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Original Article

A comparative assessment of heavy metal pollutants in plants from industrial, urban, and rural areas in Awka, Nigeria

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ABSTRACT

Plants are essential and valuable resources which provide food, fiber, medicine, and all other basic requirements needed by humans. Contamination of plants by heavy metals poses a great threat to human health when ingested. Heavy metal pollutants are probably the most harmful and insidious contaminants, due to their biological non-biodegradable nature and their potential to cause adverse effects at certain levels of exposure and absorption even in their lowest form. Most of these metals represent a portion of important environmental pollutants which accumulate in soil, air, and plants. The aim of this study was to compare the levels of heavy metals in plants in industrial, urban, and rural areas using atomic absorption spectrophotometry.

Keywords: Areas, atomic absorption spectrophotometry, contamination, heavy metal, non-biodegradable, plants, pollutants, resources

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INTRODUCTION

Recently, researchers and environmentalists' attention have been drawn to the effects of heavy metals in air, soil, plants, and finally, the food chain.[1] Plants have been shown as the primary source of heavy metal in human diet.[2] Heavy metals are widely found in nature, particularly in various mineral deposits and soils, and are available to be taken up by plants and animals that serve as food sources for humans. The WHO has reported that an element is considered essential to an organism when the reduction of its exposure below certain limit results consistently in the reduction of a physiologically important function or when the element is an integral part of the organism structure in performing vital function(s).[3] Plants absorb heavy metals from contaminated soils through their roots and those that settle on the plants get into the plant organs through their leaves.[4] In Nigeria, heavy metal toxicants are released in the environment through burning of fossil fuel, industrial activities, automobile combustion, waste incineration, and release of aerosols, pesticides, fertilizer, street dust.[5] Heavy metals are found in the range of application including utilization by living cells, organisms, and ecosystem.[6]

Heavy metals enter the human body mainly through two main routes which are inhalation and ingestion. Ingestion of contaminated plants in the forms of food and medicine is the main route of exposure to these elements in human population.[7] Absorption through the skin is another route of exposure when the metals come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure accounts for a common route of exposure for adults. Large quantities of heavy metals are discharged into the environment through the burning of fossil fuels to generate energy, mining, smelting and refining industrial goods, waste incineration, and gasoline or automobile combustion.[8]

Chronic low-level intakes of heavy metals have adverse effects on human beings and other animals due to the fact that there is no effective mechanism for their elimination from the body.[9] Metals such as lead, mercury, cadmium, and copper are cumulative poisons, as they cause environmental hazards and are reported to be exceptionally toxic.[10]

Heavy metals are non-degradable and can accumulate in the human body system, causing damage to a person's nervous system

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and internal organs. They also act as confounding factors of cardiovascular diseases, reproductive impairments, and cancer.[11]

Exposure to heavy metals has been linked with developmental retardation, cancer, kidney damage, and even death.[12]

MATERIALS AND METHODS

Sample Collection and Analysis

Eighteen plant samples were collected from the leaves of plants with sharp-edged scissors and stored in clean polyethylene bags. Six sampling spots each were collected randomly in industrial, urban, and rural areas, respectively. This was taken to the laboratory for further treatment and analysis.

The plant samples were rinsed with distilled water to remove the dust particles. The samples were then dried at room temperature, transferred to the oven, and further, dried at a temperature of 100–110°C for 1 h. They were later grounded and sieved with 2-mm mesh size.[13]

10.0 g of each ashed plant sample was weighed and transferred quantitatively into a 50 mL beaker. This was digested with 10 cm^3 of concentrated HCl and boiled for several minutes on the hot plate and allowed to cool.

The solution was cooled and filtered into a 50 mL volumetric flask and made up to mark with deionized water. The concentrations of the heavy metals were determined using the BUCK Scientific VEP 210 Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSIONS

Co concentration as shown in Figure 1 in the industrial (0.059 ± 0.0035) and urban areas (0.029 ± 0.0133) are higher than that of the rural area (0.016 ± 0.0037). This is as a result of disposal of domestic wastewater, industrial chemical waste, fuel combustion, and smoke from cigarettes and industries.[5] High concentration of cobalt can cause asthma attacks with shortness of breath, wheezing, cough, and/or chest tightness. Cobalt may affect the heart, thyroid, liver, and kidneys. Repeated exposure to cobalt dust can cause scarring of the lungs.

The concentration of the heavy metal pollutants is in the order: Industrial area >urban area >rural area.

