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# MITIGATING HEAVY METAL POLLUTION IN CAR BATTERY WORKSHOP SOILS: A CASE STUDY USING XRF ANALYSIS

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**Abstract**

A previous investigation [1] used X-ray fluorescence (XRF) technique to study soil pollution in car battery workshops situated within residential neighborhoods. To further this research, this article examines a different car battery workshop in Khartoum state where surface soil is regularly removed and replaced. Our findings reveal a substantial reduction in lead, iron, and copper concentrations compared to the initial study. The average concentrations of these heavy metals are 2.0x104, 3.9x104, and 86.2 ppm, respectively. This case study underscores the value of proactive soil management in minimizing heavy metal pollution in car battery workshops and its potential positive impact on nearby residential communities.

## Introduction

Environmental pollution is one of the main issues these days, specifically the industrial pollution and its impact on the soil. Severity of soil pollution extends to the water, plants, animals, food and to the human; unfortunately, most of the industrial workshops' activities are located within residential areas [2-5]. The high concentration of population in Khartoum state and the advanced devolvement of technology led to increase the number of workshops in Khartoum state. Unfortunately; most of these workshops are located within residential areas, so they can transfer toxic elements through soil to chain food and then to human being. This research work focuses on comparing the impact of environmental pollution in the soil by the industrial workshops within the residential areas in different areas of Khartoum state with each other and with the global limits. We have used X-Ray Fluoresce (XRF) technique to determine the toxic elements in the composite of the soil samples [6-8]. The results of the analysis of samples collected from certain workshops located in residential areas in different sites of Khartoum state can be compared with the global limits to determine its environmental pollution limits.

## Experimental Setup:

X-Ray Fluorescence (XRF) analysis is a rapid, relatively non-destructive process for analysis of rocks, minerals, sediments, fluids and soil. It used to identify the elemental abundances of the elements within a sample, Identifies both major and trace elements. In this study we used the Energy Dispersive Analysis (EDXRF). In our work we used the spectrometer available in the Applied Nuclear Science Laboratory, Department of Physics, Faculty of

Science, and University of Khartoum. The spectrometer constitutes Si(Li) detector attached to a pre amplifier and a high voltage supply, the pre-amplifier output is connected to a Multi-Channel Analyzer (MCA) through a Canberra amplifier, the data is displayed on a PC [9-11].

**Sampling:**

The samples were collected from a workshop of cars batteries that located in the residential site. The activities of this workshop include recycling in addition to the processes of extracting the lead from batteries for commercial uses. The soil samples are collected from the top thin soil layer by using a spoon metal. The distribution of the samples covered the four geographical directions away from the workshop. The first sample, in each case was taken right at the workshop fence, the second sample is 2 meters away from the first one and each other samples. Each sample is labeled and placed in a clean plastic box and then immediately taken to the laboratory. Each sample is homogeneously mixed and its specific weight is measured to obtain a good representative of the whole sample. Each milled weighed sample is pressed in a pressing machine (to about 15 ton) to form a disc of approximately 1cm. The disc is placed on the detector. The software used in acquisition the data and analyzing the spectrum is AXIL program (Analysis of X-Ray spectra by Iterative Least square fitting) [12-14].

**Analysis and Discussion:**

In this section, we show the results obtained from the current work and compare them with the earlier ones. The main goal of the current study is to explore the effect of drifting and changing the surface soil collected from workshop and around it by new one regularly, will this process reduce the concentrations of the elements under study and therefore decreases the amount of pollution to the environment.

Fig. 1 reveals the XRF spectrum of a soil sample collected from the batteries workshop, the spectrum is fitted using AXIL software program. The spectrum reflects the trances of the elements Pb, Fe and Cu with different concentrations. Fig. 2 on the other hand, displays the XRF spectrum of a soil sample collected 8 meters away from the batteries workshop. The two spectra are recorded in the same scale for the sake of comparison, one notices from the first glance the difference in concentrations of each trace elements found in both.

