International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Analysis of Sulphur Dioxide Concentration in Central University of Jammu (Rahya Suchani) Campus

Navita Verma

Lecturer, Department of Evs, Bharghava Degree College, Samba

Abstract

One major air pollutant that has a negative impact on both the environment and human health is sulfur dioxide (SO2). An analysis of the sulphur dioxide levels on the Central University of Jammu (Rahya Suchani) campus is presented in this abstract. The study's objectives are to measure the amount of SO2 pollution, locate probable sources, and analyze the effects of the pollution on the campus environment and the residents' health. In order to gather information on SO2 concentrations at different points on the university campus, the research makes use of quantitative measurements and environmental monitoring techniques. Data is gathered using specialized equipment that can measure SO2 in ambient air precisely. The study aims to investigate the temporal and spatial fluctuations in SO2 concentration, accounting for variables such as local pollution sources, automobile traffic, industrial processes, and weather patterns. The distribution patterns and locations of elevated SO2 pollution on campus are visualized by statistical analysis and spatial mapping approaches. The goal of this study's findings is to increase university stakeholders' knowledge of the level of SO2 pollution on the Central University of Jammu campus. Through the identification of pollutant sources and patterns, the study offers significant insights for the implementation of mitigation techniques and the promotion of a healthier campus environment.

Keywords: Sulphur dioxide (SO2), Rahya Suchani campus, Air Quality Index, Suspended Particulate matter

INTRODUCTION

One of the biggest issues facing the modern, civilized world is pollution. A few different forms of pollution are noise, air, water, and land contamination. The lives of people and other living things have been seriously threatened by all of these forms of pollution. The air is the only element in man's immediate environment that all life depends upon. For human existence, there must be an ongoing supply of air. The daily air requirement is roughly 1020 m3 and is comparatively consistent (Park, 2009). The breathing of humans and other animals, the breakdown of biological materials, the burning of coal, gas, oil, etc. all contribute to the impureness of the air we breathe. Because air pollution has such negative effects on health, it is a significant environmental problem in many parts of the world. Through both natural and artificial processes, a variety of pollutants, known as pollutants, are released into the atmosphere. These pollutants then interact with the environment to produce toxicity, illnesses, and environmental degradation. Primary and secondary pollutants are two categories for the air pollutants. Dangerous substances that are released into the atmosphere as a result of human activity or natural occurrences are the main sources of air pollution. When two or more airborne components combine chemically, a hazardous substance known as a secondary air pollutant is created. The secondary pollutant is created when certain elements of the atmosphere interact with primary pollutants (Naik, 2005). Gases including sulfur dioxide (SO2), nitrogen oxides (NOx), suspended particulate matter (SPM), and respirable particulate matter (RPM) are among the main air pollutants. These air contaminants, which come from a variety of sources, negatively impact human life.

SOx stands for sulfur oxides, which include sulfur dioxide (SO2) and sulfur trioxide (SO3). With sulfur dioxide (SO2) making up around 29% of the weight of all pollutants, it is the second most significant contributor to air pollution. It is one of the most prevalent and deadly air pollutants and is created when fossil fuels like coal, gas, and oil are used to generate electricity. Other sources of the pollution include industrial dust, volcanic eruptions, diesel-powered vehicles, and suspended particulate matter (SPM), which are solid and liquid particles released from a variety of man-made and natural sources (Ahmed, 1999). In the lower atmosphere, sulfur dioxide (SO2) predominates among the SOx family of chemicals (Pollution Prevention and Abatement Handbook, 1998). The colorless gas SO2 has an overpowering smell. The main industrial sources of SO2 are car emissions, home and commercial heating, diesel power generation, and flaring at oil and gas plants. Fuel's sulfur level has a direct impact on how much SO2 is emitted (Air Quality Monitoring Network, 2008).

OBJECTIVES OF THE STUDY

1. Sampling and determination of SO_2 concentration at four locations in the campus of Central University of Jammu.
2. To investigate the temporal variation in SO_2 concentration during the sampling period and to understand the influence of meteorological parameters on SO_2 concentration.
3. To review the literature to assess the present status, gaps and future scopes in this field of Sulphur dioxide research.

REVIEW OF LITERATURE

Kumar and Kriti, 2016 did a study on ambient air quality status of Jaipur city, Rajasthan, India. Air pollutants like PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO and meteorological parameters were monitored continuously for 24 hours in a day from January 2014 to December 2014. Monthly and seasonal variations of these pollutants have been monitored.

Ahmad and Bano, 2015 carried out a study to the assessment of ambient air quality of Firozabad city.One site under residential area, one commercial and one industrial were selected to assess the total air quality of this region. Firozabad is an industrial city with its supremacy in bangles and glass wares manufacturing.

Nilesh et al., 2014 did a comparative study on the ambient air qualities of Chandrapur district. It was observed that RSPM level in almost all station samples were higher during dry season. The pollution level of SO_2, NO_x and RSPM were more in the area under industrial impact. The monitoring result at Ballarpur indicates that the values of RSPM in winter as well as in summer were above the CPCB limit for residential area.

Mehraj et al., 2013 did a study on the health risks associated with manufacturing of cement on the population living in the neighborhood of a cement industry in Khrew, Kashmir, India. The main parameters considered for study included suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), nitrogen oxides (NO_x) and sulfur dioxide (SO_2).

Sharma and Raina, 2012 studied on ambient air quality of Jammu city with reference to SO_2 and NO_2 content. They have monitored the outdoor ambient air quality of Jammu due to the deteriorating air quality, for 2004 and 2005 at selected locations.

METHODS AND MATERIALS

SAMPLING DETAILS

This section includes description of sampling site, sample collection, instruments used and the protocol used for the analysis of SO_2 in the air

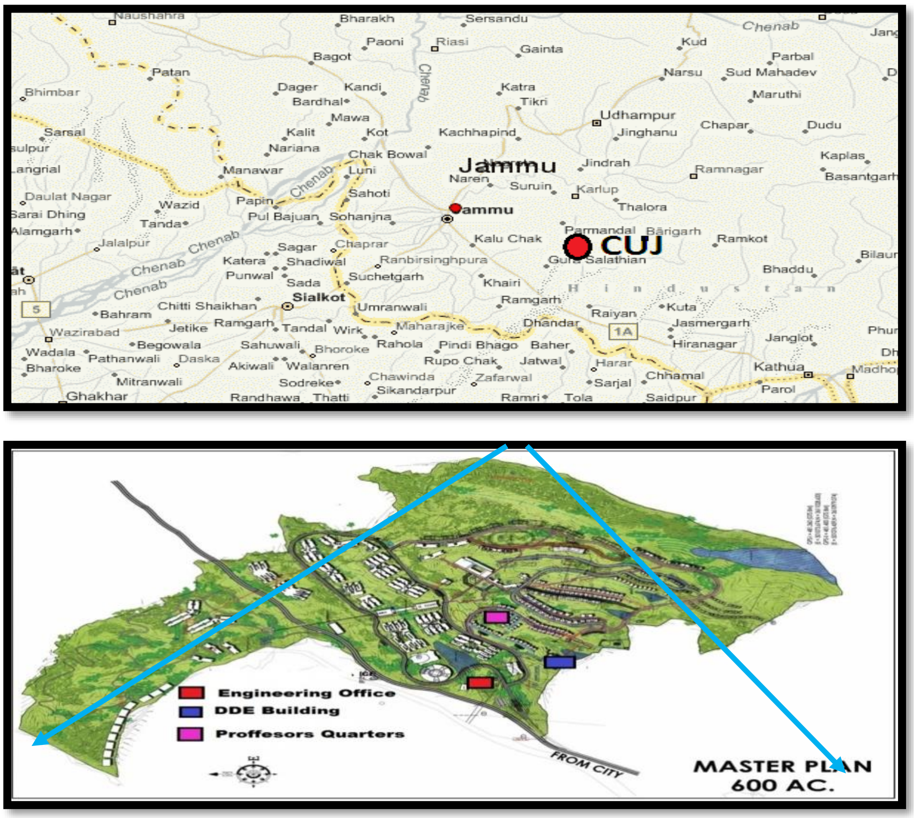


Figure 1: Map showing the location of sampling site- Engineering Office, DDE Building and Professors Quarters in the Central University of Jammu Campus.