The Cu concentration in plant samples is higher in the industrial (0.356 ± 0.1285) and urban areas (0.186 ± 0.0625) than the rural area (0.143 ± 0.0473) [Figure 2]. The observed phenomenon is as a release of sewage sludge, used motor oil, and pesticides.[14] Reported that copper might be transported from soil to groundwater or may be taken up by plants. The recommended permissible limit WHO (2006) safe for copper

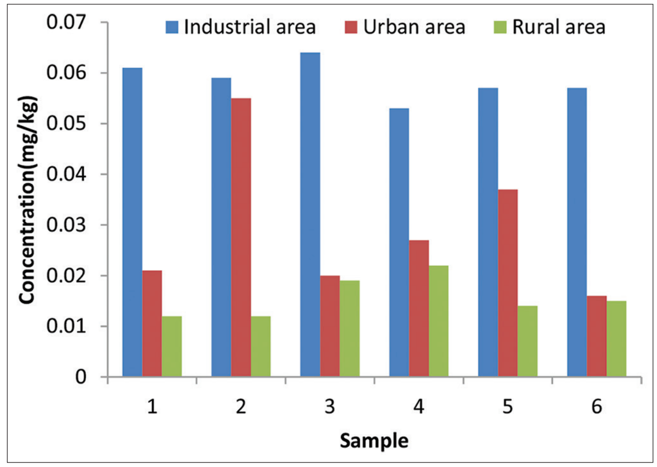

Figure 1: Concentration of cobalt in plant samples

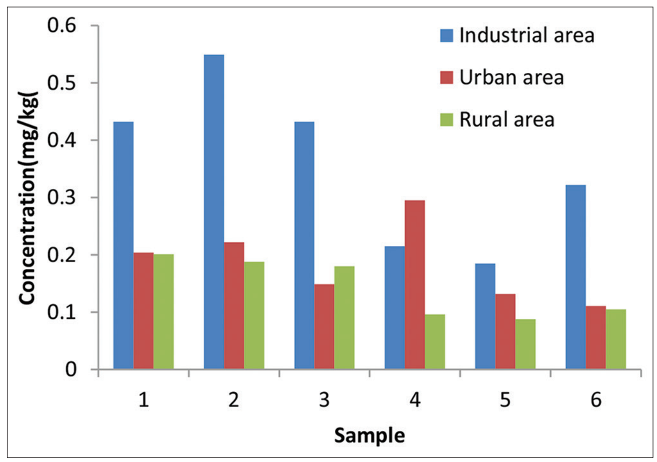

Figure 2: Concentration of copper in the plant samples

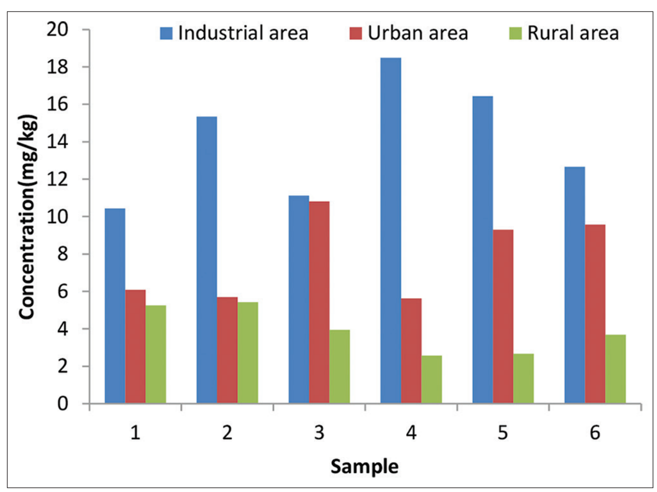

Figure 3: Concentration of iron in plant samples

in plants is 10 mg/kg, but in this study, the concentrations were below the permissible limit.[15] Conducted a research at Southwest Kenya on the profile of heavy metals on selected plants and reported 3.05 mg/kg to 7.4 mg/kg which is also within the WHO permissible limits higher than the results obtained in this work. Copper is an essential metal to human life in small quantity; it is a key component in redox enzyme, hemocyanin, and cellular metabolism, but in high doses, it can cause anemia, liver, and kidney damage. People with Wilson's disease are at greater risk for health effects from overexposure to copper.[16]

