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Atmospheric Level of SO_2 in Sokoto Metropolis, Nigeria

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ABSTRACT: The concentration of atmospheric sulphur (IV) oxide in Sokoto Metropolis was determined by sucking air in hydrogen peroxide solution, followed by the photometric determination of the sulphates ion formed. The overall mean concentration obtained (0.270 ± 0.051 mg/m^3) exceeds the recommended WHO daily guideline value of 0.125 mg m^{-3} and maximum annual level of 0.050 mg m^{-3} (WHO 2000).
KEYWORDS: Sulphur (IV) oxide, Atmosphere, Sokoto.

INTRODUCTION

Various chemicals are emitted into the air from natural and man-made (anthropogenic) sources, the quantities ranging from hundreds to millions of tonnes annually. Natural air pollution stems from various biotic and abiotic sources such as plants, radiological decomposition, forest fires, volcanic eruptions and other geothermal sources, emissions from land and seas; leading to natural background concentration that varies according to local sources or specific weather conditions. Anthropogenic air pollution has existed ever since people learnt to use fire, but got a boost when industrialization began. The increase in air pollution as a consequence of the expanding use of fossil energy sources and the growth in the manufacture and use of chemicals has been accompanied by mounting public enlightenment about its effects on health and the environment. Moreover, knowledge of the nature, quantity, physicochemical behaviour and effects of air pollutants generally has increased in recent years.

Fossil-fuel combustions generate sulphur emissions, depending on the chemical composition of the fuel used. USEPA (1982) estimated that 90% of fine particulates emitted from stationary combustion sources are combined with sulphur dioxide (SO_2). Combustion devices may emit particulates comprising products of uncompleted combustion; toxic organics and metals, present in the fuel and in some cases may be carcinogenic.

Severe acute effects of exposure to high concentrations of SO_2 can result in broncho-constriction, bronchitis and tracheitis as seen in animal experiments and in occupational exposures to more than 10000µg/m^3. Concentrations of SO_2 in the range 2.6-27 mg/m^3 give rise to effects with broncho-spasm in asthmatics (WHO, 1987). The effects of concern in relation to short-term exposures are those on respiratory tract. There is variation in the sensitivity to SO_2 exposure among individuals. This is true for normal persons, but especially so if asthmatic patients are included (Holma 1985). Asthmatic patients have labile airways and resistance is likely to change in response to other stimuli, including pollens (WHO, 1979). Repeated short-term occupational exposure to high concentrations of SO_2 combined with long term exposure to lower concentrations can give rise to increased prevalence of chronic bronchitis, especially in cigarette smokers. Several epidemiological studies have been associated with occurrence of pulmonary effects in communities with combined exposure to SO_2 and particulates. Thus, it is difficult to define a lowest- adverse-effect level since the effects appear to be a function of the sensitivity of the subject, concentration, duration of exposure, level of activity and mucus rheological properties.

MATERIALS AND METHODS

Sampling Locations: Sokoto town is located at a latitude of 13^o 03'N and a longitude of 5^o 14'E.

The sampling locations were chosen to reflect the contributions of different sources in the metropolis (ie, vehicular emission, refuse incineration etc). Six locations were chosen within the town and a control location at the permanent site of the Usmanu Danfodiyo University. These locations were the Central Bank roundabout (A 1); Maryam Abacha hospital roundabout (A 2); Federal Government College roundabout (A 3); Illela garage roundabout (A 4); Dandima roundabout (A 5); Kofar Taramniya roundabout (A 6); Usmanu Danfodiyo University permanent site (A 7). Sampling was carried out for nine months from December 2002 to August 2003. In each month, the sample was taken for six hours in any particular location and after about four days, another sample was taken in another location.