The sites selected for the sampling of SO_2 in ambient air were located in the Main Campus of Central University of Jammu, Raya Suchani, Bagla in Jammu and Kashmir. Jammu and Kashmir looks like a crown on the map of India. It is flanked by Chinese and Russian Turkistan in the north and in the east by Chinese Tibet. On the south and south west lies the states of Punjab and Himachal Pradesh and on the west lies the North West Frontier province of Pakistan, China and Russia. J&K lies between 32.17 and 36.58 latitude and east to west it lies between 73.26 and 80.30 longitudes. Jammu and Kashmir has an area of 222,236 square kilometers. The altitude varies from 395m to 6910m. Jammu is situated on the banks of River Tawi. It is the winter capital of the state. It is surrounded by Shivalik ranges in the north, east and the north east; and in the northwest the Trikuta range surrounds it. It experiences cold weather in winters and summers are relatively warm. It has an area of 2,336 square meters. It is located at

32°43N latitude and 74°56 E longitudes. Central University of Jammu is located in Samba district about 25 kms from Jammu City. This University is constructed in the Shivaliks. It covers an area of 600 acres. Samplers were installed at 3 different sites in the University from where samples were collected once in every week. One sampler is installed at the roof top of Engineering Office, second at the roof top of Professor Quarters, while the third at the roof top of Distance Department building.

SAMPLE COLLECTION

The sample was collected by using Thermoelectrically cooled Gaseous pollutant sampler Ecotech model AAS118TE. Sampling was done from 18thof January to 25th of the May. Samples were collected once in every week. The method used for the sampling was Modified West & Gaeke Method (IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur dioxide. A mixture of mercuric chloride, EDTA, and potassium chloride (30ml) was used as the absorbing reagent which was filled in the impingers. The flow rate was set up to 1 liter per minute. Initial temperature and time were noted down. Sampling was done for 24 hours. After sampling, the samples were collected in the storage bottles after making up to 30 ml, in case, if there was loss of absorbing reagent by evaporation. Final flow rate, temperature and time were noted down .the sample storage bottles were kept in an ice – box and covered with aluminum foil until taken to laboratory for analysis.

Instruments used in the method

The following instruments were used to determine the concentration of oxides of nitrogen in the ambient air.

1. Gaseous Pollutants Sampler Ecotech Model AAS118TE
2. Standard borosilicate glass impingers
3. UV Visible Spectrophotometer
4. Analytical balance
5. Refrigerator

OPERATION OF THE SAMPLER

- 30 ml of absorbing reagent (mercuric chloride, EDTA, and potassium chloride) in impinger is taken and is marked as SO_x.
- Grease is applied at the mouth of impingers for proper functioning.
- Outlet of impinger is then connected to the suction nozzle of manifold using silicon tube.
- Initial time totaliser readings is noted down.
- Power cable is connected to the IEC socket provided at the rear of the sampler.
- Pump is then switched on using red rocker switch
- Flow rate is adjusted using control needle valve of the manifold at the top of the sampler by screw driver. Flow rate is visible in rotameter when rotameter is connected at the inlet of rotameter. Flow is adjusted as 1L/min.
- Silicon tube is removed from impinge inlet and other control valves are closed if not required.
- Temperature is also noted down as given by the temperature indicator cum controller.
- The door is locked and the sampler is left for 24 hours.

DETAILS OF UV-VIS SPECTROPHOTOMETER

We used the microprocessor based UV-VIS spectrophotometer Model 1371. This instrument operates at 190-1000nm range. The use of microcontroller makes it extremely versatile and state of the art instrument. Instrument is provided with Deuterium lamp which operates in the wavelength range 190-350nm and Tungsten Halogen Lamp which operates in the wavelength range 350-1000nm. It measures the intensity of light passing through a sample (I), and compares it to the intensity of light before it passes through the sample (I_o). The ratio I/I_o is called the transmittance, and is usually expressed as a percentage (%T). The absorbance, A, is based on the transmittance:

$$A= -\log (\%T/100\%)$$

UV-VIS Spectrophotometer is used in analytical chemistry for the quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, and biological macromolecules. It works on the principle of Beer-Lambert law, which states that absorbance of a solution is directly propotional to the concentration of the absorbing species in the solution and the path length.

$$A= \log_{10} (I_o/I) = ecl$$

Where;

A= absorbance, in Absorbance Units (AU)
I_0= intensity of the incident light at a given wavelength
I= transmitted intensity
l= path length through the sample, and
c= concentration of the absorbing species

The main parts of a UV-VIS Spectrophotometer are:

- A light source which may be a Tungsten Filament (300-2500nm), a deuterium arc for ultraviolet region (190-400nm) or a xenon arc for visible region (160-2000nm).
- A holder for the sampler.
- A diffraction gratting in a monochromator or a prism to separate the different wavelengths of light.
- A detector which may be a photomultiplier tube, a photodiode, a photodiode array or a charge-coupled device.

The spectrophotometer used by us was the single beam spectrophotometer in which all of the light passes through the sample cell. I_o must be measured by removing the sample. Samples were placed in a transparent cell, known as a cuvette. Cuvettes are typically rectangular in shape, commonly with an internal width of 10mm. the most widely applicable cuvettes are made of highly quality fused silica or quartz glass because these are transparent throughout the UV, Visible and near infrared regions. Glass and plastic cuvettes are also common, although glass and most plastic absorb in the UV, which limits their usefulness to visible wavelengths. The light energy is condensed on the entrance slit. The entrance slit is placed at the focal plane of the collimating-mirror and thus a plane parallel beam strikes the grating surface. The selected wavelength further passes through the reference /sample cells. Finally, the transmitted light from the cell reaches the photocell. The electrical output of the photocell is linearly propotional to the intensity of light falling on it and represents the measurements being taken. Cuvette was placed in the sample holder and absorbance was taken at 560nm.

Stepwise protocol for the chemical analysis of SO_2 in ambient air:

PRINCIPLE OF THE METHOD

Modified West & Gaeke Method (IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur dioxide). Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely colored pararosanilinemethylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer.

Reagents / Chemicals

- Distilled water
- Mercuric chloride
- Potassium chloride
- Absorbing Reagent, 0.04 M Potassium Tetrachloromercurate (TCM) - Dissolve 10.86 g, mercuric chloride, 0.066 g EDTA, and 6.0 g potassium chloride in water and bring to the mark in a 1 litre volumetric flask. Caution: highly poisonous if spilled on skin, flush off with water immediately. The pH of this reagent should be approximately 4.0 but, it has been shown that there is no appreciable difference in collection efficiency over the range of pH 5 to pH 3. The absorbing reagent is normally stable for six months. If, a precipitate forms, discard the reagent after recovering the mercury.
- Sulphamic Acid (0.6%) - Dissolve 0.3 g sulphamic acid in 50 ml distilled water. Prepare fresh daily.
- Formaldehyde (0.2%) - Dilute 1.25 ml formaldehyde solution (36-38%) to 250litre with distilled water. Prepare fresh daily.
- Purified Pararosaniline Stock Solution (0.2% Nominal) Dissolve 0.500 gm of specially purified pararosaniline (PRA) in 100 ml of distilled water and keep for 2 days (48 hours).
- Pararosaniline Working Solution - 10 ml of stock PRA is taken in a 250ml volumetric flask. Add 15 ml conc. HCL and make up to volume with distilled water.
- Stock Iodine Solution (0.1 N) - Place 6.35 g iodine in a 250 ml beaker, add 20 g potassium iodide and 20ml water. Stir until all is dissolved, then dilute to 500 ml with distilled water.
- Iodine Solution (0.01 N) - Prepare approximately 0.01 N iodine solution by diluting 50 ml of stock solution to 500 ml with distilled water.
- Starch Indicator Solution - Triturate 0.2 gm soluble starch and 0.001 g mercuric iodide preservative with a little water and add the paste slowly to 100 ml boiling water. Continue boiling until the solution is clear, cool, and transfer to a glass-stoppered bottle.
- Potassium iodate
- Stock Sodium Thiosulfate Solution (0.1 N) - Prepare a stock solution by placing 12.5 g sodium thiosulfate pentahydrate in a beaker, add 0.05g sodium carbonate and dissolve using boiled, cooled distilled water making the solution up to a final volume of 500 ml . Allow the solution to stand one day before standardizing.
- To standardize, accurately weigh to the nearest 0.1 mg, 0.75 g primary standard potassium iodate dried at 180^oC, dissolve, and dilute to volume in a 250 ml volumetric flask. Into a 500 ml Iodine flask, transfer 50 ml of iodate solution by pipette. Add 2 g potassium iodide and 10 ml of N

hydrochloric acid and stopper the flask. After 5 min, titrate with stock thiosulfate solution to a pale yellow. Add 5 ml starch indicator solution and continue the titration until the blue color disappears. Calculate the normality of the stock solution as follows:-

$$N = \frac{W \times 1000 \times 0.1}{V \times 35.65}$$

N = Normality of sodium thiosulphate used
W = Weight of potassium iodate gm
35.67 = Equivalent weight of potassium iodate

- Sodium Thiosulphate Titrant (0.01 N) - Dilute 50 ml of the stock thiosulfate solution to 500 ml with freshly boiled and cooled distilled water.
- Standardized Sulphite Solution for Preparation of Working Sulphite- TCM Solution - Dissolve 0.15 g sodium metabisulphite ($Na_2S_2O_5$) in 250 ml of recently boiled, cooled, distilled water. Sulphite solution is unstable; it is, therefore, important to use water of the highest purity to minimize this instability. This solution contains the equivalent of 320-400 µg/ml of SO_2.
- Working Sulphite-TCM Solution - Measure 2 ml of the standard solution into a 100 ml volumetric flask by pipette and bring to mark with 0.04 M TCM. Calculate the concentration of sulphur dioxide in the working solution in micrograms of sulphur dioxide per millilitre. This solution is stable for 30 days if kept in the refrigerator at 5^oC. If not kept at 5^oC prepare fresh daily.

