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The Levels of Toxic Gases; Carbon Monoxide, Hydrogen Sulphide and Particulate Matter to Index Pollution in Jos Metropolis, Nigeria

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Abstract The levels of gaseous pollutants; carbon monoxide (CO), hydrogen sulphide (H_2S), and particulate matter (PM) were determined using Electrochemical Sensors and Infra-red based particulometer. The areas under study were some busy roads in Jos, Nigeria including; Ahmadu Bello way, Bauchi road, Tomato market, and some junctions/ terminals; University of Jos gate, Farin Gada and Gada biu. The aim was to assess the extent of vehicular emission in the immediate environment. The result showed that the concentration 0f CO obtained ranged from 6 to 110ppm. The range of H_2S obtained was 1.0 to 3.6ppm, while particulate matter concentrations was in the range of 0.1 to 0.6 mg/m^3. The peak CO concentrations was higher than the maximum tolerable limit of 50ppm with the possible consequences of causing toxicity to man. The particulate matter and H_2S levels are moderate compared to health standards but present an interesting trend for researchers and town planners to observe.

Keywords: *Toxic gases, particulate matter, pollution, vehicular emission, environment*

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1. Introduction

The world population has been on the increase, and more so in recent years. For Nigeria, whose population is currently estimated to be about 140 million people, it is estimated that her population may hit 200 million before the next one decade [1]. The growing population is expectedly accompanied by rapid increase in the number of motor vehicles plying the roads in Nigeria. Combustion of petroleum products in petrol and diesel engines give rise to the release of a variety of gaseous pollutants into the immediate environment. These gaseous pollutants include: Carbon monoxide, oxides of sulphur and nitrogen, water vapor, hydrogen sulphide as well as hydrocarbons that are not burnt [2]. With the importation into the country in recent years, of fuel refined from heavier crude oils, the level of these pollutants released into the environment has been on the increase, particularly in major cities of Nigeria. The effects of these gases on human health have been studied for many years. Of particular concern is the high level of carbon monoxide which is known to cause a wide range of health disorders and even death [3]. Particulate matter on the other hand refers to all atmospheric substances that are not gases. They can be suspended droplets or solid particles, or mixtures of the two. These inert materials do not react with the environment nor do they exhibit any morphologic changes as a result of combustion or any other process, whereas the reacting materials could be further oxidized or may react chemically with the environment. Particulate matter includes dust with particle size 1 – 100μm. Fine dust particles serve as centers of catalysis for many of the chemical reactions taking place in the atmosphere. Other examples of particulate matter in the atmosphere are smoke, fumes, mist, fog and aerosol. The presence of smoke, mist and fumes is common sight on the Plateau. They result from burning of refuse on the road side, industrial activity as well as the very prominent harsh harmattan conditions in the later months to the first two months of each year. Environmental and health agencies have published excellent reviews of how exposure to these pollutants impact human health. According to the United States Environment Protection agency (U.S. EPA): "many scientific studies have linked breathing particulate matter to a series of significant health problems, including: aggravated asthma, increases in respiratory symptoms like coughing and difficulty or painful breathing, chronic bronchitis, decreased lung function, and premature death." [4].

Of particular concern is the effect of carbon monoxide, CO, on the teeming Nigerian populace. Carbon monoxide, CO, constitute the single largest pollutant in the urban atmosphere which results from inefficient combustion systems of petrol and diesel engines [5]. It has a strong

affinity towards the hemoglobin of the bloodstream. Exposure to small amounts of CO causes headache, dizziness and general discomfort. Continuous exposure to large concentrations of this gas (above 50 ppm) can result in death within minutes to one hour [6].

2. Experimental

Electrochemical sensors referred to as Gasman equipment manufactured by Crowcon were used for measurement of gas concentrations. The equipment was supplied by the Ministry of Environment and Minerals Development, Plateau State. The electrochemical sensing element is constructed from a sensing electrode, a reference electrode, and a counter electrode. Gas is made to diffuse into the sensor where it reacts with the special catalyzed sensing electrode. The electrochemical reactions produce current (μA) which is linearly proportional to the concentration of gas in air.

