



Heavy Metal Concentration and Anthropogenic Activities at Artisanal shops at Suame Industrial Area, Ashanti Region, Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Author AOF conceptualized the research, did the soil sampling at the study area, wrote the protocol, and wrote the first draft of the manuscript. Authors AEO and SA managed performed the laboratory analysis of the soil samples. Author AAA managed the statistical analysis of the data. All authors read and approved the final manuscript.

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ABSTRACT

Pollution of heavy metals in industrial, residential areas and cities has become a public health issue in Ghana. Studies were conducted at Suame Industrial Area to investigate the degree of the pollution as a result of human activities at various artisan shops. Six (6) artisan's shops were selected namely: metal fabrication (MF), Auto mechanic (AM), car body part repair (CB), auto electrical (AE), blacksmith (BS) and auto spray. Soil samples were collected from the surface of the soil at 0–10 cm depth with the aid of an auger. A control sample was also collected (generally about 100 m away from the cluster and of the same geology) where neither car repairs, industrial nor commercial activities took place. The samples were placed in labelled polyethylene bags and

transported to the laboratory for analysis. The heavy metals analysed were: Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn). The results indicate that there was environmental contamination since the levels of heavy metals were high as compared to the background concentration. The quantification of anthropogenic input of the heavy metals was in order: Pb> Cu> Zn> Cr> Fe> Mn> Co. Public education on the need to encourage the creation of effective regulation and control measures including zoning and clear demarcation, regulation of industrial activities is recommended.

Keywords: Pollution; Anthropogenic; Suame; Heavy metals.

1. INTRODUCTION

Most cities in Ghana are densely populated, and lack of regulation, poor planning and zoning of activities, coupled with lack of resources to enforce by-laws, have led to localities with mixed activity mainly industrial, residential and commercial [1]. Exacerbating this situation, there is little or no data on such industrial activities, and in cases where data exists, it appears to have no bearing on town planning policy [1]. The following localities are typical mixed activity and congested locations: Suame industrial area in Kumasi, Abossey Okai in Accra and the Tema industrial area [1]. These unregulated activities lead to pollution of the environment and in particular, land and air pollution.

Maduka [2] defined pollution as the introduction, by man, into the environment, substances or energy, liable to cause hazard to human health, harm to living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment. Soils may become polluted by the buildup of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition. Heavy metal is a term used to describe a group of metals and metalloids with an atomic density greater than 5.0 g/cm^3 [3]. Soil can be said to be clean where the substance under environmental concern occur in concentrations equal to or lower than the value found in nature which is used as a reference and customarily called background concentration. The background concentration is the total element concentration obtained from soils that had not been affected by human activity. However, specific actions such as past land use; current activities on the site, and nearness to

pollution sources have all affected soil properties [4]. Such activities result in contaminations in various forms. The sources of contamination include: accidental spills, leaks of chemicals and human activities. Spills, runoff, or aerial deposition of chemicals used for agriculture or industry, materials stored or dumped on the site, contaminants in imported fill and demolition can also result in contamination of the soils and water at residential sites [4,5]. This research, therefore, aims at investigating the degree of the pollution as a result of human activities at various artisan shops at suame magazine.

2. MATERIALS AND METHODS

2.1 Description and Location of the Study Area

The Suame Industrial Area is a major part of Kumasi in the Ashanti Region of Ghana. It is popularly known as "Magazine". The soil type in the area is mainly sandy soil [1]. It is located in the northern part of the city at latitude $06^{\circ} 43'21.26'' \text{ N}$ and longitude $1^{\circ} 38'40.19'' \text{ W}$ [1]. The area is concentrated with many forms of industrial activities such as car body part repair, auto mechanic shops, metal fabrication workshops (smelting, moulding, welding), manufacturing of corn (cereal grains), mill parts and whole machines and manufacture of aluminium and silver utensils. Also present are blacksmiths, carpenters, and car sprayers. The study area is also known for vigorous commercial activities including trading in all kinds of automobile spare parts, building materials and electrical appliances. Food joints and drinking places are also located within the area. Besides, Suame also serves as a settlement area to some inhabitants of Kumasi and is densely populated.

2.1.1 Soil sampling, treatment and analysis

Six (6) artisan's shops were selected namely: metal fabrication (MF), Auto mechanic (AM), car



Fig. 1. Artisanal activities and vegetation at suame magazine

body part repair (CB), auto electrical (AE), blacksmith (BS) and auto spray. Soil samples were collected from the surface of the soil at 0–10 cm depth with the aid of an auger. In all, 18 samples were collected (three replicates from each sampling spot).

Three (3) control sample was also collected (generally about 100 m away from the cluster and of the same geology) where neither car repairs, industrial nor commercial activities were carried out, making a total of 21 samples. The samples were placed in labeled polyethene bags and transported to the laboratory for analysis. All soil Samples were subsequently air-dried to constant weight to avoid microbial degradation [6].