Sampling details

30 ml of absorbing solution was placed in an impinger and sample for four hours at the flow rate of 1 L/min. After sampling the volume of sample was measured and transferred to a sample storage bottle.

Analysis

Replace any water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber. Mix thoroughly, pipette out 10 ml of the collected sample into a 25 ml volumetric flask. Add 1 ml 0.6% sulphamic acid and allow reacting for 10 minutes to destroy the nitrite resulting from oxides of nitrogen. Add 2 ml of 0.2% formaldehyde solution and 2 ml pararosaniline solution and make up to 25 ml with distilled water. Prepare a blank in the same manner using 10 ml of unexposed absorbing reagent. After a 30 min colour development interval and before 60 minutes, measure and record the absorbance of samples and reagent blank at 560 nm. Use distilled water; not the reagent blank, as the optical reference.

Calibration

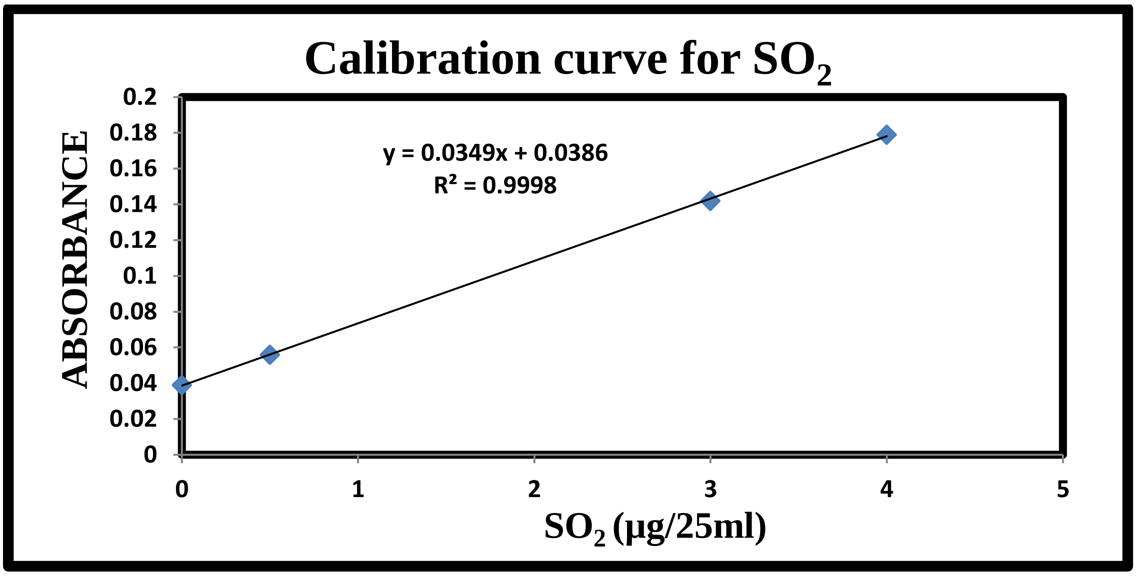
The actual concentration of the sulphite solution is determined by adding excess iodine and back titrating with standard sodium thiosulfate solution. To back-titrate, measure, by pipette, 50 ml of the 0.01 N iodine solutions into each of two 500 ml iodine flasks A and B. To flask A (blank) add 25 ml distilled water and into flask B (sample) measure 25 ml sulphite solution by pipette. Stopper the flasks and allow to react for 5 minutes. Prepare the working sulphite-TCM solution at the same time iodine solution is added to the flasks. By means of a burette containing standardized 0.01N thiosulfate, titrate each flask in turn to a pale yellow. Then add 5 ml starch solution and continue the titration until the blue colour disappears.

Preparation of Standards

Measure 0.5ml,1.0 ml, 2.0 ml, 3.0 ml, and 4.0 ml of working sulphite TCM solution in 25 ml volumetric flask. Add sufficient TCM solution to each flask to bring the volume to approximately 10 ml. Then add the remaining reagents as described in the procedure for analysis. A reagent blank with 10 ml absorbing solution is also prepared. Read the absorbance of each standard and reagent blank.

Standard Curve

Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF).



Calculation

The Concentration of SO_2 in µg/m^3 in the sample is calculated as follows:

$$SO_2\ (\mu g/m^3) = \frac{(A - A^o)\ \pi \times 10^3 \times B}{V}$$

Where:

A = Sample absorbance

A°= Blank absorbance

10^3= Conversion litres to cubic metres

B= Calibration factor

V= volume of air sampled in litres.

Conversion of µg/m^3 to ppm

If desired concentration of SO_2 can be calculated in ppm as follows:

ppm (SO_2) = SO_2 in µg/m^3 × 3.82 × 10^{-4}

All the chemicals were carefully weighed with the help of the balance (Sartorius; BSA 2245- CW).

RESULTS AND DISCUSSION

In this preliminary study, the sampling and analysis was done to determine the SO_2 concentration in the Main Campus of Central University of Jammu, Raya Suchani, Bagla in Jammu and Kashmir and to study the temporal variation in the SO_2 concentration during the sampling period. Samplers were installed at 3 different sites in the University from where samples were collected once in every week. One sampler is installed at the roof top of Engineering Office, second at the roof top of Professor Quarters, while the third at the roof top of Distance Department building. Sampling was done for a period of four and half months from 18th of January to 25th of the May. The maximum and minimum concentration of SO_2 was found to be 4.50µg/m^3 and 0.02µg/m^3 respectively over the sampling period both of which were recorded at PQ. Table 1 shows the threshold concentrations of SO_2 as given by NAAQS, where it can be seen that for the residential area, the standard limits are: 50µg/m^3 (Annual) and 80µg/m^3 (24 hours).

Table 1: Table shows the national ambient air quality standards (NAAQS) for SO_2

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Sulphur dioxide (SO_2), µg/m^3	Annual * 24 Hours **	50 80	20 80
* Annual Arithmetic mean of minimum 104 measurements in a year, at a particular site, taken twice a week 24 hourly at uniform intervals. ** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year.			

According to the WHO guidelines, the SO_2 concentration should not exceed 20µg/m^3 (24 hour mean) and 500µg/m^3 (10 minute mean). As mentioned in the standard protocol, the sampling of SO_2 can be conducted for 4 hours, 8 hours and 24 hours. In the present study, the sampling was planned for 24 hours at the three different locations. The concentration of SO_2 over the sampling period at the three locations, remained much lesser than the threshold concentrations of SO_2 given by NAAQS and WHO because there is no coal burning activities within the sampling area. The maximum value recorded was 4.50µg/m^3 on 11th May, 2017 and the minimum value recorded was 0.02µg/m^3 on 18th January, 2017.

TABLE 2: Table showing weekly concentration, mean concentration, maximum, minimum concentration of SO_2 at selected sites of the Campus of Central University Of Jammu over the sampling duration (18th January To 25th May, 2017)

S.No.	DATE	SO_2 CONCENTRATION(µg/m^3)		
		PQ	DDE	XEN
1	18-Jan-17	0.02	0.08	1.34
2	6-Feb-17	1.99	1.46	0.98
3	13-Feb-17	2.53	2.17	0.86
4	20-Feb-17	1.16	1.99	1.28

5	2-mar-17	2.77	1.34	3.61
6	9-Mar-17	1.93	2.89	3.43
7	16-Mar-17	3.49	3.61	3.96
8	23-Mar-17	0.26	2.53	1.58
9	29-Mar-17	1.46	2.17	3.43
10	6-Apr-17	4.32	3.78	2.17
11	13-Apr-17	2.41	1.70	2.83
12	27-Apr-17	2.95	1.52	3.72
13	3-May-17	3.61	1.99	2.71
14	11-May-17	4.50	3.13	3.55
15	18-May-17	2.47	4.38	3.78
16	25-May-17	1.99	3.72	2.95
Average		2.37	2.40	2.64
Standard deviation		1.27	1.12	1.10
Minimum		0.02	0.08	0.86
Maximum		4.50	4.38	3.96

The concentration of SO_2 at all the three locations in the Main Campus of Central University of Jammu at Bagla (Raya-Suchani), Distt. Samba over the sampling period is shown in the Table 2. From the table it is clear that: At PQ sampling was carried out from 18th of January, 2017 to 25th of May, 2017. A total 18 number of samples were collected from this location and the average value of SO_2 was found to be 2.37µg/m^3. The minimum and maximum values were found to be 0.02µg/m^3 and 4.50µg/m^3 respectively. At XEN the sampling was also carried out from 18th of January, 2017 to 25th of May, 2017. A total 18 number of samples were collected from this location and the average value of SO_2 was found to be 2.64µg/m^3. The minimum and maximum values were found to be 0.86µg/m^3 and 3.96µg/m^3. At DDE the sampling was also carried out from18th of January, 2017 to 25th of May, 2017 and the average value of NO_x was found to be 2.40µg/m^3 respectively. A total 18 number of samples were collected from this location. The minimum and maximum concentrations were found to be 0.08µg/m^3 and 4.38µg/m^3 respectively.. The average values of SO_2 at all the locations were nearly similar. The highest average value was recorded for Professor Quarters (4.50). The weekly variation in SO_2 concentration during the sampling period at all sampling locations is plotted in figure 14, 15 and 16 where it is clearly visible that the sampling was conducted for eighteen weeks from 18th January, 2017 to 25th May, 2017. As 24 hourly sampling was done on working days. Mostly 4-5 samples were collected per month.

