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Assessment of Heavy Metals Concentration of Particulate Matters (PM) around Metal Recycling Industrial Areas in IFE, South-Western Nigeria

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Assessment of Heavy Metals Concentration of Particulate Matters (PM) around Metal Recycling Industrial Areas in IFE, South-Western Nigeria

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Abstract- Assessment of heavy metals concentration of Particulate Matters (PM) was carried out around metal recycling areas of Ife, south-western Nigeria in other to provide information on the rate of contamination/pollution caused by the atmospheric PM particles from the iron and steel industries in the area. Twelve (12) particulate matter samples were collected, prepared, and analyzed using Inductively Coupled Plasma Atomic Emission Spectrometry (ICPAES) respectively. Interpretation of the analyzed results were carried out for their metal contents and environmental assessments.

Elemental composition analyses carried out on the PM samples showed that the mean concentrations of the elements are Mo 0.2±0.1ppm, Cu 6.4±3.3ppm, Pb 35.3±44.3ppm, Zn 169.3±162.3ppm, Ni 1.97±1.22ppm, Co 0.2±0.1ppm, Mn 28.6±18.6ppm, V 0.4±0.08ppm, Sr 1.28±0.5ppm, Cr 6.4±3.3ppm and Ba 6.2±3.4ppm. For the PM suspended in the atmosphere around the area, Zinc has the highest concentration (471ppm) and mean value of 169.25. Further geochemical evaluation of the metals using Enrichment Factor, Contamination Factor, and Pollution Load Index, revealed the significant concentration of Zn and Pb in the PM samples from the study area while the other elements are minimal. The Contamination Factor calculated showed that Zn, Pb and Ba are the elements contaminating the suspended PM mostly. They show moderate contamination of the PM (2.0, 2.0, and 1.0 respectively). The Enrichment Factor calculated also showed significant enrichment of Pb and Zn in the PM samples analyzed (0-8 and 0-5 respectively). The Pollution Load Index (PLI) showed that atmosphere of the study area, where the PM is concentrated is not highly polluted (PLI<1) but highly contaminated.

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I. Introduction

Heavy metals are any metallic chemical elements that have relatively high densities and are toxic or poisonous at low concentrations. They are metals and metalloids having a specific gravity that is five times that of water (Semhi *et al.,* 2010). Their toxicity causes an increasing degree of contamination and pollution to any matter. The natural sources of heavy metals in soils are being influenced by the parent materials, the chemical and physical soil properties, weathering, the metal speciation, and the climatic conditions. The mineral content of the parent materials is one of the most essential factors for the amount of trace metals present in the atmosphere as aerosols, (Burt *et al.,* 2003). This function leads to a negative effect on human health and on all living organisms.

Particulate Matter (PM) in the air includes a mixture of solids and liquid droplets. Some particles are emitted directly while others are formed in the atmosphere when other pollutants react. Particles come in a wide range of sizes. The particles of 2.5 micrometers (or less) in diameter are called 'fine' particles. Those between 2.5 and 10 microns (PM10) are called 'coarse' particle. Ten-micrometer particles are smaller than the width of a single human hair (Ole Raaschou-Nielsen et al. 2013).

Atmospheric Particulate Matter plays an important, but detrimental, role in everyday life and influences several atmospheric processes (Othmar, 1996). PM typically comprises a complex mixture of different elements and compounds (Dallarosa*et al*., 2008). Dust containing heavy metals is dispersed globally by atmospheric circulation and becomes a minor but potent component of sediment, soils, and the hydrosphere with a major impact on Earth ecosystems (Petrovský and Ellwood, 1999). Heavy metals can be readily detected to frame policies for reducing emissions and monitoring their long-term effectiveness (Xia et al., 2008;Sagnottiet*et al*., 2009). The methods for monitoring emissions of PM are multidisciplinary which include geochemical, mineralogical, and microstructural. PM is emitted both from natural and artificial sources (Choi et al., 2001; Fang et al., 2002; Zhang et al., 2010b) which has brought a challenge into investigations on how to separate contributions from the two primary causes. In urban areas the diversity of possible anthropogenic emissions renders source assignation difficult (Choi *et al.,* 2001; Kim *et al*., 2008; Zhang *et al.,* 2012b). Although many investigations show that geochemical methods are useful for detecting PM sources (Wang et al., 2005: Kim *et al.,* 2007).