One gram of the dried fine soil sample was weighed and transferred into a cleaned round bottom flask containing 10 cm³ concentrated nitric acid. The mixture was slowly evaporated for 1hr on a hot plate. The solid residues obtained were digested with a 3:1 concentrated HNO₃ and HClO₄ mixture for 10 min at room temperature before heating on a hot plate. The digested mixture was placed on a hot plate and heated intermittently to ensure a stable temperature of 150°C for 5 hr until the fumes of HClO₄ were evaporated entirely [7]. The mixture was allowed to cool to room temperature and then filtered through Whatman No.1 filter paper into a 50 cm³ volumetric flask and made up to the mark with deionized water. The filtrate was then stored in polyethene storage bottles ready for analysis.

Heavy metal concentrations were determined using Agilent 200 series AA Atomic Absorption Spectrophotometer (AAS) with sensitivity of 10⁻⁶ ppm. Before the calibration of the machine it was aligned and optimizes to check the energy of the lamp. The following heavy metals were determined using the AAS machine: Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn).

2.1.1.1 Quantification of anthropogenic activities and natural process

In order to have an idea about the levels of contamination of the soils surrounding the auto mechanic workshops and the extent of the anthropogenic activities, the following relation was employed:

$$QoC = \frac{Y - Y_c}{Y} \times 100$$

Where QoC was Quantification of Anthropogenic Activities, Y, average concentration of the metal in the soil under investigation and Y_c, average concentration of the metal in the control samples [8].

3. RESULTS AND DISCUSSION

To have a clear understanding about the levels of contamination of the soils surrounding the auto mechanic workshops, data obtained were compared with those from the control sample, taken to be the unpolluted or background values

[9]. The background value of an element is the maximum level of the element in an environment beyond which the environment is said to be polluted with the element [10]. Fig. 2 shows that there was environmental contamination since the levels of heavy metals were high as compared to the background value. Figs 3 and 4 show the extent of the anthropogenic activities, the total concentration of each metal in the selected artisanal shops and the level of contamination in each artisanal shop.

Each analyzed heavy metal had a concentration above its background concentration value, indicating the presence of pollution in the study area. This is directly attributable to the artisanal activities conducted in this area [1]. The presence of heavy metals in the environment is due to improper disposal of car batteries, dismantling of auto engines and leakage of diesel and engine oil from vehicles [1]. Also activities such as spraying of car parts, metal fabrication, and the burning of waste materials like car tires, plastics, etc. also release metal pollutants into the atmosphere which are then deposited. These heavy metals have adverse effects on the human health and population in the area, other living organisms and the environment. Zn has negative influence on the performance of micro-organism and earthworms, hence retarding the breakdown of organic matter

[11]. High doses of Cu and Cr lead to allergic dermatitis in human, cause anaemia, liver and kidney damage [12-14].

On the basis of the quantification of anthropogenic input of the heavy metals in the soils presented in Fig. 2, one may order the contamination with individual metals as follows: Pb> Cu> Zn> Cr> Fe> Mn> Co. The high level of the lead in the soils may be attributed to the storage batteries and the cable covers burnt to recover the metal [1]. The Pb concentrations recorded from this study were generally higher than the Pb concentrations reported by [1]; this could be explained by the fact that this study was done at different location and differences in the electronic product part worked with, the intensive nature of the activities and the method used.

Fig. 3 also indicate that the environment is highly polluted judging from the fact that the level of natural process (Geogenic process) is insignificant. The only natural environment in the study area during the fieldwork is the miniature vegetation as shown in Fig. 2. Metal fabrication (MF) and auto electrician (AE) shops were the most polluted shops (Fig. 4). Burning and dismantling activities as well as acid spillage release a lot of heavy metals in the soil environment in these shops.

