International Journal of Physical Sciences Vol. 5(4), pp. 283-286, April 2010
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 © 2010 Academic Journals

Full Length Research Paper

Air aerosol metal constituent and concentration at Okigwe, Nigeria

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Accepted 20 January, 2010

Atomic absorption spectroscopy (AAS) was used to determine the aerosol metal constituent and elemental concentration for 11 elements in air at Okigwe (Lat. 5.40°N, 6.30°N and Long. 7.05°E, 7.35°E) during the 2007/2008 harmattan. The dust sample was collected by direct deposition method under gravity on a Whatmann filter paper. The dust sample was collected for a period of 24 h per day for a total of 30 days starting from February 4 - March 5, 2008. The mass and mass concentrations obtained are 0.0510 g and 8.02 × 10^{-4} g/cm^2 respectively. The elemental constituent and concentration in mg/kg obtained during the period are 9666.67 for calcium (Ca), 2059.80 for potassium (K), 1396.08 for magnesium (Mg), 8678.43 for Iron (Fe), 20.59 for zinc (Zn), 69.61 for manganese (Mn), 94.16 for copper (Cu), 200.96 for nickel (Ni), 190.20 for chromium (Cr), 8.82 for cadmium (Cd), and 4.90 for lead (Pb). A comparison of reported results from Uturu Abia State Nigeria (05.33°N, 06.03°N, and 07.10°E, 07.29°E) and that obtained at Okigwe, Nigeria showed some differences in the concentrations and this is explained in terms of the latitudinal locations of the stations with respect to the aerosol source.

Key words: Aerosol metal constituent, concentration, atomic absorption spectroscopy (AAS).

INTRODUCTION

Sjaak (2007), opined that aerosols are small particles suspended in air with a lifetime of at least minutes, and are either emitted as primary aerosols or formed by the conversion of sulphur dioxide, nitrogen oxides, ammonia and organic compounds in atmospheric chemical reactions to sulphates, nitrates, and ammonium compounds, and non-volatile organic compounds. Chiemeka (2006) observed that the rationale for measuring pollutants includes the following (i) for developing scientific hypotheses (ii) Monitoring for trends (iii) To ascertain the level of human health effects and ecosystem damage as input to environmental decision making.

Deposition of ammonium, sulphate, and nitrate in aerosols contribute immensely to acid depositions and damage to ecosystem due to a large input of nutrients such as nitrate. Chiemeka (2007) observed that aerosols greatly damage fruits, vegetables, trees and ornamental flowers. Polluted air is a threat to living things, status and metal structures. Some of the oldest and most glorious buildings of the world are being degraded by air pollution. Mineral dust aerosols are notably drawn earth ward by gravity along their transport paths and so are deposited to lands and oceans where they provide iron and other micro nutrients to terrestrial and marine ecosystem.

Aerosols have a large impact on human health. Aerosol increase the mortality rate due to cardio-pulmonary diseases (heart and lung diseases including asthma and bronchitis). The smallest aerosols are small enough to get into human respiratory system. The elements especially manganese helps to ease symptoms associated with menstrual period, maintaining strong bones, and cause impotence in men. Getting adequate amounts of manganese may also be important with other diseases such as epilepsy, diabetes and rheumatoid arthritis. Excessive intake of manganese alters the blood-brain barrier, which is great health effect. Symptoms of manganese poisoning are hallucination, forgetfulness and nerve damage (John, 1999). Chiemeka (2006) noted that aerosols caused a measurable stratospheric temperature rise and a drop in the direct solar beam at the Earth's surface. One of the global effects of aerosols is to cool the planet by reflecting back to space part of the incoming solar radiation. Surabi (2002) observed that absorbing aerosols heat the air, alter regional atmospheric stability and vertical motions and effect the large-scale circulation and hydrological cycle with significant regional climate effects. Jasper (2006), opined that mineral dust particles influence Earth's climate by

absorbing and scattering radiation and by serving as nuclei for cloud formation. Chineke (2006) observed that aerosols are characterized by low relative humidity, degradation of visibility, depletion of solar radiation, and attenuation of radio signals.