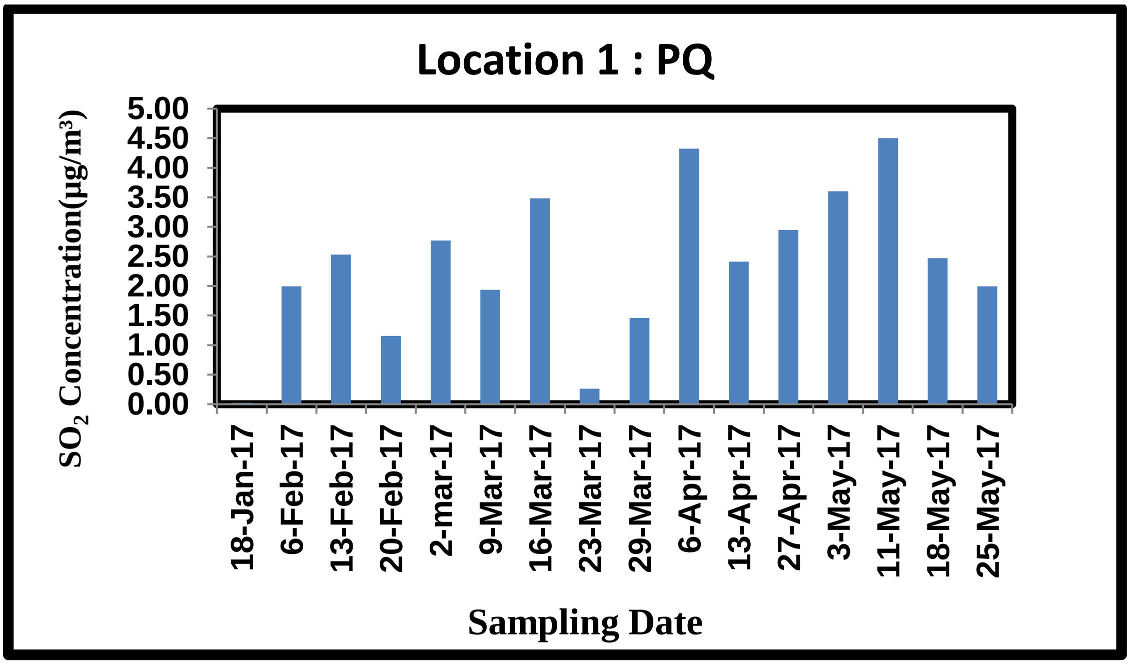


FIGURE 2: FIGURE SHOWS THE WEEKLY VARIATION IN SO_2 CONCENTRATION DURING THE SAMPLING PERIOD AT LOCATION SITE 1 (PROFESSOR QUARTERS).

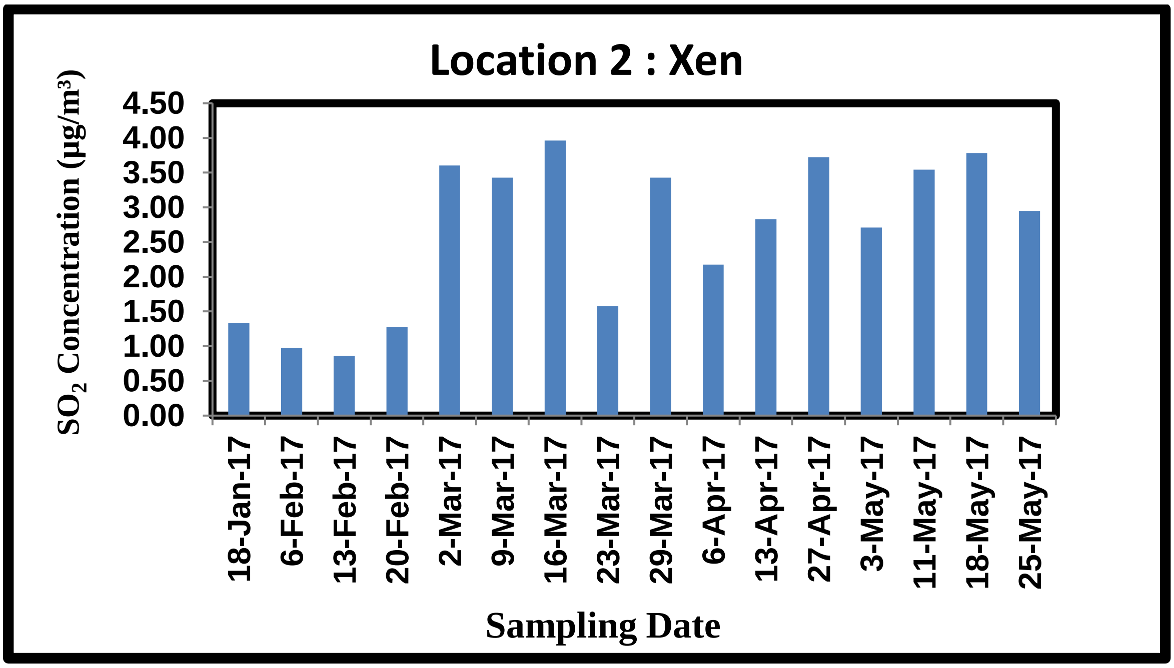


FIGURE 3: FIGURE SHOWS THE WEEKLY VARIATION IN SO_2 CONCENTRATION DURING THE SAMPLING PERIOD AT LOCATION SITE 2 (XEN).

