**Title**

# Concentrations of Heavy Metals in Soil and Cassava Plant on Sewage Sludge Dump



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**Publication Date**
2009-08-07

Peer reviewed

## Introduction

Another environmental aspect of toxic metals in sludge is their accumulation in plants, especially food crops. This accumulation depends on the plant specie and on the chemistry of the metals in the soil. Stehouwer (2006) also posited that the consequences of such contamination are that trace metal concentrations in locally grown vegetable and crop may greatly exceed accepted standards, as may the metal uptake by the consumer. Recognising plant different abilities for metal uptake and accumulation especially where the concentration is located in the consumable part is very crucial because when heavy metals are absorbed by plants which may serve as food and medicine to man and as forage to animals, they find their ways into the body system and pose serious health problems ranging from cancer to heart disease (Corey *et al.,* 1996). Consequently, the concern over-application of sewage sludge to the farm land is that, some sewage sludge contain high concentrations of heavy metals and questions about their potential health and environment effects have continued to be crucial (Atlas *et al*., 1998; Bragatho *et al*., 1998). In spite of awareness on the dangers associated with the ingestion of high volume of these heavy metals, farmers are known to produce vegetables and other crops in old garbage dumps in small and large cities around the world where improper management of municipal waste exists (Helmore and Ratta, 1995). Walker (1989), in an assessment of the new regulations for sludge disposal, indicated that, even for "low contaminant" sludges, heavy metal content could be the limiting factor in sludge application to agricultural land. Base on numerous studies and findings, determination of concentrations of heavy metals in both soil and plant have been proposed (Brown, 1987) to detect the toxic and phytotoxic levels to plant and animal-mammals.

This work aimed at determining the soil heavy metal concentrations and accumulation in cassava plant cultivated on sewage sludge dump for urban agriculture, and also ascertain if these heavy metals are in high and toxic concentration. The perspective of this work is to educate government agencies, policy makers and farmers on the environmental consequences of cultivating on sludge dump. Evidence show that this sewage sludge was not treated.

## Materials and Methods

A sewage sludge dump site cultivated with cassava plant by a farmer was used for this study. The dump was under severe and intense deposit of sewage sludge for about 2 years, abandoned for about 3 years before subsequently cleared and cultivated with cassava plant (*manihot esculenta*). Also a non-dump site (control site) half a kilometer from the dump site was selected (The site is a fallowed agricultural land with secondary re-growth). Soil samples (for all site type) were randomly collected using soil auger. The sampling was restricted to 0-15 cm since previous work by Nyana-gababo and Hamya (1986) showed that surface soils are better indicator for metallic burdens. 15 soil samples were randomly collected and each 5 bulked, for 3 composite replicates, according to Plank (1988). Soil samples were spread on clean and dried paper sheet for air drying. After air drying, the samples were crushed in clean ceramic mortar using a small ceramic pestle. These samples were passed through 2-mm sieve to get a fine soil fraction (Nelson and Sommers, 1982). The fine soil fraction was used to extract heavy metals using the DTPA (Lindsay and Norvell, 1978; Westerman, 1990). A 10g of soil samples were mixed with 20ml DTPA (0.05 M – adjusted to pH 7.3 with TEA), then shaken on a reciprocation shaker for 30 – 45 minutes before filtering through whatman No 1 filter.

The filtrate were analysed for heavy metals (Cu, Pb, Zn, Ni, Hg,) on Atomic Absorption Spectrophotometer (AAS), Perkin Elmer model 306. Soil pH was determined in distilled (deionised) water (1:2.5 soil-water ratio) using glass electrode pH meter (Dewer model). Organic carbon was determined by the Walkley-Black wet oxidation method (Heanes, 1984). Exchangeable acidity was determined by the titration method (Westerman, 1990).

For the Cassava plant, cassava tubers were randomly sampled at maturity. 15 samples were collected, each 5 bulked, for 3 composite replicates, according to Plank (1988). The tubers variously collected were washed and peeled to remove soil particles. Each sample was placed in a forced-draft oven at $55^0$C for about 12 hours, then grounded and passed through a 2-mm sieve. A 0.50g sample was dry-ashed in a porcelain crucible for 4-6 hours at $500^0$C. The residue (ash) was dissolved in 25ml of 1 M hydrochloric acid. Analysis for Ni, Cu, Zn, Pb, Cd were done on the ash solution according to Reuter and Robinson (1986) using Atomic Adsorption Spectrophotometer. Accuracy was assessed by analyzing 3 replicates of the selected samples. Comparisons was done between the result from the non-dump site and the result from the dump site using t-test procedure.