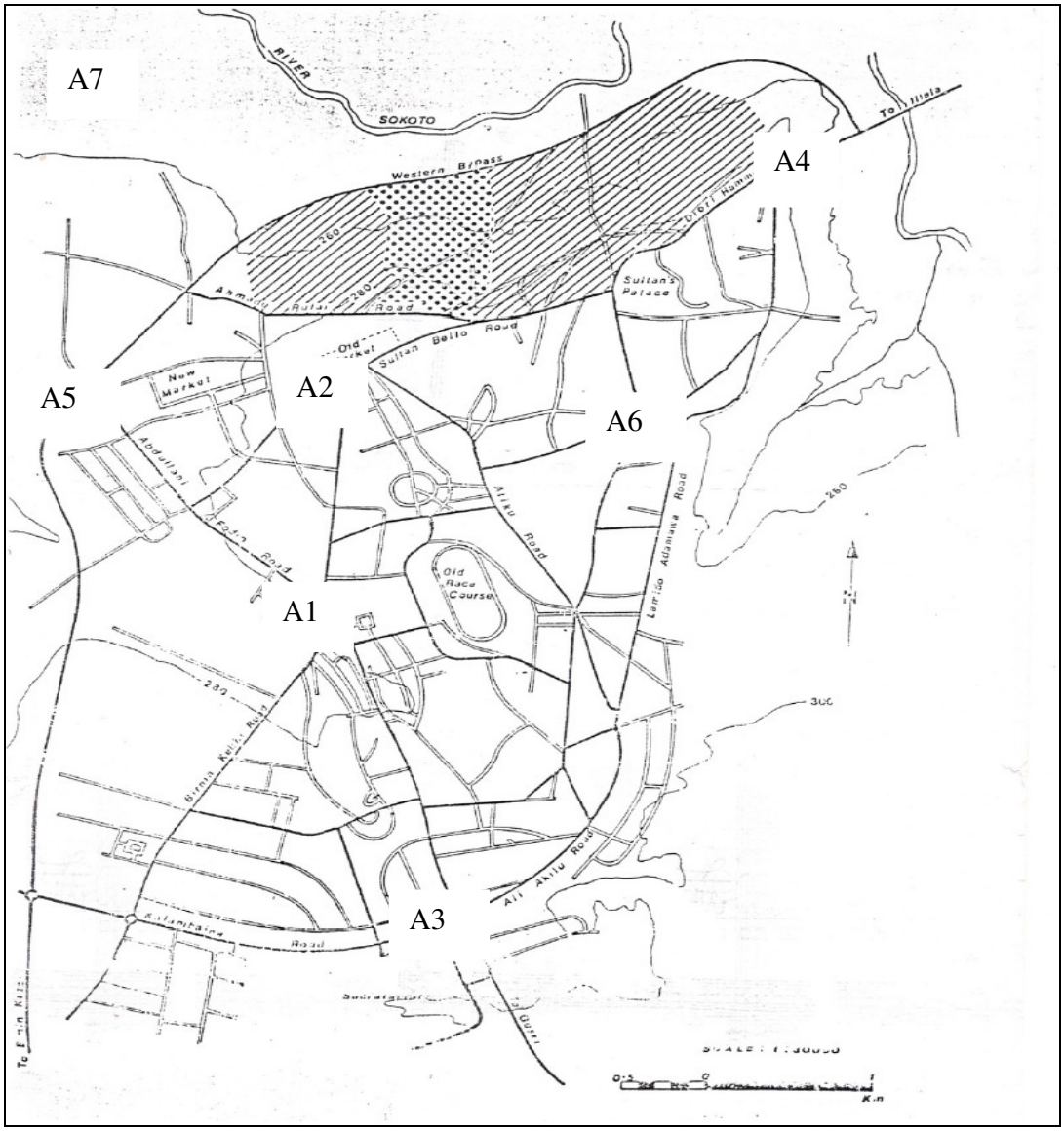

Figure 1: Map of Sokoto Metropolis Showing Sampling Locations

Description of the Sampling Train: The sampling train has four essential elements: (i) a sample line through which the air is sampled; (ii) a device by which the pollutant under study was collected for analysis, (iii) a means to measure the air volume (or flow); and (iv) a pump to suck the air through the system. These

four components were connected together with rubber tubing.

