

**FULL LENGTH RESEARCH PAPER****Phytoremediation of Metals from Contaminated Soil using *Lycopersium Esculentum* (Tomato) Plant**Oyelola, O. T<sup>1</sup>, Babatunde, A. I.<sup>2</sup> and Odunlade, A. K<sup>3</sup><sup>1</sup>Chemical Science Dept, Yaba College of Technology, Lagos<sup>2</sup>Chemistry Dept, University of Lagos, Akoka, Lagos<sup>3</sup>Biological Science Dept, Yaba College of Technology, Lagos

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**ABSTRACT**

It is a common practice for farmers in Nigeria to use soils in municipal waste dump sites as fertile ground for the cultivation of a variety of leafy vegetables and the soils are also used as 'compost' by farmers without regards for the probable health hazards the heavy metal contents of such soils may pose. This was the case of farmers using the abandoned dumpsite soil at Isolo for their livelihood. It was this concern that prompted the determination of heavy metals in the soil and the edible part of *Amaranthus cruentus* planted on the soil and the control planted on Yaba College of Technology Botanical garden and that of the tomato plant used to inactivate metals in the dumpsite soil. The concentration of heavy metal in the edible part of *Amaranthus* vegetable from the dump site and the control are: Pb (35.00 – 23.68ppm); Zn (8.70 – 4.00ppm); Cu (7.68 – 4.34ppm); Cr (0.08 – 0.05ppm) and Fe (98.00 – 24.50ppm), respectively. The concentration of heavy metal in tomato plant is Pb (46.75ppm); Zn (85.64ppm); Cu (13.35ppm); Cr (0.25ppm) and Fe (86.94ppm). The levels of heavy metals in the dumpsite soil and the soil after harvesting the tomato plant are: Pb (127.50 – 56.75ppm); Zn (157.60 – 65.80ppm); Cu (27.60 – 12.25ppm); Cr (3.60 – 1.50ppm) and Fe (785.50 – 653.75ppm), respectively. The *Amaranthus* specie from the dump soil accumulates more heavy metals than that of the control. The level of heavy metal in the dump soil decreases rapidly after harvesting the tomato plant.

**Keywords:** Heavy metals, dumpsite, health hazard, phytoremediation.

**INTRODUCTION**

Phytoremediation is a general term used to describe various mechanisms by which living plants alter the chemical composition of the soil matrix in which they are growing. Essentially, it is the use of green plants to clean-up contaminated soils, sediments, or water. Phytoremediation is considered an innovative, economical, and environmentally compatible solution for remediating some of heavy metal contaminated sites (Cummingham *et al*, 1997). There is a remarkable agricultural practice that

“is defined as the use of green plants to remove pollutants from the environment or to render them harmless”. There are several species of plants known for their phytoremediative abilities. Several of these plants are Tomato, Indian mustard, Sudan grass, sunflowers, and lemon-scented Geranium. This means that they are able to uptake large quantities of heavy metals and continue to thrive while storing these heavy metals in its plant tissue (Davies, 1983).

Many metals such as Zn, Mn, Ni, and Cu are essential micronutrients. In common nonaccumulator plants, accumulation of these micronutrients does not exceed their metabolic needs (<10ppm). In contrast, metal hyper accumulator plants can accumulate exceptionally high amounts of metals (in the thousands of ppm) (Alloway, 1996). Hyper accumulator plants do not only accumulate high levels of essential micronutrients, but can absorb significant amounts of nonessential metals, such as Cd (Howden *et al.*, 1995).

Heavy metal absorption is governed by soil characteristics such as pH and organic matter content. Thus, high levels of heavy metals in the soil do not always indicate similar high concentrations in plants. The extent of accumulation and toxic level will depend on the plant and heavy metal species under observation (Alloway, 1996).

Most abandoned waste dump sites in many towns and villages in Nigeria attract people as fertile ground for cultivating varieties of crops (Amusan *et al.*, 2005). According to Alloway (1996), plants grown on soils contaminated with heavy metal concentration have increased heavy metal ion content due to pollution. The cultivated plants take up the metals either as mobile ions present in the soil solution through the roots (Davies, 1983) or through foliar adsorption (Chapel, 1986). The objective of this study, therefore, was to evaluate the contaminations of heavy metals in the dump soil and investigate the potentials of tomato plant to reduce the concentration of heavy metals from the contaminated soil.

## MATERIALS AND METHODS

Isolo dumping site was the main dumping site for all the manufacturing industries along Apapa – Oshodi express way and Ire-Akari Estate for years even before man started living near the place. The dumpsite was closed in 1996 after nineteen years of operation, due to varying problems from the localities (Odunaiya, 2002). The abandoned dumpsite became a common place for farmers to cultivate a variety of crops. This is because it is generally believed that the

native fertility of the soil from waste dump sites is high. The area sampled was divided into four quadrants. The top soils (0 - 15 cm) were taken from each of the quadrants. *Amaranthus* seeds were plant on each quadrant. Tomato seeds were also planted where the soil samples were collected. *Amaranthus* seeds were also planted randomly in four different quadrants in Yaba College of Technology Botanical garden and harvested after four weeks. *Amaranthus* and tomato samples were collected from each quadrant in a diagonal basis following the method of Nounamo *et al.* (2000), after four weeks. The plants were carefully uprooted and bagged.