## Results and Discussion

### *Soil Total Metal Concentration*

Heavy metal (Ni , Zn ,Cu, Pb, and Cd) levels were increased at the dump site soil relative to the non-dump site. This is shown in Table 1. For Ni, a value of 25.15 mg $kg^{-1}$ in the dump site was obtained and this may have being significantly increased by sewage sludge deposit when compared with non-dump site value. This is within the critical soil concentration range of 20-70 mg kg-1 according to Kabata-Pendias and Pendias (1992). The Zn content of the dump site soils (79.7 mg $kg^{-1}$) increased by 392%. The value obtained for Zn were in excess relative to non-dump site but were within the normal range obtained in soil (10-100 mg $kg^{-1}$, Logan and Chaney, 1983).

The soil Cu concentration increased in the dump site soil significantly relative to non-dump site. A value (68.2) which is within soil critical range (50-250 mg $kg^{-1}$) as given by Kabata-Pendias and Pendias (1992) was obtained.

Soil Pb level in the dump site soil (16.85) increased but not within soil critical range (35-180 mg $kg^{-1}$).

The Cd value of the dump site soil is 8.38 mg $kg^{-1}$. This value is also high but not within soil critical range (12-70 mg $kg^{-1}$).

Table 1. Metals Concentration in the Soil as Influenced by Sewage Sludge Deposit.

| | mg $kg^{-1}$ | | | | |
|---|---|---|---|---|---|
| Sources | NI | Zn | Cu | Pb | Cd |
| Dump site | 25.15a | 59.7a | 68.2a | 10.85a | 8.38a |
| Non-dump site | 10.35b | 17.7b | 15.5b | 2.50b | 1.10b |

Within each column, means with different letter (superscript) are significantly different ($p<0.05$) according to Fishers Least Significant Different

### *Cassava Tuber Total Metal Concentration*

The accumulated heavy metals in cassava tuber was summarise in Table 2 .The deposit of sewage sludge markedly increased the concentrations of heavy metal in the cassava tuber (Table 2).

The Ni content of the Cassava tuber was highly increased relative to non-dump site. A total value of 38.25 mg $kg^{-1}$ was obtained.

For Zn, a total concentration of 138.7 mg $kg^{-1}$ was obtained which is an indication of significant different between the two sites respectively. The value obtained for Zn fall within the critical range of 40-150 mg $kg^{-1}$.

The cassava tuber value for Cu is 125.8 mg $kg^{-1}$. This is within the critical range (20-100 mg kg-1) of metal concentration in a cassava plant tissue. However, Amusan *et al*. (1999) found that leaves of waterleaf plant grown in dump site soil contained 29.20 mg $kg^{-1}$ Cu which was well within the critical range found in plant tissue (20-100 mg $kg^{-1}$).

For Pb, the accumulation is 16.85 mg $kg^{-1}$. The deposit of sewage sludge increased the accumulation level significantly but not within the critical range in tissue (15-120 mg $kg^{-1}$).

Cadmium accumulation was also increased in the dump site cassava tuber relative to non-dump site. Accumulation of 3.60 mg $kg^{-1}$ to against 0.14 mg $kg^{-1}$ in the non-dump site was obtained. This value is in excess but not above maximum limit for metal accumulation in plant tissue.

Table 2. Metals concentration in the cassava tuber as influenced by sewage sludge deposit.

| | mg kg-1 | | | | |
|---|---|---|---|---|---|
| Sources | NI | Zn | Cu | Pb | Cd |
| Dump site | 38.25a | 138.7a | 125.8a | 5.50a | 3.60a |
| Non-dump site | 7.0b | 28.80b | 30.3b | 0.80b | 0.14b |

Within each column, means with different letter (superscript) are significantly different ($p<0.05$) according to Fishers Least Significant Different

Miller and Miller (2000) noted that Zn and Cu are toxic to plants before they accumulate in sufficient (maximum) tissue concentration to affect animal or humans. As a result, over application tend to kill or stunt plants, minimizing opportunities to affect animals or humans consuming them. Also, Miller and Miller (2000) showed that cassava plant are not hyperaccumulator.

The increase in Ni, Zn, Cu, Pb and Cd content in both the soil and the plant in the dump site relative to the non-dump site must be attributed to dumping of sewage sludge on that soil (dump). Increased heavy metal content of the soil can lead to increased plant uptake of metals that may be injurious to human and animal health. Sewage sludge reduced the pH of the dump relative to non-dump. Ademoroti (1996) reported that repeated application of sewage sludge can greatly reduce the pH of the soil and adversely increase the heavy metal concentrations of a soil. Jimoh (2001) recommended that the impact of toxic wastes, including heavy metals be studied in individual cities and that crops with least susceptibility to contamination be grown.

Results obtained from this work indicate that sewage sludge especially untreated sewage sludge increased the soil heavy metal concentration and accumulation in cassava tuber in sewage sludge dump used for urban agriculture. The result suggest that farming on this dump should be discouraged. This site can be used for farming if the dump is treated by any process of managing and remediation of metal(s) contaminated soils.

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