



# Analysis of Cr in Dumpsite Soil Samples Using AAS and EDXRF Techniques

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## Abstract

*In this research, speciation analysis of dumpsite soils from Kurmin Mashi (KM), Narayi (NY) and Tudun Wada (TW) of Kaduna metropolis, Nigeria was carried out. A modified Tessier extraction procedure was employed for the analysis. The concentration of Cr in the samples was determined using atomic absorption spectrometry (AAS) and Energy Dispersive X-Ray Fluorescence (EDXRF) techniques. The results revealed that KM dumpsite had the highest amount of Cr. From the ANOVA ( $P = 0.000 < 0.05$ ), it was established that there is a significant difference in the total chromium content across the three locations. The results also showed that the metal was distributed between oxides, carbonate and carbonate/organically bound fractions and that acetic acid extracted the highest amount of Cr across the dumpsites. Similarly, the ANOVA ( $P = 0.020 < 0.05$ ) indicated a significant difference in the Cr extracted using the three extraction media.*

**Keywords:** speciation analysis, dumpsite soil, AAS, EDXRF, Kaduna metropolis.

## Introduction

Anthropogenic activities usually create wastes which constitute risks to the environment and public health, as a result of the way and manner these wastes are handled, stored, collected and disposed of. In the urban areas, especially a rapidly urbanizing city like Kaduna, problems and issues of solid waste management are of immediate importance. The rapid population growth presents a serious challenge to the authorities, so much so that when wastes are collected; they are disposed of in uncontrolled dumpsites and/or burnt, polluting water resources and air<sup>1-3</sup>. Municipal solid waste includes waste generated from residential, commercial, industrial, institutional, construction, demolition, process and municipal sources. Residential single and multifamily dwellings generate food wastes, paper, cardboard, plastics, textile, leathers, yard waste, wood, glass, metals, ashes, special wastes e.g. bulky items, consumer electronics, white goods, batteries, oils, tires and household hazardous wastes. Commercial stores, hotels, restaurants, markets generate paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, office buildings etc<sup>4,5</sup>.

The levels of heavy metals in the environment have been seriously increased during the last few decades due to human activities. It is important to note that total heavy metal content is a critical measure in assessing risk of a refuse dumpsite, but it alone does not provide predictive insights on the bioavailability, mobility and fate of the heavy metal contaminants<sup>6-7</sup>. Since the toxicity of the heavy metals is related to their existing species<sup>8-9</sup>, the speciation of them increasingly was attracting more attentions. However, the determination of specific chemical species is difficult and sometimes impossible. So, the so-called exchangeable or carbonate-bound forms defined by the operational procedure could be a good compromise to provide environmental information and have been commonly applied

through different sequential extraction procedures in environmental studies<sup>10</sup>. The objective of this work therefore, was to determine the total concentration and chemical forms of chromium in some refuse dumpsites in Kaduna in order to assess the human health and ecological risks associated with the refuse dumpsites.

## Material and Methods

A flame atomic absorption spectrophotometer model 8010 Young Lin and Energy Dispersive X-ray Fluorescence spectrometer model minipal 4 were used in the Cr determination. In the extraction procedures, 1.0M oxalic acid, 0.05M Na<sub>2</sub>EDTA and 1.0M acetic were used.

Preparation of samples: The research covered three sites in Kaduna, Nigeria. The sites are: Kurmin Mashi (KM), Narayi(NY) and Tudun Wada (TW). The dumpsites are situated around residential areas within metropolis. The samples were collected during the rainy season in September and October, 2011. The soil samples from the dumpsites were collected from different areas enumerated as shown in figure-1. Triplicate sample from each dumpsite were collected and composite samples were made in the laboratory. The samples were air dried and sieved using 2mm sieve.

**Digestion and extraction of soil:** Soil extracts from the dumpsite were obtained by shaking separately 5g of soil samples with 10cm<sup>3</sup> of 0.05M Na<sub>2</sub>EDTA ( for carbonate and organically bound phases) 1.0M of oxalic acid (for oxide phase) and 1.0M acetic acid (for carbonate phase) occasionally on a hot plate. Four (4)cm<sup>3</sup> of 1.5M HNO<sub>3</sub> was added to the residue and centrifuged. The digest was diluted to 60cm<sup>3</sup> with distilled water<sup>9</sup>. The clear digest was analysed for Cr using FAAS model 8010 Young Lin. A blank digest was carried out in the same way.