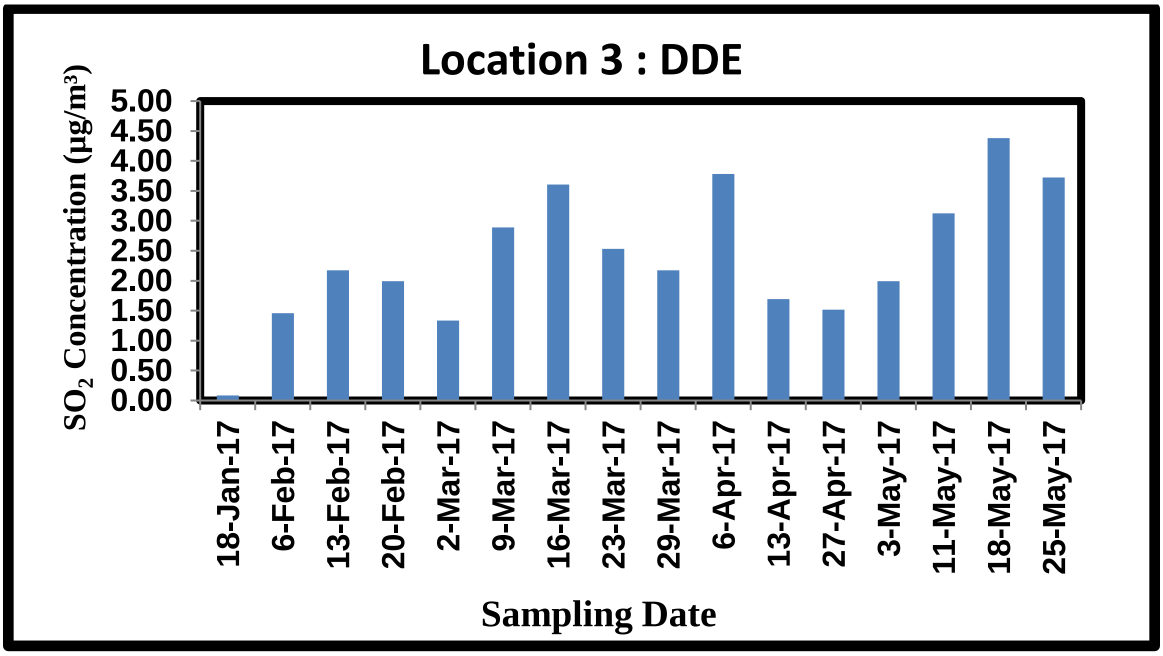


FIGURE 4: FIGURE SHOWS THE WEEKLY VARIATION IN SO_2 CONCENTRATION DURING THE SAMPLING PERIOD AT LOCATION SITE 3 (DDE

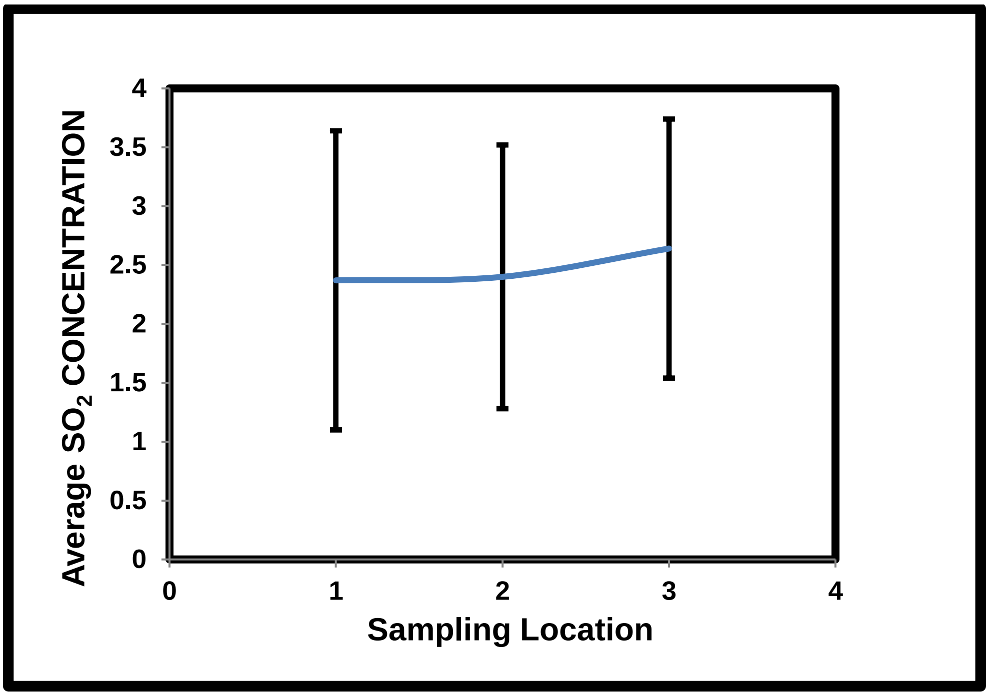


Figure 5: Figure shows the average concentration (µgm^{-3}) of SO_2 with Standard Deviation at four locations- 1. Professor Quarters (PQ) 2. Engineering Office (XEN) 3. Directorate of Distance Department building. 4. Top

The monthly variation is also shown in the Table 5. From the table it is clear that for PQ maximum and minimum average value was recorded for the month April and january respectively, for XEN maximum and minimum average value was recorded for the month May and February respectively, for DDE maximum and minimum average value was recorded for the month January and may respectively.

Table3: Table showing monthly average concentration of SO_2 at three sampling sites over the sampling period.

MONTHS	Monthly average concentration of SO_2 in µg/m^3.		
	PQ	XEN	DDE
January	0.02	1.34	0.08
February	1.89	1.04	1.87
March	1.98	3.20	2.51
April	3.23	2.91	2.33
May	3.14	3.25	3.31

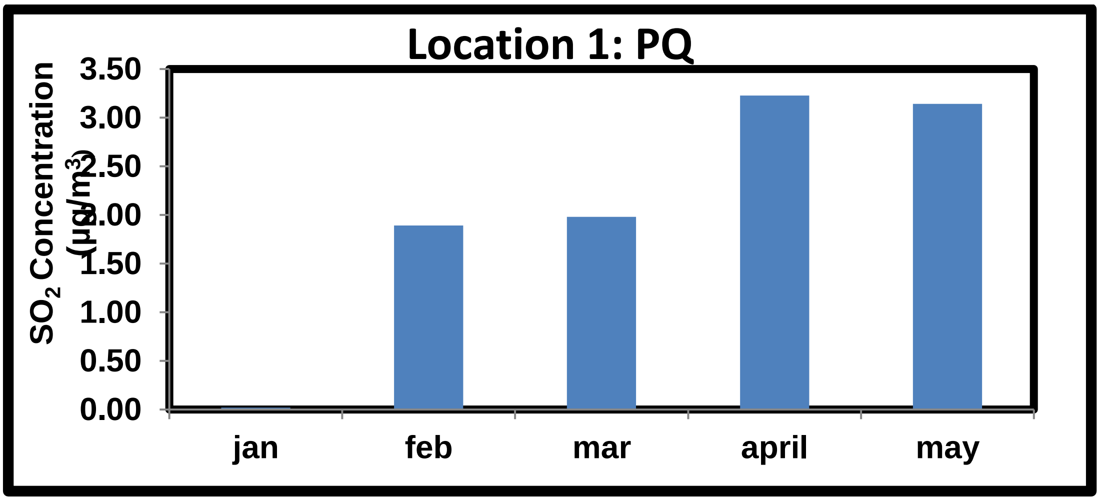


Figure 6: Figure showing monthly average concentration (µgm^{-3}) of SO_2 of at Professor Quarters.

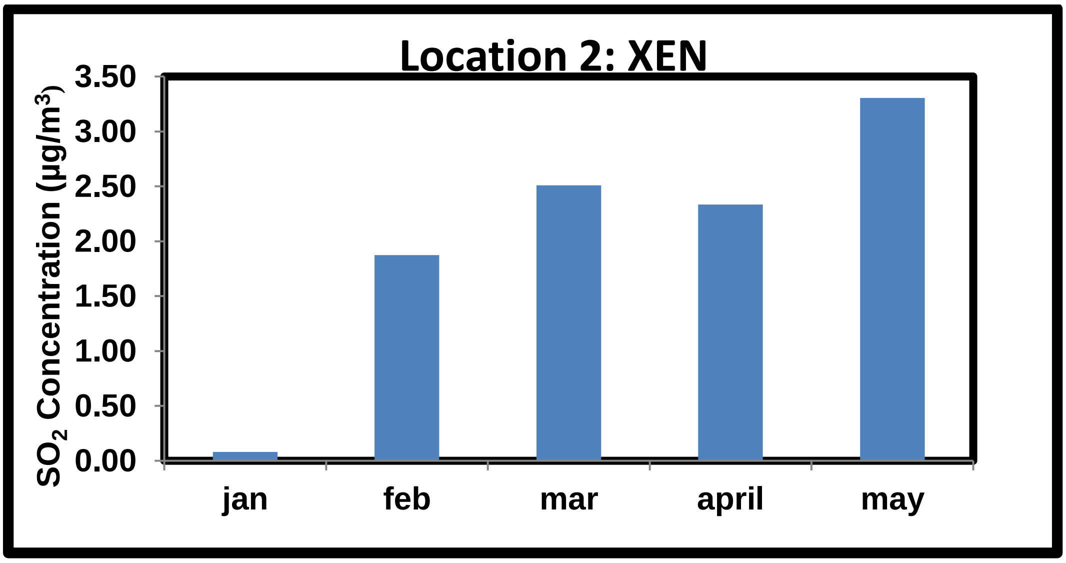


Figure 7: Figure showing monthly average concentration (µgm^{-3}) of SO_2 at Engineering Office.

