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Determination of Levels of Heavy Metals in Soils at Suame Magazine

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Abstract— *Background and objectives of study; Auto mechanics in Ghana have positively contributed to the transportation sector. However, they leave behind diverse waste materials on the soil within their workshops and the surrounding areas. These materials contain heavy metals, which in high concentrations, negatively effects the nervous, reproductive and vascular systems. This research aims at determining the levels of heavy metals such as lead, zinc, chromium and cadmium at the magazine. The results shall indicate the extent of pollution of the soils, and thereby contribute to data on heavy metals in Ghana. Methods: Fourteen soil samples were collected from two zones at Suame magazine in Kumasi in the Ashanti region of Ghana. Seven (7) samples from the spare parts dealers (lower zone) and the other seven from the working site (upper zone).The samples were digested and the concentrations of the metals determined by the Atomic Absorption Spectrophotometer. Results: Zinc had the highest concentration of 58.52 mg/kg and the least being chromium with concentration of 1.70 mg/kg. These concentrations were within the permissible limits of WHO. Conclusion: Heavy metals concentration was higher at where artisans work and low at the spare parts zone.*

Keywords— ***Auto mechanic workshop, Heavy metal uptake, soil pollution, soil samples.***

I. INTRODUCTION

Heavy metals are chemical elements mostly with density greater than 4 g/cm3. They include metals, such as Fe, Zn, Cd, and Pb. Human activities are blamed for soil pollution arising these heavy metals. (Masindi and Muedi, 2018).[1]

In Ghana, auto mechanics /artisans play a major role in the maintenance of vehicles and thereby generate varieties of waste materials via disposal of dirty engine oil, vehicle battery acid water, carbide from welding and metal scraps (Marahatta et al., 2018)[2]. Other sources include spraying, painting, and combustion processes (Pam et al., 2013) [3] . which may lead to risks in human health and the environment especially when they enter the food chain (Adelekan & Alawode, 2011) [4].

Soil, as a widespread receptor, naturally contains significant quantities of heavy metals, which vary in concentration depending on various sources, whether they are of natural or human origin (Adelekan & Alawode, 2011) [5] .

For so many decades, environmentalists and scientists in ecotoxicological studies have used the phrase "heavy metals". Heavy metals have been widely employed in many industrial applications such as manufacturing of batteries, alloys, electroplated metal parts, agro-chemical applications, and road constructions [6]. Heavy metals which have densities about 5 times greater than density of water [7], are non-biodegradable and are therefore monotonously contaminating the air, deposited into soil, water, as well as sediments [8] . The presence of heavy metals in the environment has aroused great concern due to their potential long-term detrimental effects on human, animal, and plant life particularly in developing countries where mitigation processes are fledgling [9]. For instance, the degeneration of spermatogenesis and semen quality in

human male, has been attributed to Cd contamination [10], hypertension and other cardiovascular have been attributed to Pb exposure even at low levels, and the adverse alteration of neurological, nervous, digestive, immune, and reproductive systems in humans and wildlife has been linked to Hg pollution [11].

Human exposure to heavy metal toxicants in surface soils usually occurs through suspended dust inhalation, oral ingestion, and dermal contact [12]. Surface soils instead of other soil horizons usually record higher levels of heavy metals as a result of human activities [13]. Elevated levels of the toxic` metals defy goals 1 and 3 of the Africa Union's Agenda 2063 [14]. That is, they represent a momentous threat to quality of life and well-being for all citizens, as well as impede living resources and ecological systems because of their increased discharge, poisonous nature, and other adverse effects on the environment.