The air was sucked by a pump placed at the end of the sampling assembly at the rate of 7.5 dm^3/min. The air passed through an inverted funnel suspended on a wooden stand (1.5m high). It enters the bottle containing 100 cm^3 of 10% hydrogen peroxide solution where the SO_2 is trapped by reaction with the H_2O_2 to form H_2SO_4 (ie, $SO_{2(g)} + H_2O_{2(l)} = H_2SO_{4(aq)}$). Next was the flow-meter indicating the flow rate of the gases, before leaving the pump. The concentration of the SO^{2-}_4 ion (in mg/dm^3) was determined using a Spectronic spectrophotometer (DR/2010), which is subsequently converted to SO_2 concentration in parts per million (ppm) using the following formula (Harrison and Perry, 1986).

$$SO_2 \text{ (ppm)} = \frac{mg/dm^3\ SO_4^{2-} \text{ x } 0.255 \text{ x Va}}{V}$$

Where Va is the volume of absorbing solution (100 cm^3).

V is the volume of air in litres at 1 atmosphere and 25 ^oC

0.255 is the volume of SO_2 in cm^3 at 1atmosphere and 25^oC Corresponding to 1µg SO^{2-}_4 ion.

To convert the SO_2 concentration in ppm to mg/m^3 (milligram per metre cube)

$$SO_2\ (mg/m^3) = \frac{\text{Conc.in ppm x molar mass}}{24.45}$$

(at 1 atm. and 25^{o}C)

RESULTS AND DISCUSSION

The level of SO_2 in the atmosphere of Sokoto is mostly as a result of fossil fuel combustion. That is why low levels were observed in the windy harmattan season of December, January and February (see fig.1) in all the locations. Beginning from April during the summer period, higher levels were observed in all the locations. This is because of the low wind speed at that period and thus local concentrations can be convected into the atmosphere due to vertical expansion.

The concentration range of 131-352 µg/m^3 was observed during the study period, with the lowest concentration seen in December and the highest in March. Several people have evaluated the level of SO_2 and SO_4 particulates in the atmosphere. Yang et al (2005) have reported a SO_4 concentration range of 11.5 – 24.4 µg/m^3 in Nanjing, China, a level below the findings of this work. Alonso et al (2005) have reported an SO_2 range of 15.5-41.8 µg/m^3 near the Salton sea, California. In a survey conducted by the WHO (1976), an average annual and daily SO_2 mean for many European cities were as follows; Brussels 107 and 347µg/m^3, Frankfurt 119 and 455µg/m^3, London 150 and 503µg/m^3, Madrid 161 and 763µg/m^3, Prague 126 and 482µg/m^3, Rome 108 and 600µg/m^3, Zagreb 173 and 893µg/m^3. The mean annual levels in major cities in Europe are now within the range of 100µg/m^3 (WHO 1979). Similarly, the maximum daily mean values, are now in the range 250-500µg/m^3. Peaks over shorter averaging periods, such as 1hr extend to 1000-2000µg/m^3 and in some situations higher transient peaks may occur. Indoor concentrations of SO_2 are lower than outdoor concentrations, since absorption of SO_2 occurs on walls, furniture, clothes and ventilation systems. An exception is the occupational exposure, where concentrations of several thousand micrograms may occur (WHO 1979). Natural concentrations of SO_2 are normally below 5µg/m^3. The annual mean SO_2 concentrations in most rural areas of Europe are between 5µg/m^3 and 25µg/m^3. Also, the Canadian ministry for the environment (2002) has reported a guideline value of 120µg/m^3 for 24hr sampling period.

Concentrations of sulphur dioxide, higher than those found in urban air, may be present in some industrial environments, arising from processes in which the gas is handled or evolved, as well as from combustion sources. Paper mills, sulphuric acid plants, steel works, nonferrous metal foundries, and oil refineries are among the places where such concentrations may be found. However, emissions are usually localized and intermittent, presenting major problems in

assessing concentrations to which individuals may be exposed.