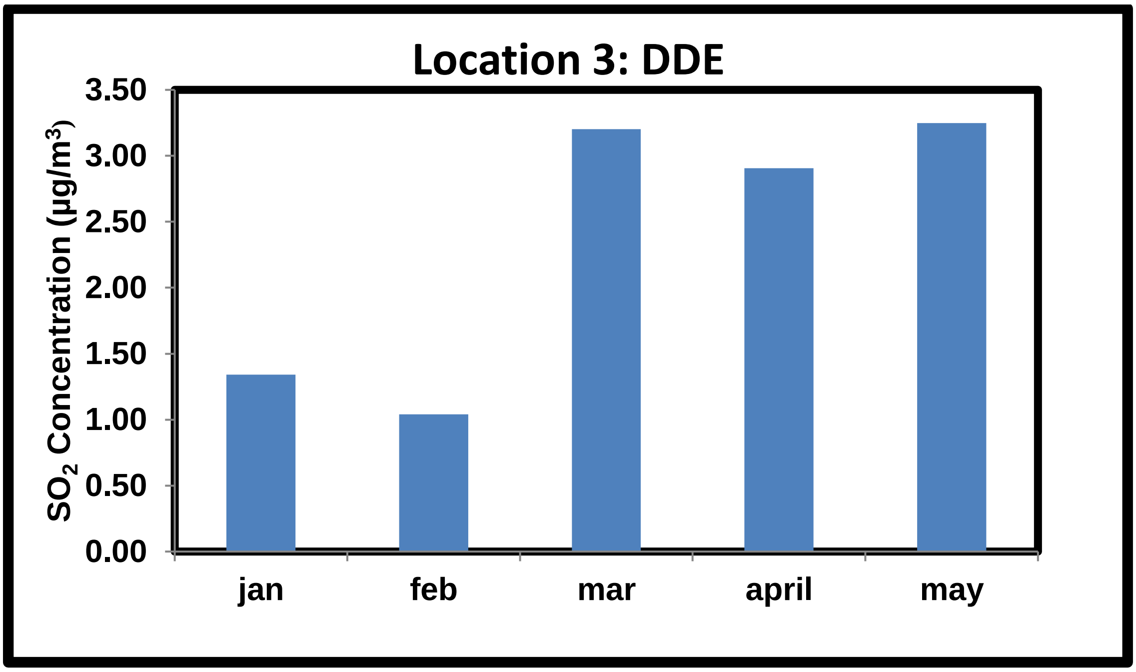


Figure 8: Figure showing monthly average concentration (μgm^{-3}) of SO_2 at Directorate of Distance Department building.

The major source of SO_2 is coal combustion and the high levels of SO_2 emissions from coal burning have today become the subject of concern. In coal, mainly, sulphur is in the form of pyrite, FeS_2 and organic sulfur. The following reaction shows that how SO_2 is emitted from combustion of pyrite in coal (Manahan, 2001):

$$FeS_2 + 11O_2 = Fe_2O_3 + 8SO_2$$

The selected area is not an industrial area so the concentration of SO_2 remained much lesser than the threshold concentrations of SO_2 given by NAAQS and WHO. In this area the major contributor of SO_2 emission is the vehicular exhaust from mobile sources. These mobile sources include light vehicles such as cars and bikes, heavy vehicles such as buses deployed for university students and staff members. In addition to these, trucks, tankers, tractors for carrying transportation materials also contribute to SO_2 emission in the selected site.

METEOROLOGICAL PARAMETERS AND THEIR EFFECT ON SO_2 CONCENTRATION.

Research shows that the meteorological parameters have a significant effect on the presence and variation of air pollutants in the ambient air. To assess the variation in the meteorological parameters and their correlation (if any) with the SO_2 concentration noticed in the present study, the average data for Temperature (T) in °C, Relative Humidity (RH) in % and Wind Speed (WS) in km/hr, Planetary Boundary Layer (PBL) in meters, Dew point in °C was taken from wunderground.com for the corresponding sampling dates. The average values of T, RH, and WS have been plotted in figure 21. The average values for temperature, relative humidity and wind speed, Planetary Boundary Layer and Dew Point over the sampling period were as follows 19.54ºC., 38.46% and 5.40 km/hr, 614.55mts and 3.50°C respectively.

The concentration of air pollutants in ambient air is governed by the meteorological parameters such as atmospheric wind speed, wind direction, relative humidity, and temperature.

(https://www.hindawi.com/journals/ijas/2013/264046/). Temperature plays a major role in determining the concentration of air pollutants. During summers when the temperature is high the air parcel near the ground is warmer than the air parcel above it. This is because during summers the surface temperature is high which causes the air parcel near it to become warmer. The warm air parcel rises above while the colder parcel above it sinks down. This results in greater mixing heights and hence effective mixing. Therefore pollutants are mixed up efficiently in the atmosphere which leads to their dilution and hence lesser concentrations. In contrast to this, in winters low temperature results in stable air and mixing depths are low. Vertical air movements are less prominent. Thus the pollutants remain trapped in the surface layers which lead to their higher concentration. Temperature inversions also results in stable air which in turn leads to high concentration of pollutants in the surface layers. Major air pollution episodes such as photochemical smog had occurred during winter seasons. Wind also influences the concentration of SO_2. If the winds are strong, the pollutants are well mixed in the air and are hence diluted. The concentration of pollutants becomes lesser. Light winds cause less turbulence and hence the concentration of pollutants remain high. Therefore air pollution episodes are associated with calm winds rather than strong winds. Relative humidity affects the SO_2 concentration by providing moisture necessary to promote atmospheric chemical reactions. The previous study (Tripathi et.al, 2013) indicated high concentration of SO_2 during winters due to low temperature and low mixing height and vice versa in summers. By investigating the meteorological parameters, correlations between meteorological parameters and SO_2 concentration was calculated. Correlation is the mutual relationship between two variables. If increase or decrease in one parameter leads to corresponding increase or decrease in another parameter, the correlation is said to be direct. Correlation is positive when increase in one parameter causes a corresponding increase in another parameter. It is termed as negative when increase in one parameter causes decrease in another parameter. The value of correlation coefficient ranges from +1 to -1. If the value ranges from +8.0 to 1.0 and -0.8 to 1.0, correlation is strong, is moderate when it ranges from +0.5 to +0.8 and -0.5 to -0.8. Correlation is weak if the value of correlation coefficient ranges from -0.5 to +0.5. In the present study, weak positive correlation i.e. 0.42 was found between SO_2 concentration and Temperature. The reason might be the more sources in summers than in winters due to which higher concentrations were recorded in summer months (April and May). Weak correlation was found between SO_2 concentration and other meteorological parameters. Significant correlation was found between dew point and SO_2 concentration.

Table 4: Showing correlation of meteorological parameters with SO_2 concentration

	Concentration (SO_2) in µg/m^3	Temperature (˚C)	PBL (m)	Dew point (˚C)	RH (%)	wind speed (Knots)
Concentration(SO_2) in µg/m^3	1.00					
Temperature (˚C)	0.42	1.00				
PBL (m)	0.44	0.88	1.00			
Dew point (˚C)	0.53	0.65	0.74	1.00		
RH (%)	-0.12	-0.76	-0.56	-0.01	1.00	
Wind speed(Knots)	0.27	0.38	0.35	0.47	-0.09	1

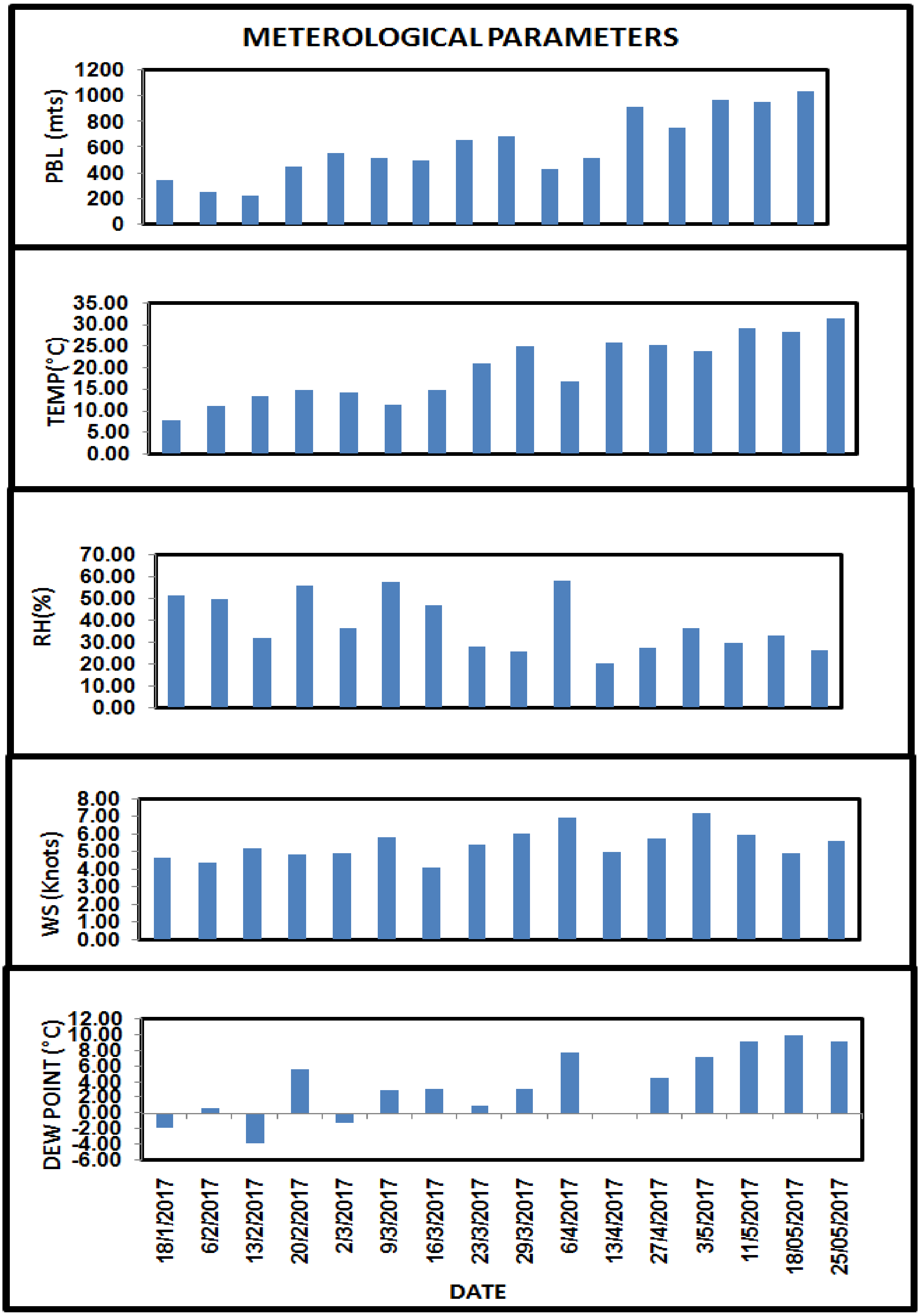


Figure 9: Figure showing the Meteorological Parameters of the corresponding dates.