**Total Metal Concentration:** In determining the total metal concentration in the various dumpsites, 5g of fresh samples from each site were air dried and pulverized. These were analysed using the EDXRF spectrometer model minipal 4.

**Results and Discussion**

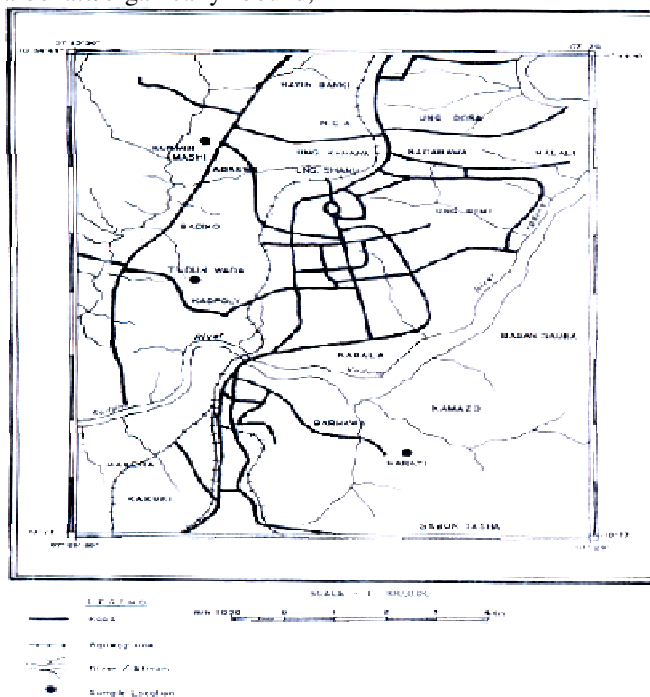
**Total chromium content in the dumpsites:** The total chromium content in the dumpsites varied from one location to another. The results are shown in table 1. From the results Kurmin Mashi (KM) dumpsite had the highest amount of chromium. This could be attributed to the nearness of the dumpsites to residential single and multifamily dwellings, markets, commercial stores, office buildings, mechanic workshops. Similar observations were made by the other investigators<sup>2,10-12</sup>. The chromium contents in Kurmin Mashi (KM) and Narayi (NY) are below the allowable limits of 1000mg/kg<sup>13</sup>. From the ANOVA (P = 0.000 < 0.05), there is a significant difference in the total chromium content across the three locations.

**Chromium Speciation:** The chromium distribution in the dumpsites varied from one location to another as shown in table-1. The metal existed in carbonate/organically bound,

carbonate and oxide fractions. The chemical forms of the metal in KM are carbonate/organically bound and carbonate species and hence bioavailable and mobile in this location<sup>14-16</sup>. The oxide phase is virtually nonexistent in KM. Similar observations were made in NY and TW.

The pH values of the dumpsites from KM and NY are acidic. This could be attributed to the presence of metal scrap, waste materials in the dumpsites and other human activities taking place around the dumpsites<sup>2</sup>. The Dumpsite in TW appeared to be alkaline. The acidity of dumpsites enhances the bioavailability, solubility and mobility of the metal<sup>17-21</sup>.

From the ANOVA (p = 0.000 < 0.05 and p = 0.020 < 0.05), there is a significant difference in the chromium concentrations across the three locations and in the chromium extracted using the three extraction media employed. From the Duncan multiple range test, it was established that soils from TW have the highest amount of chromium from the dumpsites, followed by EDTA and oxalic acid, as shown in figure-2 and figure-3.