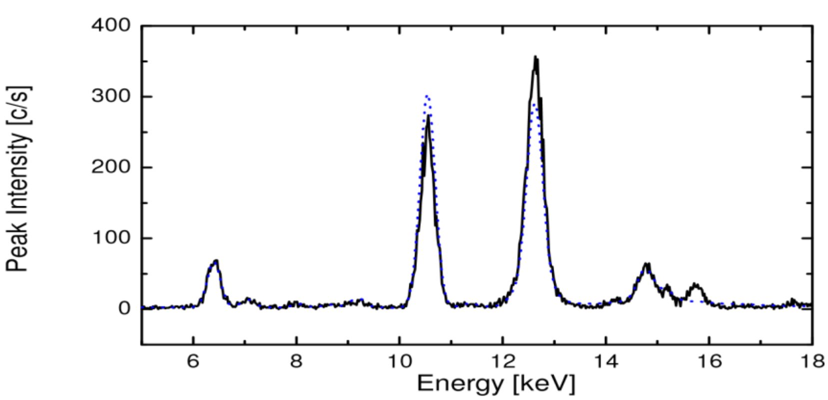



Fig. 1: The measured (solid line) and the fitted (dotted line) spectra of the soil sample collected from the batteries workshop.

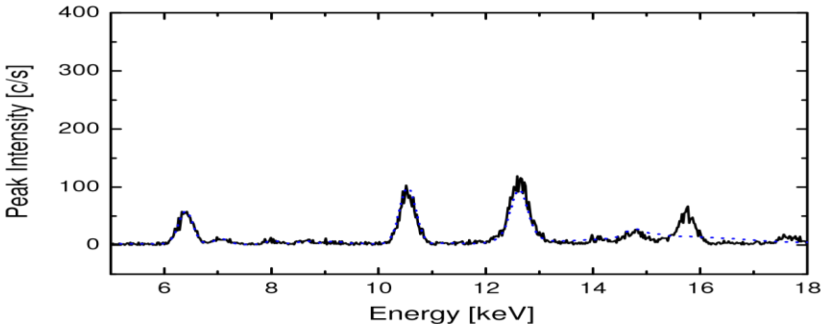



Fig. 2: The measured (solid line) and the fitted (dotted line) at a distance of 8 meters from the workshop.

Furthermore, the information extracted from these spectra are tabulated in Table 1 and Table 2 respectively.

**Table 1: Shows the data extracted from the XRF spectrum of the soil sample collected from cars batteries workshop**

| Element. | Ene. keV | Int. c/s | Sen. ppm-1 | Enh. % | Con. ppm | Error |
|---|---|---|---|---|---|---|
| Fe | 6.400 | 1.924 | 2.38E+03 | 0.0462 | 7.96E+04 | 4.28E-02 |
| Cu | 8.041 | 0.152 | 9.69E+04 | 0.0580 | 1.23E+02 | 6.97E-05 |
| Pb | 10.540 | 10.240 | 1.07E+04 | 0.1070 | 4.30E+04 | 2.31E-02 |

**Table 2: Shows the information extracted from the XRF spectrum of the soil sample collected 8 meters from the batteries workshop**

| Element. | Ene. keV | Int. c/s | Sen ppm-1 | Enh. % | Con. ppm | Error |
|---|---|---|---|---|---|---|
| Fe | 6.400 | 1.770 | 3.75E+04 | 0.0776 | 2.93E+03 | 1.57E-03 |
| Cu | 8.041 | 0.198 | 1.53E+06 | 0.1380 | 4.49E+00 | 2.47E-06 |
| Pb | 10.540 | 3.374 | 1.68E+05 | 0.2636 | 3.64E+02 | 1.96E-04 |

In a comparison between the two tables one observes great discrepancies in the concentrations of the targeted elements: the iron, the copper and the lead between the values obtained from the soil samples right at the batteries workshop and that taken at a distance of eight meters away from it. The later values are much lower than the ones obtained right at the workshop. This result implies that the contamination to soil surface is becoming less as one goes away from the workshop as expected. This is shown clearly in Fig. 3 which illustrates the spatial analysis between the averaged concentrations of the Fe, Pb and Cu elements graphed as a function of distances away from the batteries workshop.