The gas sensor, powered by DC batteries, was assembled and then calibrated using the standard samples of each gas supplied along with the equipment as described in the instruction manual [7]. After calibration, the equipment was moved to the sampling sites and positioned to detect air pollutants in the direction of the prevailing wind at each location as suggested and described in the user's manual. All measurements were made between the first four hours of each working day. The gas concentrations were read and recorded in parts per million.

Particulate matter (of size range 0.1-50μm only) was measured using particulate monitor manufactured by Environmental Devices Corp., USA. The equipment which utilizes infrared rays for detection was calibrated by exposing the sensor to clean air in a clean enclosed room and setting the digital reading to zero. Measurements were then taken directly in mg/m^3 at each location.

3. Area Covered for the Tests

Figure 1 shows the part of Jos, Nigeria and environs covered in the work.

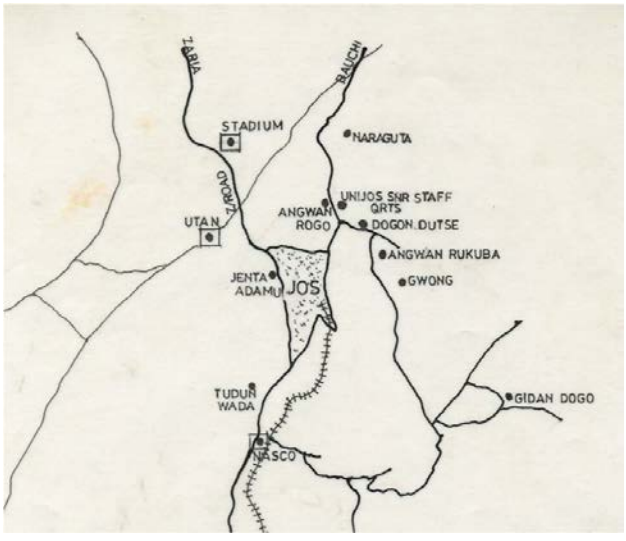

Figure 1. Street map of Jos-Bukuru, Plateau state of Nigeria

4. Results and Discussion

The pollution levels measured during four separate months covering both dry and rainy seasons of November 2006 to August 2007 are presented below in Figure 2 to Figure 8.

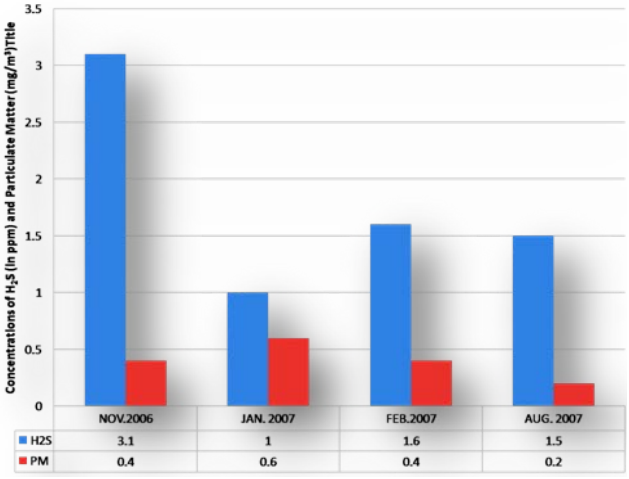

Figure 2. Peak concentrations of H_2S (in ppm) and Particulate Matter (mg/m^3) at Terminus, Jos

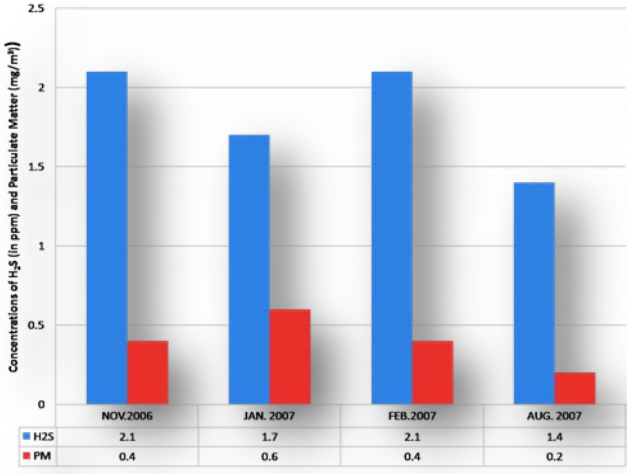

Figure 3. Peak concentrations of H_2S (in ppm) and Particulate Matter (mg/m^3) at Dilimi Junction, Jos

