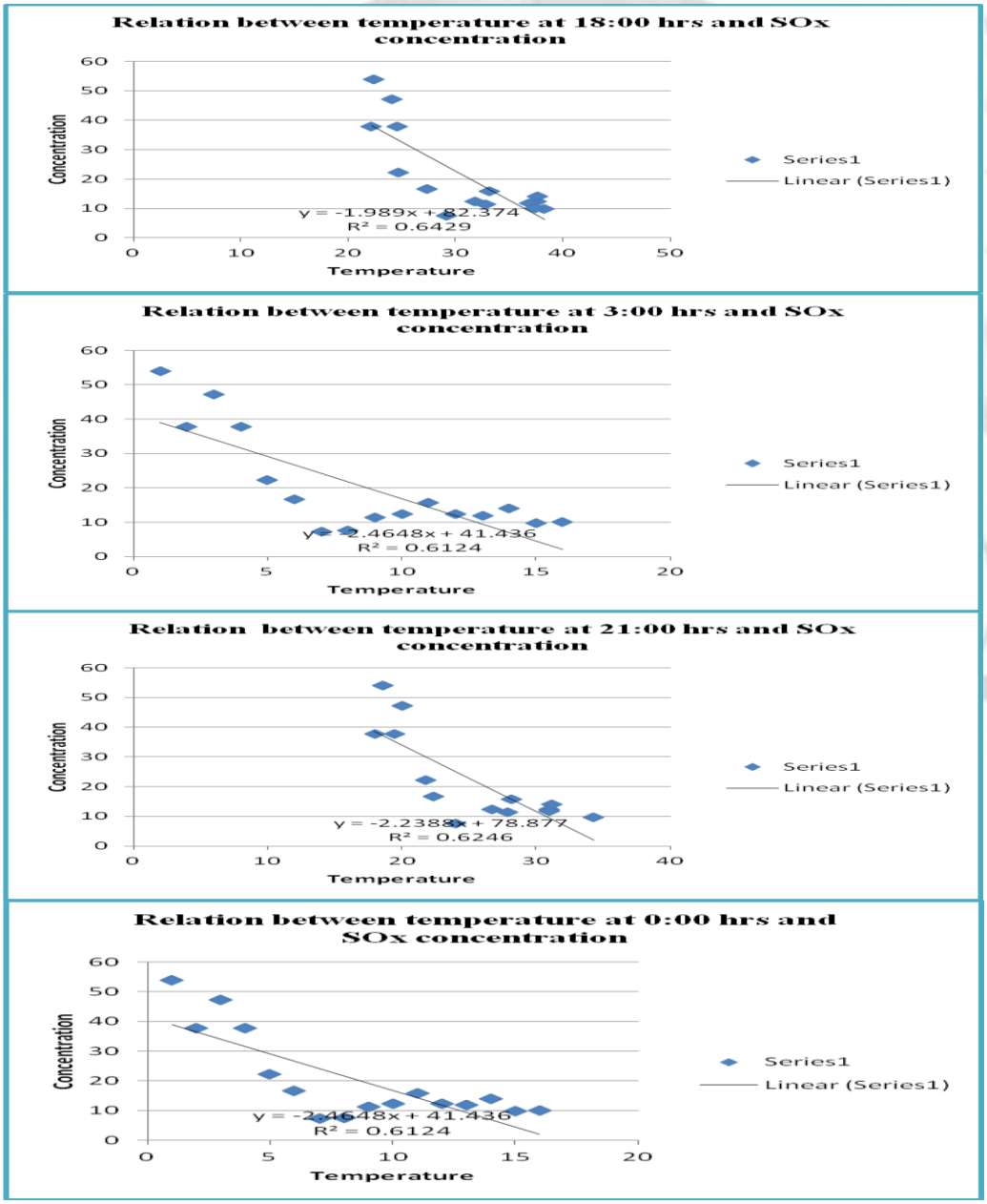

Figure 2: Relation Between Instantaneous Temperature and 24 Hrs Average SOx Concentration in the Study Area.

4. Conclusions

Experimental determination of 24 Hrs average SOx concentration in the campus of Hindustan College of Science and Technology for the period from February 2010 to April 2010 indicate that concentrations are higher in winter i.e. in February when temperature were low where as concentration decreases from March onwards when temperature began to rise. However concentration were below the National Ambient Air Quality Standards of Central Pollution Control Board, India i.e. 80µg/m3 for residential and rural area for all the duration of the study. Correlations between 24 Hrs average SOx concentration and average daily wind speed on the same day, one day before and two day before the measurement of SOx concentration were found to be very poor to be considered as a predictor variable of SOx concentration. However correlation between 24Hrs average SOx concentration and instantaneous values of temperature at 0.0 Hrs, 18.0 Hrs, 21.0 Hrs and 3.0 Hrs were found to be excellent. Regression equations were derived to predict the 24 Hrs SOx concentration in the study area based on these variables. These equations can be used to predict the SOx concentration in the study area when the experiment to determine the SOX concentration is not possible and hourly meteorological parameters are available.

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