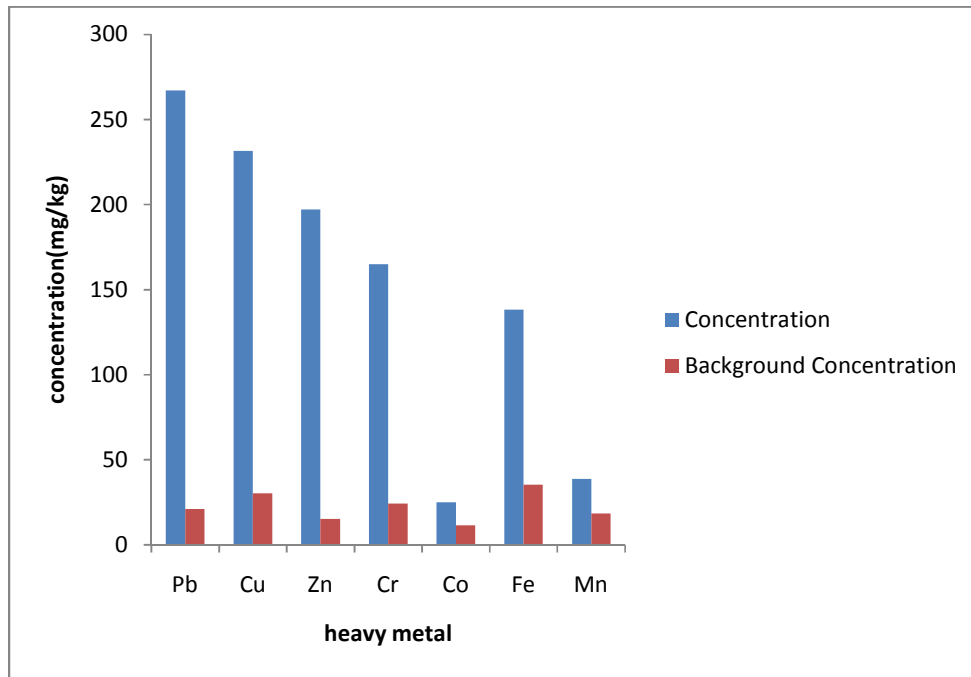


Fig. 2. Levels of contamination as compared with background concentration

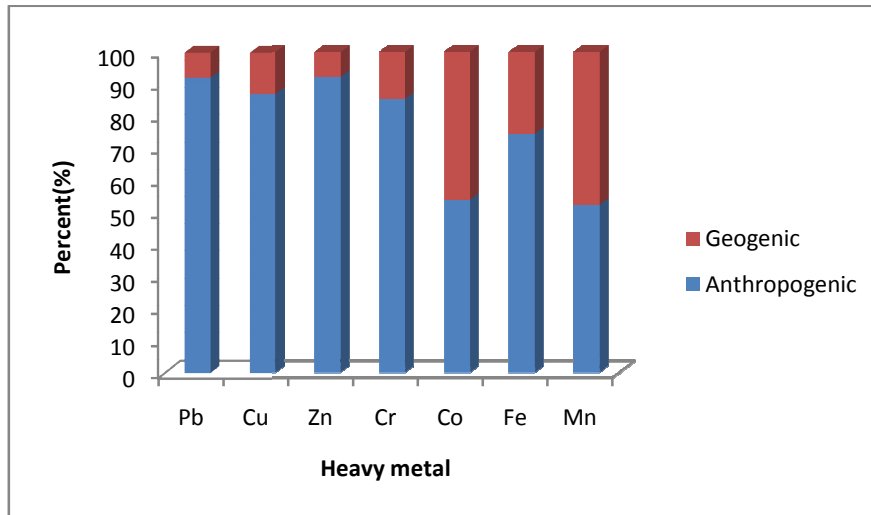


Fig. 3. Anthropogenic and Geogenic contributions of heavy metals of the selected areas

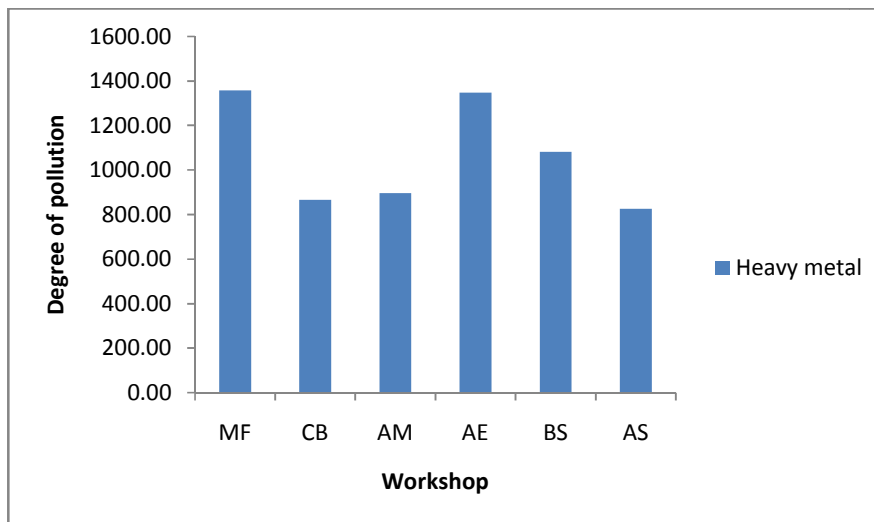


Fig. 4. Degree of pollution in artisanal shops

MF= Metal fabrication, CB= Car body part repair, AM=Auto mechanic, BS= Blacksmith, AE= Auto electrician, AS=Auto spray, BG= Background concentration

4. CONCLUSION

From the results of the present study, it is evident that heavy metals are present in considerably high concentrations in the soil in the Suame industrial area. The levels of Pb, Cu, Zn, Cr, Co, Fe and Mn have exceeded their background concentration values. The quantification of anthropogenic input of heavy metal is in the order of Pb> Cu> Zn> Cr> Fe> Mn> Co with metal fabrication and auto electrical shops being the most polluted area. This pollution may have come from the

artisanal activities such as acid and oil spillage, dismantle of auto engines and burning of cable covers to expose the metals in the environment. The degree of the pollution in the artisanal shops at the study area is also in the order Metal fabrication shop> Auto electrician's shop> Blacksmith shop> Auto mechanic> Car body parts repair shop > Auto spray shop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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