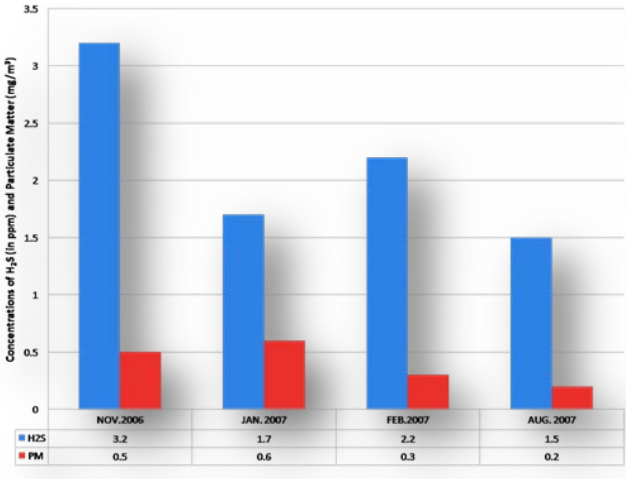

Figure 4. Peak concentrations of H_2S (in ppm) and Particulate Matter (mg/m^3) at Bauchi Road motor Park, Jos

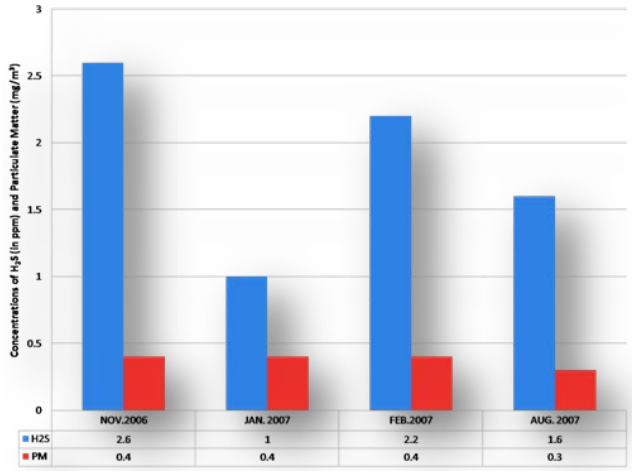

Figure 5. Peak concentrations of H_2S (in ppm) and Particulate Matter (mg/m^3) at Tomato Market, Farin Gada, Jos

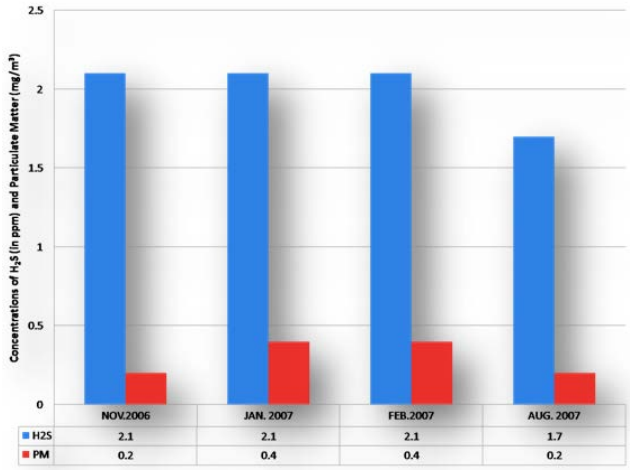

Figure 6. Peak concentrations of H_2S (in ppm) and Particulate Matter (mg/m^3) at Gada Biu/ Polo Roundabout, Jos

From the results above, it could generally be observed that for most of the locations, H_2S and particulate matter are present in levels that are within acceptable limits as stated by various environmental/ health organizations and regulating bodies. However, the CO concentrations in several locations exceeded the acceptable limits set by regulating bodies. For instance, the CO level observed each week at Polo roundabout/ Gada biu, Terminus area, Dilimi junction, Bauchi Motor Park and Tomato market at Farin Gada are rather high and worrisome. These spots are accompanied, not only with constantly high traffic, but also with high traffic jam. Indeed, all the results indicate that, the high pollution levels recorded are more as a result of slow moving traffic, rather than high traffic alone. While WHO sets the half hour limit of 48 ppm for CO concentrations, the then Federal Protection Agency of Nigeria (now Federal Ministry of Environment) put the half hour limit at 20 ppm. With these, the CO levels observed in most of the areas covered reaches and actually exceeds the limits. Levels recorded for particulate matter within the size range of 0.1 to 50 µm are moderate in almost all cases with Abattoir (0.6 mg/m^3), where a lot of burning activities takes place, having one of the highest recorded values.