In the laboratory, the plant samples were placed under running tap water to wash off soil particles from the leaves, stems and roots. Stainless steel knife was used to cut the plant samples into different parts. The plant parts were dried in an oven maintained at 80°C, and then pulverized to fine powder using a laboratory stainless grinder. Ground plant samples collected in labeled polythene bags were placed in a desiccator. From each plant sample, 2g was accurately weighed into clean platinum crucibles, ashed at 450°C and then cooled to room temperature in a desiccator. The ash was completely dissolved in 5ml of 20% HCl and the solution was made up to volume in a 100ml volumetric flask. Analysis of the digest for the heavy metal content was carried out using the atomic absorption spectrophotometer. The soil samples were air – dried, crushed and passed through a 2mm sieve. One gram of the soil sample was digested in a 1:1 mixture of concentrated nitric acid and perchloric acid by heating the mixture plus sample on a water bath in a fume cupboard. The solution was heated to dryness while the residue was re-dissolved in 5ml of 2M HCl (Alloway, 1996)

## RESULTS AND DISCUSSION

The heavy metal content of the vegetable tissue is presented in Table 1. The transfer ratio of the heavy metals in vegetables in Table 2, and the metal Content of dump soil before and after planting tomato is presented in Table 3, respectively.

**Table 1:** Heavy metal content (ppm) in the vegetables

Heavy Metal	Edible part of <i>Amaranthus</i> from the Dumpsite (ppm)	Edible Part of <i>Amaranthus</i> from the Botanical Garden (Control) (ppm)	Tomato Plant (ppm)	Normal Range in Plant* mg/kg	Critical Concentration in Plant* mg/kg
Pb	35.00	23.68	46.75	0.2 – 20	5 – 30
Cr	0.08	0.05	0.25	0.03 – 14	2 – 18
Cu	7.68	4.34	13.35	5 – 20	20 – 100
Fe	98.00	24.50	86.94	-	-
Zn	8.70	4.00	85.64	1 – 400	100 - 400

\* (Alloway, 1996)  
 ND = Not Detected

**Table 2:** Transfer ratio of the heavy metals in the vegetables

Heavy Metal(ppm)	<i>Amaranthus</i>	Tomato
Pb	0.27	0.37
Cr	0.02	0.07
Cu	0.28	0.48
Fe	0.12	0.11
Zn	0.06	0.54

**Table 3:** Heavy metal content (ppm) of the soils

Heavy Metal	Conc. Of Metals in the dump soil before Planting Tomato (ppm)	Conc. Of Metals in the dump soil after Planting Tomato (ppm)	Range in Soils* (mg/kg)
Pb	127.50	56.75	2 -300
Cr	3.60	1.50	5 – 1500
Cu	27..60	12.25	2 - 250
Fe	785.50	653.75	-
Zn	157.60	65.80	1 - 900

\* (Alloway, 1996)

The tomato accumulates more metals than the *Amaranthus* from the dump soil as well as the control from the farmland. The result shows that vegetables harvested in soils of the refuse dump site presented higher levels of the metals when

compared to that from the control site (Table 1). This means that the level of these metals in dump soil is significantly higher than that of farm land (Odukoya *et al.*, 2001). Schnoor *et al.* (1995) reported that plant grown on soils

possessing enhanced metal concentrations have increased heavy metal ion content. The length of time that the soils were exposed to the contaminants affected the levels of concentrations; also the uptake of metal ions has been shown to be influenced by the metal species and plant parts (Juste and Mench, 1992). The transfer ratio (Table 2) is the level of the metal in the vegetable as a fraction of the soil total in the dump soil (Oyedele *et al.*, 1995). The level of Pb in the three samples is higher than the normal range in plant as reported by Alloway (1996), but lower than the critical level in plants.

The values of transfer ratio obtained, show that the uptake of each metal differs from one plant to another. *Amaranthus* has lower transfer ratio with the exception of Fe, which is greater than that of tomato. It was observed that the *Amaranthus* has more affinity for Fe than tomato. The ratios obtained for tomato were particularly high. This shows the potential of tomato plant for remediation. With increasing metal load in dump soils (Table 3), where these vegetables are grown, there is a greater tendency for their bio-accumulation.

#### Heavy metal content of the soils

The results show that soils from the dumpsites before and after harvesting tomato differ significantly ( $P > 0.05$ ) in their total metals content as shown in Table 3 below.

The level of metals after harvesting tomato plant reduced considerable for Zn, Pb and Cu. This indicates the remarkable ability of tomato plant to absorb and accumulate high concentration of these three metals. Tomato crop has been shown to have an exceptionally high tolerance for heavy metals (Baker *et al.*, 2000).

#### CONCLUSION AND RECOMMENDATIONS

The results of this work show that soils in refuse dump sites are high in heavy metal contents and that plants that grow in these sites bio-accumulate heavy metals than those in normal agricultural soils. It was also observed that plants differ in their ability to up-take metals. An enabling act advising and enforcing the non – use of refuse dump sites for farming is desirable. This will keep, in check, possible excessive consumption of these metals by man. If the consumption of these metals through plant sources is not carefully regulated, it may lead to accumulation in man with attendant health

hazards. Tomato plant was able to extract different concentrations of heavy metals from the soils.

In view of this tomato, plant can be used to clean up dump soil by farmers. This will decrease some of the metal elements present in the dump soil before the soil can be used as compost or for agricultural purposes. It is therefore, recommended that dump soil should not be used for agricultural purpose until after a cleaning process with metal hyper-accumulated plants, which must not be consumed by man or animal after harvesting.

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