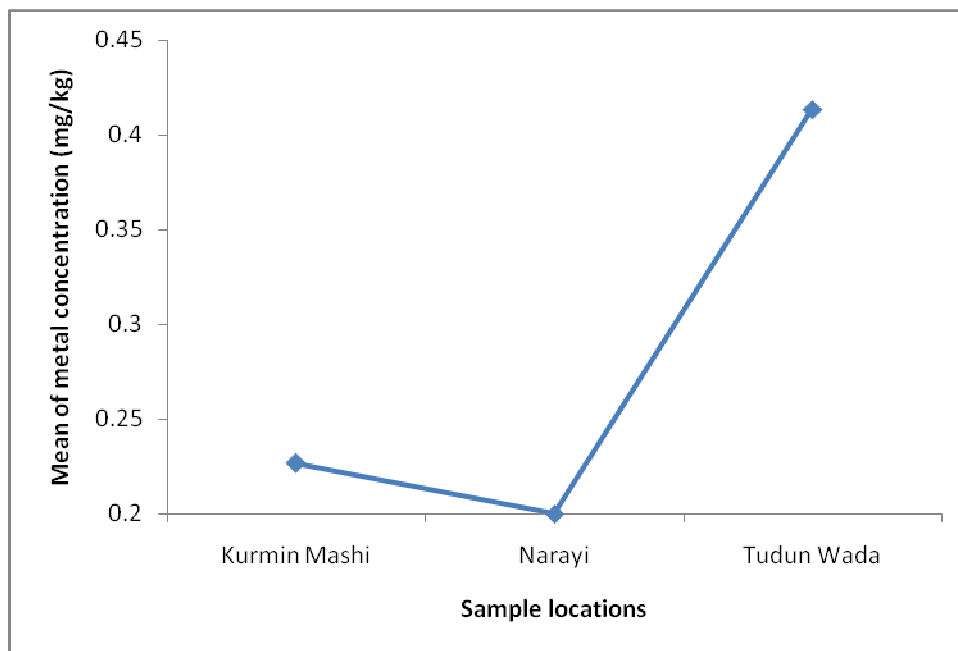


**Figure-1**  
 Map of Kaduna Metropolis showing sampling sites

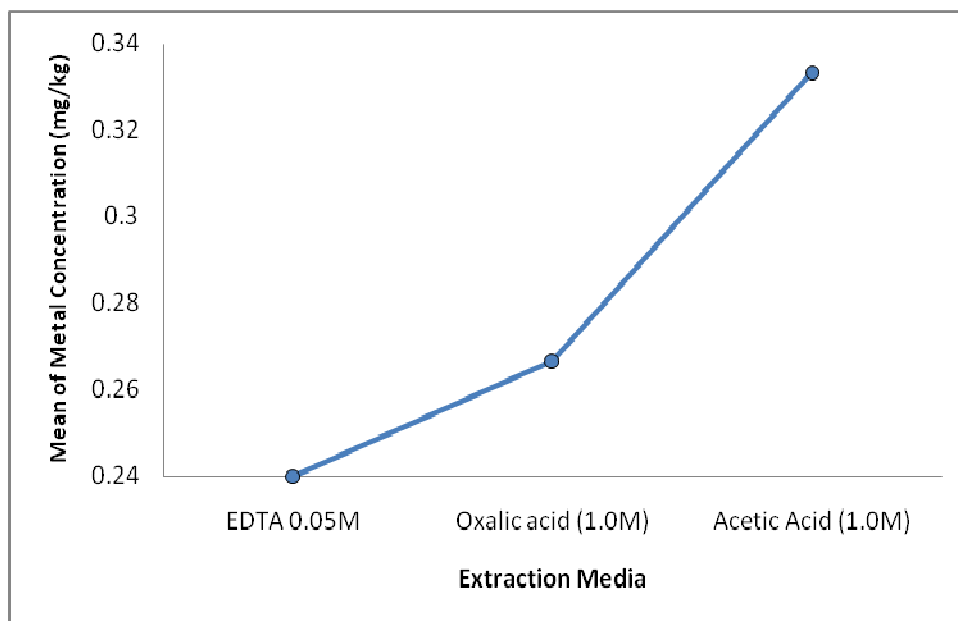
**Table-1**  
 Results of Chromium concentration in the dumpsites across the sample locations

Sample Site	pH	EDTA 0.05M	Oxalic acid (1.0M)	Acetic Acid (1.0M)	Total Cr Conc. mg/kg
KM	5.13	0.20 ± 0.069	0.00 ± 0.000	0.48 ± 0.000	303.33 ± 70.95
NY	5.23	0.16 ± 0.069	0.24 ± 0.000	0.20 ± 0.069	260.00 ± 40.00
TW	8.37	0.36 ± 0.120	0.56 ± 0.069	0.32 ± 0.069	NIL

The results are mean values (mg/kg) ± standard deviation n = 3



**Figure-2**  
Mean plot of chromium concentration in the dumpsites



**Figure-3**  
Mean plot for chromium concentration in the extraction media

### Conclusion

The research work reveals high level of accumulated Cr in the soil of the three dumpsites studied, hence the pollution of these areas. The contamination of the soil by the metal can be traced to the various anthropogenic activities at the dumpsites. The

imminent danger associated with the continuous pollution of the soil of the dumpsites by Cr begs for concerted efforts towards effective management of municipal solid waste. The level of heavy metals can be reduced to reasonable and manageable level if solid wastes are sorted and the inorganic parts reduced.

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