According to Oleka (2007), most parts of West Africa, during the months of November to subsequent year's February, the atmosphere is loaded with a dry dusty air having a high concentration of fine dust particle whose origin is the Sahara Desert and blown to this part of the world (Okigwe) by the cold North East Trade winds locally called harmattan. Aerosols originate both from anthropogenic (man made) and natural sources. Aerosol concentration depends largely on air distribution and relative location to the aerosol sources (Brockmann, 1993). The determination of the aerosol mass, mass concentration, metal constituent and elemental concentration at Okigwe is of interest from the stand point of environmental impacts and potential health effects. The concentrations of eleven elements (Ca, K, Mg, Fe, Zn, Mn, Cu, Ni, Cr, Cd, and Pb) were determined by analyzing the deposited dust that is collected during an average of 30 days sampling period using Atomic Absorption Spectroscopy (AAS). The choice of the metals was based on their prevalence in the atmosphere and the ability of AAS to detect and locate them.

Theoretical background

Atomic Absorption Spectroscopy (AAS) work on the principle that the amount of energy absorbed in flame is proportional to the concentration of the element in the sample, since each element has its own characteristics absorption wave length. When dealing with substance in solution, it is found that the measured extinction coefficient is proportional to the concentration, δ, of the absorbing substance and hence according to Chiemeka (2007) we write

$$\mu = K \delta \quad (1)$$

Where μ is the linear extinction coefficient and K is the extinction coefficient per unit concentration.
The determination of the elemental composition of air has been carried out at Uturu, Abia State (Chiemeka, 2007). The mean of the elemental concentrations in mg/kg obtained as revealed by AAS for the period of sampling were reported as 5.071 for potassium (K), 2.600 for magnesium (Mg), 102.765 for calcium (Ca), 14.859 for iron (Fe), 25.130 for zinc (Zn), 4.012 for manganese (Mn) and 1.023 for lead (Pd). The conversion of the concentration in mg/l to mg/kg is achieved using the relation

$$\text{Mg/kg} = \frac{\text{Reading (mg/l) x 50 ml}}{\text{Weight of dust (g)}} \quad (2)$$

MATERIALS AND MEASUREMENT PROCEDURE

Okigwe is the headquarters of the Okigwe Local Government Area (L.G.A.) in Imo State. In comparison with other parts of Imo State, Okigwe is located in a relatively high terrain rising 130 - 200 m above sea level. Okigwe is bounded by Isuikwuato L.G.A in East, Umuahia in the South, Ideato North and South L.G.As in the North and West. Okigwe experiences high annual rainfall of about 1500 mm. The region however witnesses a dry period around November to March, while the rain period usually with it's peaks regime in June and September, beginning in April and lasts till October. The region has a high temperature of about 27°C. The mean monthly maximum air temperature ranges from 28 - 35°C with annual mean monthly air temperature range of 17 - 24°C. The hilly nature of Okigwe forms obstacles in the path of air stream. Okigwe is an undulating land with large number of residual hills. The vegetation type of Okigwe consists mainly of mixed formation of grass and shrubs on the crest of the hills and upper slope as well as trees and shrubs forest on the basal slopes, and plains all in various stages of succession. The surrounding communities are characterized by less dense vegetation of tall trees, shrubs, and palm trees.

The dust sample was collected on a Whatmann filter paper by direct deposition under gravity. The filter paper initially weighed empty was placed inside a plastic jug and raised to the top base of an uncompleted storey building of height 3.0 m. The collected dust sample was initially preserved by placing a lid over it in a plastic jug. The dust sample was digested to dissociate and to dissolve the elemental constituent. The sample was digested by wet ash method over a low heat (supplied by a hot plate) using 10 ml concentrated nitric acid (HNO_3), 5 ml perchloric acid ($HCLO_4$) to ensure complete digestion. The digested sample when cold was diluted with deionized water and filtered into a 50 ml volumetric flask and make up to volume with deionized water. Filtration is necessary so as to remove silicate and other insoluble materials that could clog the atomizer.

RESULTS AND DISCUSSION

The mass, mass concentration obtained and elemental constituent and concentrations in mg/l as revealed by AAS and in mg/kg is as shown in Table 1.

It is important to determine quantitatively the mass of metal element in mg that is present per kg (1000g) of dust sample. This gives a better understanding of the concentration of metal element in solid per kg since the aerosols are solid particles. A look at table 1 shows that the concentration levels of Ca, K, Mg, and Fe are quite significant and yet below the deleterious level on comparison with the acceptable levels. A comparison of the result obtained at Okigwe with the acceptable levels in air stipulated by WHO (2000), FEPA (1991), and Arizona Ambient Air Quality Guideline (AAAQ, 1999) showed that the concentration of these elements in air are generally below the acceptable limits and hence the air quality at Okigwe is clean relative to these elements. The only exception being that of Manganese which is 139% higher in concentration when compared with the acceptable level and hence the air quality at Okigwe is not clean relative to manganese. Man made pollution emissions from industries, and chemical and physical weathering of rocks at Okigwe may have injected these elements into the atmosphere.