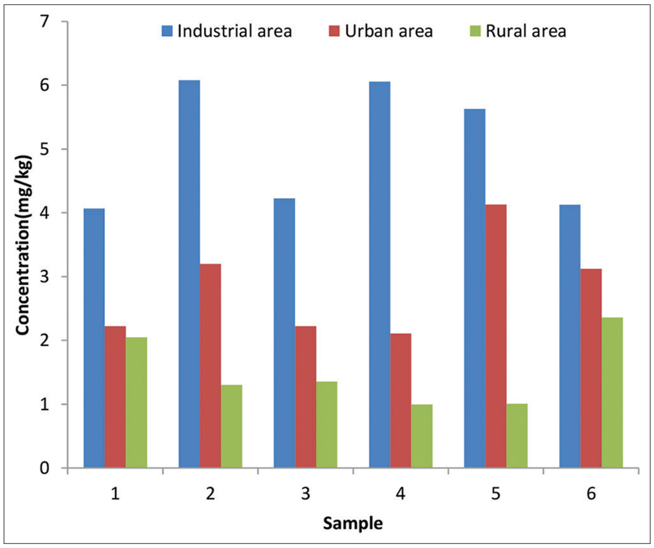

Figure 4: Concentration of manganese in plant samples

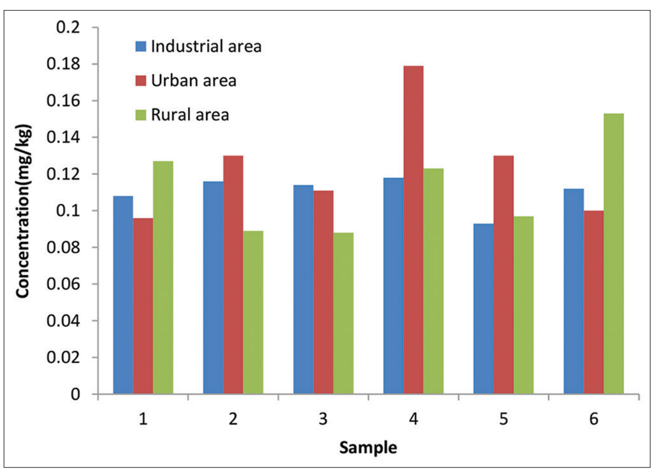

Figure 5: Concentration of nickel in plant samples

The concentration of Fe in plant samples as shown in Figure 3 in the industrial (14.082 ± 2.9035) and urban areas (7.852 ± 2.1007) is higher than that of the rural area (3.931 ± 1.1177). The observed trend is as a result of metal galvanizing/forging and smelting activities. It might also be attributed to anthropogenic activities such as disposal of structural components of building materials and condemned automobile parts which are made up of iron into the areas. Iron is a heavy metal with low toxicity but concentrations in excess of 200 mg/day are considered toxic for human.[17] The WHO permissible limit for iron in plants is 200 mg/kg. The results obtained from this research were below the permissible limit and therefore constituted no risk. Many researchers have reported similar results,[18] conducted a research on heavy metals and macronutrients content in selected plants in Ibadan Nigeria, and reported similar results. Fe is an essential element with the most common nutritional deficiency worldwide, affecting older infants, young children, and women of childbearing age. However, chronic Fe toxicity occurs by excessive accumulation of Fe in the body, either through transfusion siderosis, hereditary hemochromatosis, or excessive dietary intake. Fe deficiency causes tissues damage and some other diseases in humans such as anemia.[19] It also causes congestion of blood vessels, leading to increased respiration rate and hypertension.[20] The concentration of the heavy metal pollutants is in the order: Industrial area> urban area> rural area.

The Mn concentration of heavy metals in plant samples as shown in Figure 4 in the industrial (5.029 ± 0.9027) and urban areas (2.834 ± 0.7262) in Mn is higher than that of the rural area (1.510 ± 0.5162). This is due to emission from automobile exhaust, manufacturing emissions metal refining, and sewage sludge burning.[6] The WHO (1998) permissible limits of manganese in plants are 200 mg/kg, while its daily intake is 11 mg/day. The results obtained in this study showed that the concentrations of Mn were below the recommended permissible limit. Similar research was reported by[18] the WHO conducted a research on heavy metals and macronutrients content in selected plants in Ibadan, Nigeria, by the use of Atomic Absorption Spectrophotometry and reported the concentration of Mn 80.90 ± 0.04 mg/kg below the[3] limits also lower than the results obtained in this work. Manganese is very essential trace heavy metal for plants and

Table 1: Mean and standard deviation of heavy metal concentrations (mg/kg) of plant samples

	Metal concentration (mg/kg)				
Sample area	**Co**	**Cu**	**Fe**	**Mn**	**Ni**
Industrial	0.059±0.0035	0.356±0.1285	14.082±2.9035	5.029±0.9027	0.110±0.0083
Urban	0.029±0.0133	0.186±0.0625	7.852±2.1007	2.834±0.7262	0.124±0.0278
Rural	0.016±0.0037	0.143±0.0473	3.931±1.1177	1.510±0.5162	0.113±0.0236
WHO permissible Limit	10	10	50	200	10

animal growth. Its deficiency produces severe skeletal and reproductive abnormalities in mammals.[12] The concentration of the heavy metal pollutants is in the order: industrial area > urban area > rural area. The mean and standard deviation of heavy metal pollutants (mg/kg) as shown in Table 1 compares the concentrations of these pollutants.

The concentration of heavy metals in the urban (0.124 ± 0.0278) and rural areas (0.113 ± 0.0236) as shown in Figure 5 in Ni is slightly higher than that of the industrial area (0.110 ± 0.0083). This is due to emission from automobile exhaust, cigarette smoke, manufacturing emissions, and airborne waste.[3] The maximum permissible limit of nickel in consumed plants is 1.5 mg/kg, while its routine requirement for humans is 1 mg/day. From the results obtained in this study, all the concentrations were below the WHO permissible limits. Nickel at high-level becomes toxic and causes severe diseases such as, loss of vision, as well as heart and liver failures.[21] The concentration of the heavy metal pollutants is in the order: Urban area> rural area> industrial area.

CONCLUSION

The adverse effects of heavy metal pollutants on the environment are quite enormous. If this is not mitigated, human, plants, animal, and at large, the environment will be endangered. The high concentration of heavy metal pollutants can therefore have a long-term and serious impact on human health. The concentrations of the heavy metals (Co, Cu, Fe, Mn, and Ni) compared in the industrial, urban, and rural areas indicate that none of them is above the WHO permissible limits.

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