II. Methodology

Materials used for field sampling include the vacuum sampler, generator, filter papers, Global Positioning System (GPS), stepdown transformer, field boots and notebooks, measurable foils, sample bags, elbow-length gloves, e.t.c. The field research took place in November, which is the tail end month of the rainy

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season at Ife axis. Hence, the effects of rain affecting the collection of particulate dust samples were reduced. The sample locations were concentrated mainly on Iron and steel industries.

Collection of the PM samples was done with the aid of a filter paper and a vacuum sampler. The sampler was placed 200m away before and after each industry. Because the exhausts of the industries are placed high above the ground, the sampler was left for four hours to allow the suspended PM dust particles coming out from the industrial exhaust to settle on the filter paper. After four hours, the sampler was switched off, and the filter was immediately removed from the supporting screen, folded and then placed in a measurable foil. The vacuum sampler was moved to other locations still within the environment of the industries of concentration. A total of 27 particulate dust samples were collected on the filter papers out of which the best 12 were selected and analyzed for elemental constituents.

III. Results and Discussion

The results of the analysis for the PM samples revealed varying concentrations for different trace metals in the sampled medium employed in the study. The identified trace element content of the analyzed particulate matter dust samples include Cr, Cu, Pb, Zn, Ba, Co, Mn, V, Sr, Mo, and Ni.

From the descriptive statistical table (Table 1), it was observed that the zinc concentration (471ppm) suspended in the PM of the atmosphere in one of the industries of study area is high when compared with the Average Shale Content (ASC) of Zn (90), and the PM concentrates of Lagos lagoon which has a range concentrate of 4.7-47.5ppm (Popoola et al., 2014). The high concentration of Zn displayed can be said to be due to Zn usage in galvanizing iron, thereby forming particulate matter with the geogenic atmospheric particles present in the area. The peak concentration of lead (160ppm) suspended in the PM of the atmosphere in one of the industries of the study area is also high when compared with the ASC of Pb (20) and the Pb concentration of Warri PM which is 1.02ppm (Okuo et al., 2006). The copper concentrates present in the particulate matter (with the highest quantity of 11ppm) are insignificant when compared to the Average Shale Content (ASC) of Cu (50). They are still higher than the Cu concentrates of Ikeja town which has a concentration of 1.36ppm (Oluyemi and Asubiojo*.,* 2001). The highest quantity of Mn in the particulate matter samples is 60ppm, and this is insignificant when compared with the ASC of Mn (850ppm) but is also higher than the concentrates of Warri and Lagos which have concentrations of 0.01ppm and 5.0-20.0ppm respectively (Popoola *et al*., 2014, Okuo *et al*., 2006).

The concentrations of Cobalt (Co), Chromium (Cr), Molybdenum (Mo), Vanadium (V), Strontium (Sr) and Nickel (Ni)are lesser than their various ASC in the particulate matter samples. This indicates little or no significance of the distribution of these metals in the study area.

Table 1: Summary Table for Particulate Matter Metal

Concentration

Factor Analysis

The Factor Analysis was used for data reduction of the number of variables into one of considerably fewer linear combinations variables that account for the proportion of the total data variance and which can often be more readily related to recognizable geological and environmental processes than the input variables themselves (Olatunji and Olisa, 2014). Factor analysis finds a suitable application in geochemical interpretation, and it can be used to identify the source of contamination.