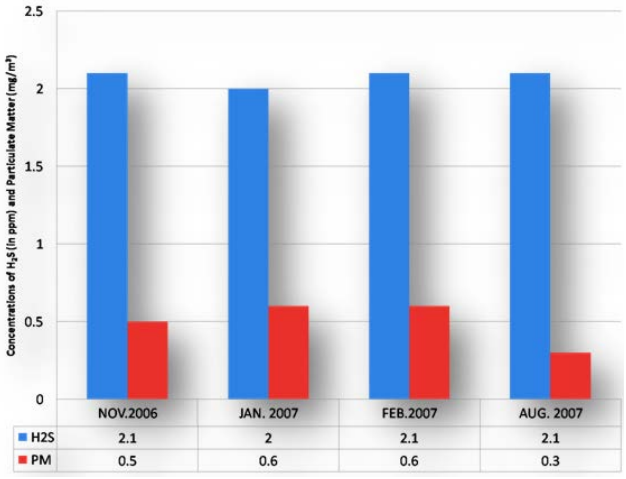

Figure 7. Peak concentrations of H_2S (in ppm) and Particulate Matter (mg/m^3) at Abattoir, Jos

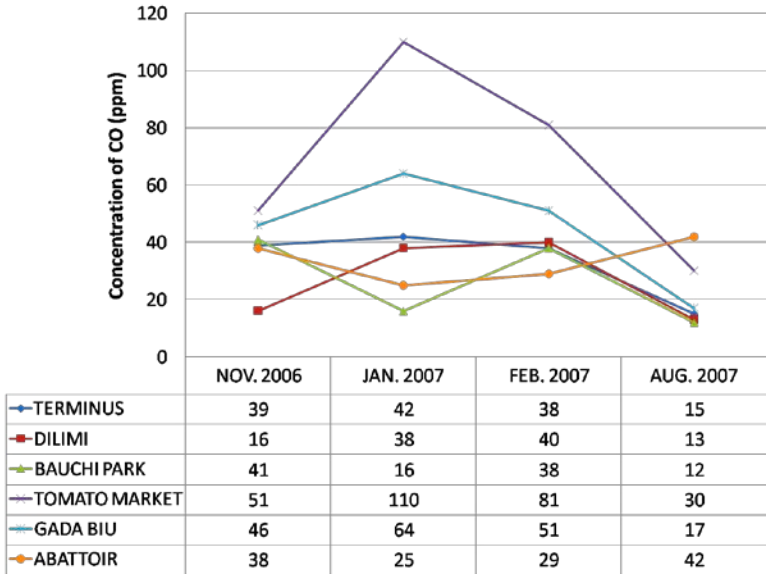

Figure 8. Peak concentrations of CO (in ppm) at different locations

The rainy season results (August 2007), as expected; indicate generally low levels of each of the gaseous pollutants and particulate matter. This is due to the fact that during rainfall, the gases are washed into rain water. This explains why urban air is fresher after rainfall or generally during rainy seasons.

5. Conclusions

The results presented in this paper indicate that there is gross atmospheric pollution along the main streets of Jos due to vehicular traffic. The CO levels particularly points to the fact that many vehicles on Nigerian roads are not road worthy due to lack of proper optimal tuning for combustion efficiency. Many are too old to be on the roads. Residents and commuters in Jos, and indeed of several, if not all major Nigerian cities, who do their businesses or live along major roads are at risk. Most of such people are exposed to vehicular pollution for several hours every day. The levels of other pollutants like H_2S are usually universal. They are often detected at moderate levels far away from the emission source and the levels may remain constant over a wide area from the source as the results in this work also suggests. Generally, whereby it could be stated that the levels of these pollutants studied in this work are not extremely alarming, Nigerians will be safer if government agencies rise up to the challenge and plan for the near future.

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