About 20% of the total burden of disease in the developing countries is due to environmental pollution. Therefore raising awareness and increasing efforts to reduce the risk of pollution, including heavy metal pollution, would further decrease the burden of disease, and therefore, improve the well-being of the population and hence increase productivity. The aim of this study therefore is to monitor the extent of heavy metal pollution in selected areas of the magazine and automobile waste disposal deposition of particulate matter from the atmosphere, the disposal of sewage sludge and effluents enriched with metals, and the by-products generated during metal mining processes. Soil serves as a significant repository for human-generated waste. Through biochemical processes, these heavy metals can be mobilized, leading to water pollution and impacting food chains. Heavy metals such as copper (Cu), chromium (Cr), cadmium (Cd), nickel (Ni), and lead (Pb) pose a potential risk as soil and water pollutants. The issue of environmental pollution caused by heavy metals has become a global concern, especially in major cities, as it can result in the accumulation, bioaccumulation, and biomagnification of these contaminants within ecosystems. Eventually, heavy metal contaminants in the environment are deposited in soils in forms of low solubility compounds like pyrite (Huerta-Diaz & Morse, 1992),[6] or they become sorbed onto reactive surface phases such as iron (Fe) and manganese (Mn) oxides (Cooper, Neal, Kukkadapu et al., 2005; Hamilton, Smith, Davison & Sugiyama, 2005).[7]

II. MATERIAL AND METHODS

2.1. Study Area

The Suame industrial area also known as magazine is an integral part of Kumasi in the Ashanti Region, Ghana. It lies at latitude 06º43'21.26"N and longitude -1 º38'40.19"W.The area sees many forms of industrial use, such as car body part repair, auto mechanic shops , metal fabrication workshops and manufacture of aluminum and silver utensils. Also present are blacksmiths, carpenters, and car paint sprayers. Suame is also known for vigorous commercial activities including trading in all kinds of automobile spare parts, building materials and electrical appliances.

Figure 1 shows the sampling sites at the magazine.

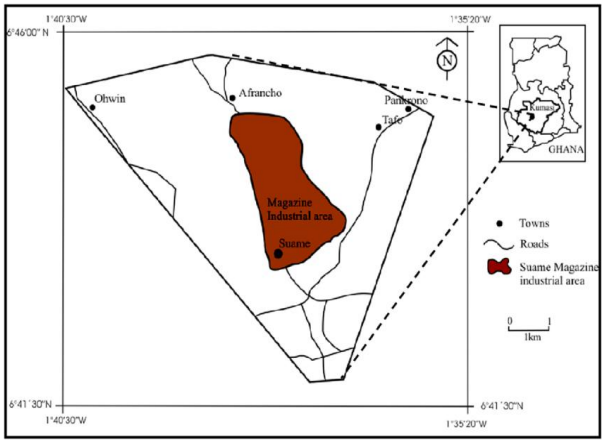

Fig.1: Location of sampling at Suame magazine

2.2. Collection of samples

Soil samples were taken from the surface of the soil at 0-10 cm depth with the aid of a core sampler. The sample site was divided into two zones namely; the lower part (area of spare parts dealers and houses) and upper part (artisans working area). Seven Soil samples were taken from each zone to make a total of 14 soil samples. Quadrat and core sampler were used in the collection of the sample. The quadrat was placed at a place in the upper part, the core sampler was then used to take spoil samples at a depth of 0-10 cm taken three soil samples from the quadrat. This step is then repeated twice to give six soil samples from the upper zone. This procedure is repeated at the lower zone to get a sum of 12 samples from the two zones. Two additional soil samples were taken at random making a total of 14 samples. The samples were labelled separately, and sent to the laboratory for analysis.

2.3. Laboratory analysis of sample

Soil samples were labelled for easy identification. The soils were air-dried and digested to determine the concentration of the heavy metals by the AAS.

0.5M EDTA was prepared by weighing 18.64g of the EDTA into a 2L flask, ammonium acetate was added, dissolved and topped to the mark with deionized water.
Five (5) g of the soil sample was added to 25mls of EDTA solution. The mixture was shaken for two (2) hours with a mechanical shaker at 180 rpm. The mixture was filtered and the filtrate was analysed for Zn, Cr, Cu and Pb using AAS.

III. RESULTS

This section highlights the various results obtained and describes the trend in accumulation at both zones, and compared to FAO/WHO acceptable limits in soils.

Table 1: Concentration (mg/kg) of Heavy Metals in the Soil Samples.