In the Particulate Matter (PM) particles, 11 elements (Cu, Mo, Zn, Pb, Ni, Mn, Co, V, Sr, Cr, Ba) were placed on R-mode factor analysis; the computation was done using SPSS computer software package. Identification of three components was done from the factor analysis, and these accounted for 95.15% in the suspended dust particulate samples (Table 3).

Factor 1: Cu, Mo, Zn, Ni, Co, Sr, Cr, Ba accounted for 55.84% of the total variance of the three components present in the dust particles. These can be said to be derived mainly from atmospheric deposition forming PM deposits from alloying materials; vehicular emissions; incineration of waste dumps.

Factor 2: Pb, Mn, V, Sr accounted for 29.05% of the total variance of components present in the dust particles. These can be said to be derived from the extraction of metals, vehicular emissions, wear and tear of old vehicle parts and combustion of fuels which forms has PM particles in the atmosphere.

Factor 3: Zn and Co accounted for 10.26% of the total variance of components present in the dust particles. It is derived from the electroplating emissions, and emissions from metal refuse in the industries which also form PM with the already present natural atmospheric particles.

Environmental Assessment

Enrichment Factor (EF), Contamination Factor (CF), and Pollution Load Index (PLI) were used to assess the quality of the study area.

Enrichment Factor

The Enrichment Factor (EF) classification (Table 4) was used to evaluate the status of environmental enrichment of metals present as PM in the area.

Table 4: Enrichment Factor Classification(Simex and Helz, 1981)

For the PM samples, the calculated enrichment factor (Table 5) shows that only Pb and Zn have moderate to significant enrichment (0-8 and 0-5 respectively) and this could be due to the gaseous emissions (smelting of recycled lead and galvanizing process) that are released from the factories.

Table 5 Summary Table for Enrichment Factor of Particulate Matter Samples

Contamination Factor

The level of contaminations of heavy metals in the PM samples analysed was determined using the contamination factor calculation. It is shown as;

Contamination Factor = Mean concentration/ background value of metal (Hakanson *et al*.,1980)

The classification table (table 6) showed that Sr, Co, Ni, Cr, Mo, V, Mn, and Cu are not forming any form of contamination with the atmosphere of the area while Ba, Pb, and Zn have moderately contaminated the atmosphere of the study area with a CF of 1, 2 and 2 respectively (table 7)

Table 6 Contamination Factor Classification

Table 7 Summary Table of Contamination Factor for Particulate Matter Samples

Pollution Load Index (PLI)

PLI was used to measure the pollution status of the study area. The composite PM samples were analyzed, and the quality is measured using the Contamination Factor, and the number of heavy metals studied. The equation for PLI is shown as;

PLI = (CF1*CF2*…*CFn) 1/n, where n is the number ofmetals and CF is the Contamination Factor of PM samples.

Table 8 Pollution Load Index Classification

Using the PLI classification (Table 8), it is shown that individual PM samples shows no pollution in the area of study, consequently the atmosphere has not attained a noticeable status of pollution (calculated PLI=0).

IV. Conclusion And Recommendation

Metal concentration and distribution in Particulate Matters (PM) of Ife metal recycling industrial area using various environmental assessment revealed different levels of contamination in the dust samples analyzed. The assessed evaluation revealed that Pb and Zn are the most enriched in the PM and are also the major causes of contamination in the study area and their principal source is from the metal-laden PM generated in the area. The industries are agents of high contamination to the $_{154}$ atmosphere of the study area and are also enriching the already present geogenic heavy metal composition of the environment.

Although, PLI shows zero (0) indicating no pollution of the atmosphere, increasing urbanization and industrial activities will increase the contamination rate, thereby leading to pollution. The enrichment and contamination of metals, especially Pb and Zn, (through particulate matters) occurring in the study area are enough factor to check the daily activities of these iron and steel industries. Consequently, greater environmental awareness is needed to develop ways to reduce environmental contamination of the study area. The industries and buildings in the study area should have a greater distance in between them. This will reduce the effect of the industrial activities on the habitants and their environments

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