COMPARISON OF SO_2 CONCENTRATION IN PRESENT SHORT TERM STUDY WITH WORK DONE PREVIOUSLY.

SO_2 estimation in Jammu is done by the State Pollution Control Board (SPCB) of Jammu. For this three monitoring stations are established in the city. These are Station I- SPCB Complex Narwal Station II- M.A.M. Stadium and Station III- Bari Brahmna Industrial Complex. Station I and Station II are residential areas while Station III is an industrial area. The sampling was done according to NAAQS standards. The sampling was done in the months of April and May, 2017 at all the stations. The concentrations were well below the NAAQS standards for each station. In our study also, the concentration of NO_2 is less than the NAAQS standards. The present study was carried out from January, 2017 to May, 2017 while the data given by SPCB is for April, 2017 and May, 2017 only. By comparing our data with the SPCB data it was found that the SO_2 concentration in our study was less than the data calculated by SPCB for the months April and May. The reason might be the heavy traffic and other stationary sources associated with the monitoring stations of SPCB whereas in the site selected for the present study, there is no such heavy traffic and other sources.

Kumar and Kriti, 2016 did a study on ambient air quality status of Jaipur city. Highest concentration of SO_2 was obtained in the month of December (24.2µg/m^3). Captured value of SO_2 may be attributed to congested traffic, garbage burning at nearby highways and residential area. Nilesh et al., 2014 did a comparative study on the ambient air qualities of Chandrapur district. The SO_2 value was from 8µg/m^3 to 61µg/m^3. Ahmad and Bano, 2015 carried out a study to the assessment of ambient air quality of Firozabad city. The highest concentration of SO_2 in the studied area was 24.58µg/m^3.Neelima et al., 2014 did an investigation to analyse the ambient air in Udaipur city and to determine the air quality. It was observed that, in the industrial area, highest sulphur dioxide concentration was found, that is 6.80ug/m^3. A study by Mehraj et al., 2013 was conducted on the health impacts of SO_2 in Kashmir area. The area was close to the cement industry and SO_2 was high about 115.2µg/m^3. Similarly Ede and Edokpa, 2015 studied the air quality of Niger delta and the highest concentration of SO_2 was found in Port Harcourt. Wamoto, 2010 did a study in Nairobi city to check the concentration of SO_2 and found that it was about 181.35µg/m^3 along Nairobi mumbasa road. Mohammed et al., 2013 did a study that aimed at determining concentrations of sulphur dioxide in ambient air of some selected areas such as: high vehicular traffic area (TafawaBalewa Roundabout), industrial area (Kakuri), residential area (Kawo New Extension) and a control site (NFA base) in Kaduna metropolis Nigeria. The highest concentration of SO_2 (0.75µg/m^3) was found in the industrialized area (Kakuri). Lu et al., 2010 studied sulphur dioxide emission in China. In their study, they found that SO_2 emission in China increased by 53 percent from 2000 to 2006 that is from 21.7Tg to 33.2Tg at an annual growth rate of 7.3 percent.The main source of SO_2 in China was thermal power plants. In the present study, the sampling and analysis was done to determine the SO_2 concentration in the Main Campus of Central University of Jammu, Raya Suchani, Bagla in Jammu and Kashmir. The highest concentration of SO_2 found in Location 1 i.e 4.50µg/m^3.

When compared this study with the previous studies, it was found that concentration of SO_2 of the present study was less than the concentration found in the previous studies except the concentration reported by Mohammed et al,. in Kakuri which was 0.75µg/m^3.

TABLE 5: Showing the comparison of previous study with the present study

City	Latitude	Longitude	SO$_2$Concentration (µg/m^3)
Jaipur	26°55′0″N	75°49′0″E	23.2
Chandrapur	19.9705ºN	79.3015ºE	61
Kashmir	33.7782ºN	76.5762ºE	115.2
Firozabad	27°09′N	78°24′E	24.58
Udaipur	24°35′N	74°42′E	6.80
Aliaga	38.7996ºN	26.9707ºE	137
Nairobi	1.2921ºS	36.8219ºE	181.35
Niger Delta	5º1920.40”N	6º28 8.99”E	90
Kakuri	10.46 78ºN	7.45 17ºE	0.75
China	35.86 17ºN	104.19 54ºE	33.27
Jammu (present study)	32°43N	74°56 E	4.50

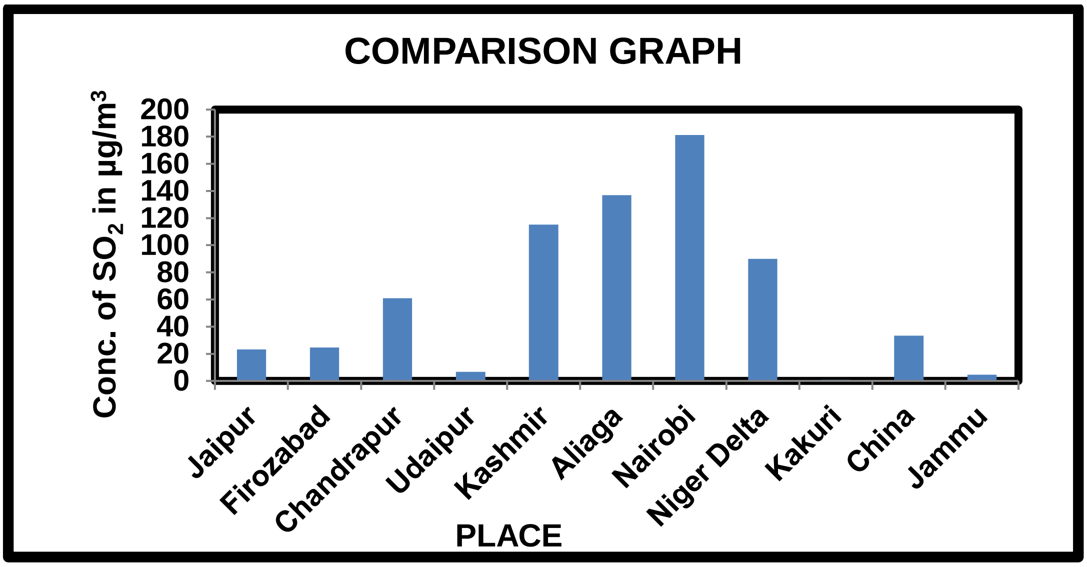


FIGURE 10: Showing the comparison histogram.