Samples	**Lower Zone**				**Upper Zone**			
	Pb	Zn	Cr	Cd	Pb	Zn	Cr	Cd
1	10.63	32.61	3.046	3.547	15.432	58.52	4.459	5.827
2	12.63	35.47	3.242	3.569	15.219	56.89	4.265	4.049
3	12.57	32.84	3.391	3.902	15.128	55.64	4.218	4.984
4	13.52	25.85	2.868	4.326	18.432	36.42	5.496	8.182
5	11.58	28.30	2.163	4.439	18.332	48.95	5.323	8.051
6	13.60	25.68	2.114	4.542	18.541	48.57	5.361	8.095
7	14.09	40.37	1.705	2.215	16.321	34.68	2.987	3.839
WHO/FAO (2001)	**50**	**300**	**50**	**3**	**50**	**300**	**50**	**3**

Source: Bartels/ Mensah laboratory results, 2023

Table 2: Mean Concentrations of Heavy Metals (mg/kg)

	Upper zone	**Lower zone**
Heavy metals	**Mean concentration**	
Pb	**12.66±0.462**	**16.77±0.601**
Zn	**31.59±2.032**	**48.52±3.647**
Cr	**3.79±0.735**	**6.15±0.735**
Cd	**2.65±0.245**	**4.59±0.337**

IV. DISCUSSION

The average concentrations of some of the heavy metals detected in a control soil at the Central Agricultural Research Station at Kwadaso, Kumasi were Pb: 9.5 mg/kg, Cd: 7.2mg/kg and Zn: 15 mg/kg (Sadick et al .,2015) [15]. This indicates that the metal concentrations at the study site exceeded those of the control even though the sites are just 5.3 km apart. This corroborates the finding that areas with higher tempo of anthropogenic activities of urban settlements have high soils contaminants (Adelekan and Alawode (2011) [16]

The Zinc content had a mean of 31.59±2.032 and 48.52±3.647 at the lower and upper zones respectively as shown in Table 1. These values are higher than the control and suggest an anthropogenic contribution, and solely attributed to the contribution from the auto mechanic shops, since Zn is an additive of lubricating oils (Abenchi et al., 2010) [17]. The values of Zn obtained in the study area conform to the acceptable limit of 50 mg/kg (Lacatusu, 2000) [18].

The mean concentration of Cd in the study area was 2.65±0.245 and 4.59±0.337 mg/kg in the lower and upper zones respectively. The main source of environmental Cd pollution is the ferrous-steel industry (Onder et al., 2007)[19], the accumulation of Cd in the area is likely to come from lubricating oils, vehicle wheels and metal

alloys used for hardening of engine parts (Dabkowska - Naskret, 2004)[20]. The Cd concentration was above the WHO/FAO acceptable limit of < 3mg/kg as indicated in Table 1. This concludes that the soils at Suame magazine are highly polluted with cadmium than other heavy metals.

The mean value of Pb in soils obtained in this study was 14.72 mg/kg, higher than the control, 9.5 mg/kg and could easily be attributed largely to the activities in the auto mechanic shops. Lead has the highest composition of heavy metals in waste oils (Oguntimehin et al., 2008)[21] and that high concentration of Pb in the study area could be due to the waste oil, and expired motor batteries indiscriminately dumped.

The mean concentration of chromium was 4.59 mg/kg, and below the WHO/FAO permissible limits of 50 mg/kg in soils as shown in Table 1. The control soil however did not reveal any traces of chromium in the study area. Chromium is a highly toxic heavy metal that can have adverse effects on human health and the environment. It is crucial to address and remediate the elevated levels of chromium to mitigate the associated health and environmental risks.

The soils at Suame magazine recorded high concentrations of heavy metals than the control plot located just 5.3km apart. Hence, the soils at Suame magazine can be said to be polluted by the activities of the artisans though the levels of pollution were found to be within the permissible limits of WHO/FAO with the exception of Cadmium which was found to be significantly higher than the permissible limit.

V. CONCLUSION

1. The mean concentrations of lead, zinc and chromium in soils at the automobile workshop were within the permissible limits recommended by WHO/FAO.

2. Cadmium, however, recorded concentrations above the permissible limits of WHO.

3. Soils at Suame magazine are polluted relative to the control plot.

4. The artisans are the prime contributors of heavy metal pollution at Suame magazine.

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RECOMMENDATION

- The artisans need to be educated about the negative consequences of improper disposal of spent fuels and battery acid on the environment.
- Workshops should create special waste chambers for proper disposal to prevent the spread of heavy metals, especially into nearby fields where crops are cultivated.

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