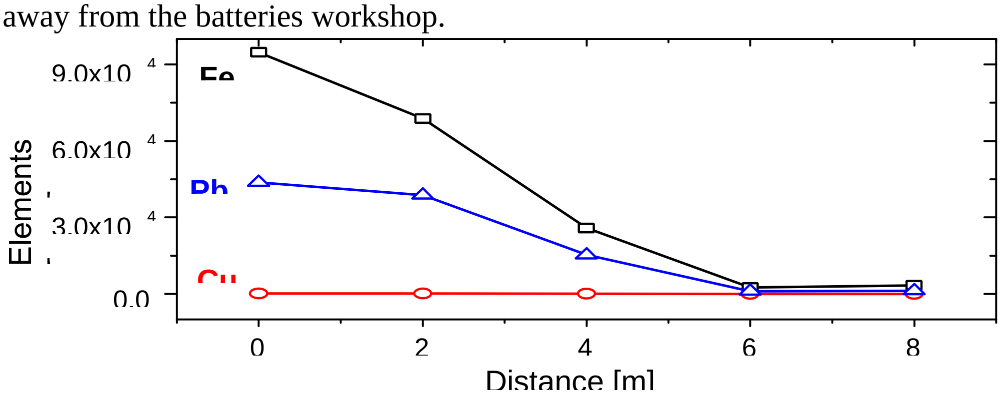
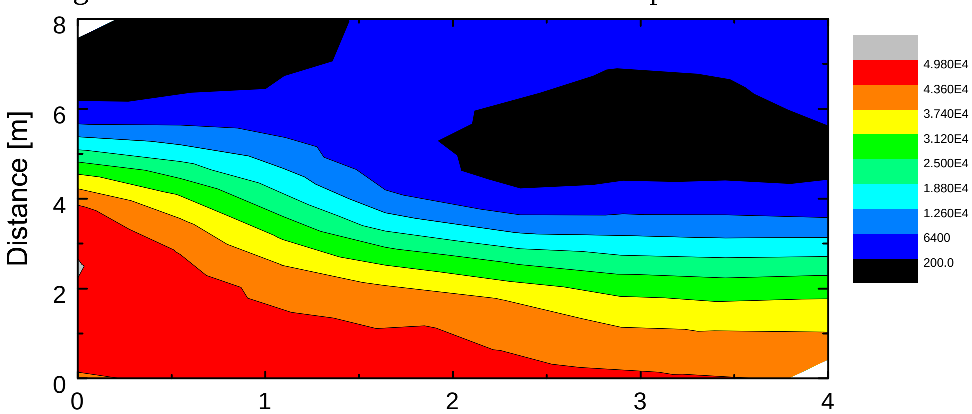


Fig. 3: Shows the averaged values of concentrations (in ppm) of the elements Fe, Pb, and Cu plotted as a function of distances (in meters) from the cars batteries workshop.
Fig. 3 also displays the reduction in the elements' concentrations. Furthermore, we notice the huge drop in the concentrations of the elements: from $9.5x10^4$ to $3.3x10^3$ ppm for iron; $4.4x10^4$ to $1.2x10^3$ ppm for lead; and $1.9x10^2$ to 2.1 ppm for copper. For the case where the surface soil of the batteries workshop is accumulated with time then one expects the concentrations to be higher than these. This was the purpose of the earlier article [1]. They dropped to $1.4x10^5$ to $1.37x10^5$ ppm for iron; $8.5x10^5$ to $9.0x10^5$ ppm for lead; and $1.2x10^4$ to $6.6x10^3$ ppm for copper. In addition to the slight decrease in the concentrations, one also notices that in our present study the lead concentration in the vicinity of the batteries workshop is not too high compared to the previous study. This is due to the procedure of drifting and changing the soil by new one regularly.
The averaged values of the lead concentration in our current study is found to be $2.0x10^4$ ppm, which is still too high with respect to the international limits. For instance, the classification of the high-risk level as given by the United States Environmental Protection Agency (US EPA), is between 1000 and 2000 ppm. For pb [15].
To have an idea about the distribution of the lead's concentration within the vicinity of the batteries workshop we plot in Fig. 4 a contour graph displaying the concentration as a function of distances. The contour viewing the high amount of lead near the batteries workshop.




Distance [m]

Fig. 4: A contour plot shows the distribution of the lead plotted as a function of distances (in meters) from the cars batteries workshop.

**Conclusion:**

We classified the cars batteries workshops into two kinds: The ones in which the soil surface is accumulated with time and therefore, keeping the toxic elements in the soil that can be extended to the residential area as long as the workshops are located near to them. The other kind are the ones where the surface soil is changed from time to time which means fewer toxic elements accumulation. It is known that the soil pollution increases health threats to people resident nearby. In this study, we investigated the second type. The results showed that the concentrations of the elements under study became less when compared with the first kind batteries workshops. Even though the averaged values are still high relative to the international levels recommended by EPA.
According to results obtained from this study we insist on our first recommendation regarding these batteries workshops. They should be transferred to uninhabited places, and away enough from any cities.

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