Table 1. Elemental constituent and concentrations as revealed by AAS.

Mass of dust deposited	**0.0510 g**	
Mass concentration	**8.02×10^{-4} g/cm^2**	
Element	**Concentration (mg/l)**	**Concentration (mg/kg)**
Ca	9.86	9666.67
K	2.101	2059.80
Mg	1.424	1396.08
Fe	8.852	8678.43
Zn	0.021	20.59
Mn	0.071	69.61
Cu	0.094	94.16
Ni	0.205	200.96
Cr	0.194	190.20
Cd	0.009	8.82
Pb	0.005	4.90

Error = ± 0.001 mg/l.

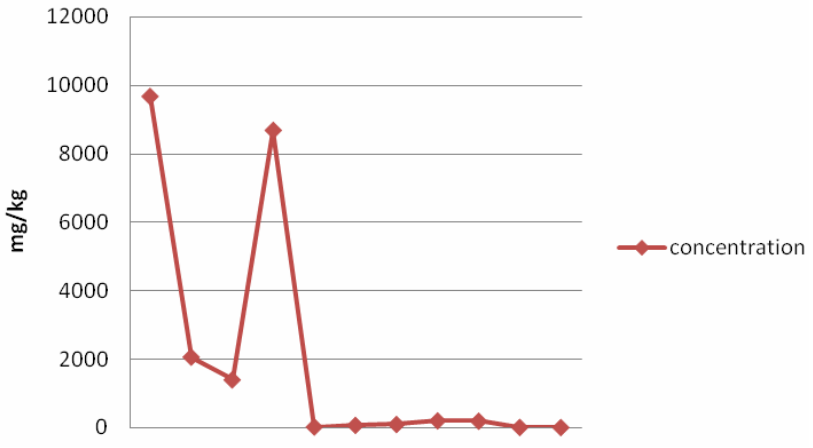

Figure 1. Concentration and elemental constituent at Okigwe.

A comparison of the reported result by Chiemeka (2007) obtained at Uturu for Ca, K, Mg, Fe, Zn, Mn, and Pb and that obtained at Okigwe showed that the concentration of these elements in air at Okigwe are generally higher than that obtained at Uturu. The only exception being that of Zinc, for which the concentration at Uturu is 22.1% higher than that obtained at Okigwe. The graph of concentration and the elemental constituent is as shown in Figure 1.

Conclusion

Atomic Absorption Spectroscopy (AAS) was used to determine the aerosol mental constituent and elemental concentration for 11 elements in air at Okigwe during the 2007/2008 harmattan. The dust sample was collected by direct deposition method under gravity on a Whatmann filter paper. The dust sample was collected for a period of 24 h per day for a total of 30 days starting from February4 - March 5, 2008. The mass concentration of the collected particulates per unit surface area of the filter paper was determined by calculation. The mass and mass concentrations obtained are 0.0510 g and 8.02 x 10^{-4} g/cm^2 respectively. The elemental constituent and concentration in mg/kg obtained during the period are 9666.67 for Calcium (Ca), 2059.80 for Potassium (K), 1396.08 for Magnesium (Mg), 8678.43 for Iron (Fe), 20.59 for Zinc (Zn), 69.61 for Manganese (Mn), 94.16 for Copper (Cu), 200.96 for Nickel (Ni), 190.20 for Chromium (Cr), 8.82 for Cadmium (Cd), and 4.90 for Lead (Pb). A comparison of reported results from Uturu Abia State Nigeria (05.33°N, 06.03°N, and 07.10°E, 07.29°E) and that obtained at Okigwe, Nigeria showed some differences in the concentrations and this is explained in terms of the Latitudinal locations of the stations with

respect to the aerosol source.

These elements are capable of reducing visibility due to reduction in solar radiation, increase or decrease albedo and lead to atmospheric heating if they absorb radiation and may bring about cooling effect in the Earth if there is back scattering of light by particulates into space. In order to understand these optical effects, it is necessary to know the constituent of the aerosols and their sizes, as these characteristics determine the scattering and absorption properties. These elements and atmospheric gases can interact and react to form new particles or to modify existing ones by homogenous, homo molecular nucleation or homogenous, hetero molecular nucleation. For these elements to pose a significant health risk relies on their ability to get into the human respiratory system.

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