CONCLUSION:

Sulphur dioxide (SO_2) is the second most important contributor of air pollutant as it accounts for about 29% of the total weight of all pollutants. It is one of the most common and poisonous air pollutants and is formed when fossil fuels such as coal, gas, and oil are used for power generation; suspended particulate matter (SPM), solid and liquid particles emitted from numerous man-made and natural sources such as industrial dust, volcanic eruption and diesel-powered vehicle. SO_2 is a colourless gas with a pungent and suffocating smell. Major sources of SO_2 include industrial activities such as flaring at oil and gas facilities and diesel power generation, commercial and home heating and vehicle emissions. The amount of SO_2 released is directly related to the sulphur content of the fuel. About 86 percent of the 15 million tons per year of anthropogenic. Only 5 percent of the SO_2 comes from highway vehicles. Petroleum refining, cement manufacturing and copper smelting are the significant non-combustion sources of sulphur emissions. Sulphur dioxide in the atmosphere is converted to sulphuric acid, so that in area with high levels of sulphur dioxide pollution, plants may be damaged by sulphuric acid aerosols. SO_2 lead to smog formation and its result has already been seen in past that lead to death of thousands of people. So looking at the negative effects of SO_2 to human beings and other life forms on earth it is important to monitor the concentration of SO_2 to assess the quality of ambient air. This study involves the continuous monitoring of SO_2 in the Main Campus of Central University of Jammu at Bagla (Raya-Suchani), Distt. Samba. Main objectives of this study are: 1.To understand the national and international status of SO_2 research through review of literature. 2. To determine the concentration of Sulphur Dioxide in Main Campus of Central University of Jammu at Bagla (Raya-Suchani), Distt. Samba. 3.To study the temporal variation in SO_2 concentration during the sampling period. Jammu is located at 32°43N latitude and 74°56 E longitudes. Central University of Jammu is located in Samba district about 25 kms from Jammu City. This University is constructed in the Shivaliks. It covers an area of 600 acres. Samplers were installed at 3 different sites in the University from where samples were collected once in every week. One sampler is installed at the roof top of Engineering Office, second at the roof top of Professor Quarters, while the third at the roof top of Distance Department building.Sampling was done for a period of four and half months from 18th of January to 25th of the May. The sample was collected by using Thermoelectrically cooled Gaseous pollutant sampler Ecotech model AAS118TE. Samples were collected once in every week. The method used for the sampling was Modified West & Gaeke Method (IS 5182 Part 2 Method of Measurement of Air Pollution: Sulphur dioxide. A mixture of mercuric chloride, EDTA, and potassium chloride (30ml) was used as the absorbing reagent which was filled in the impingers. The maximum and minimum concentration of SO_2 was found to be 4.50µg/m^3 and 0.02µg/m^3 respectively over the sampling period both of which were recorded at PQ. At PQ sampling was carried out from 18th of January, 2017 to 25th of May, 2017. A total 18 number of samples were collected from this location and the average value of SO_2 was found to be 2.37µg/m^3. The minimum and maximum values were found to be 0.02µg/m^3 and 4.50µg/m^3 respectively. At XEN the sampling was also carried out from 18th of January, 2017 to 25th of May, 2017. A total 18 number of samples were collected from this location and the average value of SO_2 was found to be 2.64µg/m^3. The minimum and maximum values were found to be 0.86µg/m^3 and 3.96µg/m^3. At DDE the sampling was also carried out from18th of January, 2017 to 25th of May, 2017 and the average value of NO_x was found to be 2.40µg/m^3 respectively. A total 18 number of samples were collected from this location. The minimum and maximum concentrations were found to be 0.08µg/m^3 and 4.38µg/m^3 respectively.. The average values of SO_2 at all the locations were nearly similar. The highest average value was recorded for Professor Quarters (4.50). The concentrations of SO_2 at all the locations were found to be less than the NAAQS and WHO standards. The monthly average was also calculated and it was found that PQ maximum and minimum average value was recorded for the month April and january respectively, for XEN maximum and minimum average value was recorded for the month May and February respectively, for DDE maximum and minimum average value was recorded for the month January and may repectively.

The concentration of air pollutants in ambient air is governed by the meteorological parameters such as atmospheric wind speed, wind direction, relative humidity, and temperature. (https://www.hindawi.com/journals/ijas/2013/264046/). Temperature plays a major role in determining the concentration of air pollutants. During summers when the temperature is high the air parcel near the ground is warmer than the air parcel above it. This is because during summers the surface temperature is high which causes the air parcel near it to become warmer. The warm air parcel rises above while the colder parcel above it sinks down. This results in greater mixing heights and hence effective mixing. Therefore pollutants are mixed up efficiently in the atmosphere which leads to their dilution and hence lesser concentrations. In contrast to this, in winters low temperature results in stable air and mixing depths are low. Vertical air movements are less prominent. Thus the pollutants remain trapped in the surface layers which lead to their higher concentration. Temperature inversions also results in stable air which in turn leads to high concentration of pollutants in the surface layers. Major air pollution episodes such as photochemical smog had occurred during winter seasons. Wind also influences the concentration of SO_2. If the winds are strong, the pollutants are well mixed in the air and are hence diluted. The concentration of pollutants becomes lesser. Light winds cause less turbulence and hence the concentration of pollutants remain high. Therefore air pollution episodes are associated with calm winds rather than strong winds. Relative humidity affects the SO_2 concentration by providing moisture necessary to promote atmospheric chemical reactions. The previous study (Tripathi et.al,2013)s indicated high concentration of SO_2 during winters due to low temperature and low mixing height and vice versa in summers. But in this study the winters were characterized with low concentration and summers with high concentration. The reason might be less sources during winter and more sources during summer.

References:

1. Ahmad, A; and Bano, N; 2015, Ambient Air Quality of Firozabad city-A Spatio-temporal Analysis, *Journal of Global Biosciences*, Volume 4, 1488-1496.
2. Andres,R.J; 2000, A time averaged inventory of subaerial sulphur emission, Prepared for the GEIA, IGA activities Newsletter 22 December 2000.
3. Chaudhary,P; Singh,D; Kumar,J; and Singh,K; 2013, Assessment of ambient air quality in Northern India using Air Quality Index method, Bulletin of Environmental and Scientific Research, Volume 2, 12-17.
4. Ede, P; and Edokpa, D; 2015, Regional Air Quality of the Nigeria's Niger Delta; Open Journal of Air Pollution, Volume 4, 7-15.
5. Forster et al; 2007, Anthropogenic sulfur dioxide emissions: 1850–2005.
6. Girard,J; 2005, Principals of Environmental Chemistry, Jones and Barlett Publishers 40 Tall Pine Drive Subdury, MA 01776.
7. Hudson,T; 2012, Living with Earth- an Introduction to Environmental Geology, published by Pearson Education, Inc., publishing as Pearson Prentice Hall.
8. Lu,Z; Streets,D.G; Zhang,Q; Wang,S; Carmichael,G.R; Cheng,Y.F; Wei,C; Chin,M; Diehl,T; and Tan,Q; 2010, Sulfur dioxide emissions in China and sulfur trends in East Asia since 2000, Atmospheric Chemistry and Physics, Volume 10, 6311-6331.
9. Manahan, Stanley. E; 2001, " Frontmatter" Fundamentals of Environmental Chemistry Boca Raton; CRC Press LLC.
10. Masters,G.M; and Ela,W.P; 2009, Introduction to Environmental Engineering and Science, third edition, published by Pearson Education, Inc., publishing as Pearson Prentice Hall.
11. Mehraj,S.S; Bhat,G.A; Balkhi,H.M; and Gul,T; 2013, Health risks for population living in the neighborhood of a cement factory, African journal of Environmental Science and Technology, Volume 7, 1044-1052.

12. Mehtap, EVCI; 2009, Determination of Ozone, Nitrogen Dioxide and Sulphur Dioxide pollution around Aliga by Passive Sampling, Graduate School of Natural and Applied Sciences of Dokuz Eylul University, pp 1-66.
13. Mohammed,Y; Uzairu,; Ujoh, J.O; 2013, Determination of Sulphur Dioxide Concentrations in Ambient Air of Some Selected Traffic Areas in Kaduna Metropolis, Research Journal of Applied Sciences, Engineering and Technology, Volume 6, 2923-2930.
14. Nandanwar,N.P; Dixit,A.K; Dixit,K.R; and Wazalwar,S.S; 2014, Comparative Study of Ambient Air Quality around Chandrapur, International Journal of Scientific Engineering and Technology, Volume 3, 267-275.
15. Neelima,N; Bamniya, B.R; Mahecha, G.S; and Dhavan, S; 2014, Analysis of Ambient Air Pollution and Determination of Air Quality Status of Udaipur, Rajasthan, International Research Journal of Environmental Sciences, Volume 3, 5-10.
16. Pollution Prevention and Abatement Handbook World Bank Group; Effective July 1998.
17. Sharma, A; and Raina, A.K.; 2012, Ambient Air Quality of Jammu City: A case study with reference to SO_2 and NO_2 contents, International Journal of Environmental Sciences, Volume 3, 650-658.
18. Sharma,S.K; and Sharma,K; 2016, Ambient Air Quality Status of Jaipur city, Rajasthan, India, International Research Journal of Environmental Sciences, Volume 5 , 43-48.
19. U.S.department of health and human services, Public Health Service ,Agency for Toxic Substances and Disease Registry, December 1998.
20. Wamoto, J.M; 2010, Determination of NO_X and SO_2 concentration levels in Nairobi city, Kenya by use of passive samplers.
21. West,P.W., Gaeke,G.C; 1956, ISC method No.42401-01-697, Anal. Chemistry, 28:1816. http://dx.doi.org/10.1021/ac 60120 a005.
22. WHO; 1979, Sulfur Oxides and Suspended Particulate Matter, Environmental Health Criteria World Health Organization, Geneva (available on-line at http://www.inchem.org/documents/ehc/ehc/ehc008.htm).
23. www.cseindia.org/userfiles/managingairpdf.pdf.