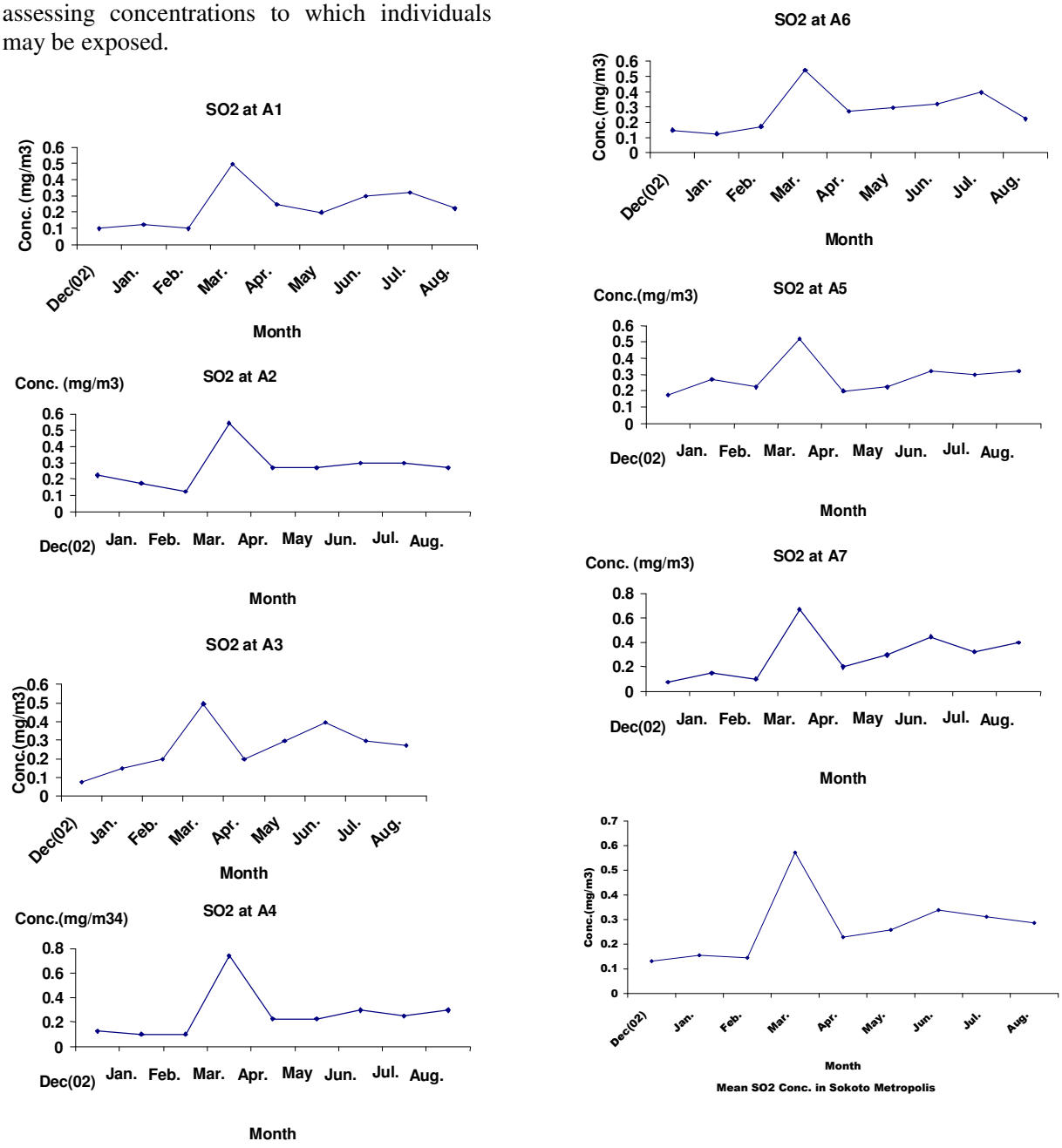

Figure 2: Plots of monthly concentration of sulphur dioxide at the various locations.

CONCLUSION

Finally, it can be concluded that Sokoto atmosphere is not yet polluted with SO_2 considering the levels reported elsewhere. This is not surprising because there are fewer vehicles and industries in Sokoto town compared to those cities reported. However, constant monitoring is very necessary because, that is the only way of knowing when acceptable limit is exceeded.

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