



## Determination of the levels of heavy metal (Cu, Fe, Ni, Pb and Cd) up take of pumpkin (*Telfairia occidentalis*) leaves cultivated on contaminated soil

ECHEM, OGBONDA G

Department of science laboratory technology, Rivers State Polytechnic, Bori

**KEY WORDS:** Pumpkin Leaves, Cultivate, Contaminate.

**ABSTRACT:** The aim of this study was to use AAS to determine the levels of concentration (g/kg) of heavy metals: copper (Cu), Iron (Fe), Nickel (Ni), lead (Pb) and Cadmium (Cd) uptake by pumpkin (*Telfairia occidentalis*) leaves cultivated in Pots containing varying concentrations of contaminated soil samples labeled A to E. The results showed that leaves from soil sample A had heavy metal concentration level of Cd: 0.268, Ni:0.040, Pb:0.033, Fe:0.025 and Cu: 0.003. The order of uptake was Cd> Ni> Pb> Fe> Cu. In soil sample B, the concentration level of the metals were Fe:0.091, Cd:0.406, Ni:0.118, Pb:0.058 and Cu:0.006. The order of uptake was Cd> Fe>Ni> Pb> Cu. Results from soil sample C showed that the level of heavy metal concentration in the leaves were: Fe:0.311, Cd:0.380 Pb:0.204, Ni:0.116 and Cu:0.029. The order of uptake is Cd> Fe> Pb> Ni> Cu. In soil sample D, the results were Fe:0.101, Cd:0.087, Ni:0.070, Pb:0.07 and Cu:0.004. The order was Fe> Cd> Ni= Pb> Cu. The results from soil sample E gave the concentration levels as Fe:0.266, Cd:0.135, Ni:0.122, Pb:0.017 and Cu:0.004. The order of uptake was Fe> Cd> Ni> Pb> Cu. The result for the uncontaminated soil sample F, showed that the heavy metal concentration levels were Fe:0.035 Cu:0.003, Pb:0.008, Cd:0.050 and Ni:0.008. The order of concentration levels was Cd> Fe> Ni= Pb> Cu. The findings of this study reveal that pumpkin leaves bioaccumulate Cd more, followed by Fe while Cu was the least. Consequently, any agricultural soil suspected to have high concentrations of Cd, Fe, Ni and Pb will not be suitable for use in the cultivation of pumpkin leaves meant for human consumption or animal feed. This because the ingestion level of these metals are far above the WHO tolerable limit. However, pumpkin plants can serve as a good scavenger of Cd and Fe in polluted soil. © JASEM

<http://dx.doi.org/10.4314/jasem.v18i1.10>

**Introduction:** The determination of the level of uptake of heavy metals (Cu, Fe, Ni, Pb and Cd) in pumpkin (*Telfairia occidentalis*) leaves has become imperative since it is the most cultivated and consumed vegetable in Port Harcourt metropolis. The indiscriminate cultivation of pumpkin vegetable in every available space especially within the Trans Amadi area, domestic dumpsites, industrial dump sites and the common uncontrolled urban dumpsites is of much concern. A study by Eddy (2004a) has shown that the extent of soil pollution by heavy metals some of which were soil micronutrients is very alarming, (Awokunmi *et al.* 2010).

Echem (2010) has reported high level of Pb and Cd in cassava (*Manihot esculenta crantz*) harvested from oil polluted soil in Ogoni land. Van (1998) in his study, estimated the amount of Cd ingested by man that comes from terrestrial foods to be 98%. This study confirms earlier investigation carried out by

Elinder (1985) and WHO (1984) which reported that terrestrial foods grown in contaminated soil contain high level of Cd.

Lead has no known beneficial effect to man (Tyler 1981, and Moly 1984). According to Fatoki (2003), about 7% of the lead in the soil is taken up by plants.

Schwartz *et al.* (1986) had argued that chronic exposure to lead retard growth in children. International Agency for Research on Cancer (IARC, 1987) publication has shown that lead compound is carcinogenic to humans. Soil contaminated by heavy metal such as Cu, Cd, Ni and Pb is a threat to human life and the environment (Purves 1995). Ademoroti (1993), in correlating the total metal content of vegetables and of the soils where they were grown, concluded that the environment is significantly polluted by Cd, Pb and Ni. This is because the correlation between Cd, Pb and Ni content in the soils and vegetables grown in them shows that there

\*Corresponding author: e-mail: ogboweri@yahoo.com

is a positive linear correlation. According to Eddy *et al.* (2006), the natural range of the concentration of some of the metals in the soil are: iron (Fe) 3,000 to 500,000ppm; copper(Cu) 7 to 80ppm; lead (Pb) 15 to 25ppm and nickel (Ni) 0 to 100ppm.

Prolonged exposure to heavy metals such as cadmium, copper, lead, nickel and zinc can cause deleterious health effects in humans (Reilly 1991). Metal contamination of garden soils may be widespread in urban areas due to past industrial activity and the use of fossil fuels (Chronopoulos *et al.* 1997; Sanchez-Camazano *et al.* 1994; Sterrette *et al.* 1996; Van-Lune 1987; Wong 1996). Heavy metals may enter the human body through inhalation of dust, direct ingestion of soil, and consumption of food plants grown in metal-contaminated soil (Cabra *et al.* 1999; Dudka and Miller 1999; Hawley 1985).

## MATERIALS AND METHODS

A total of 12kg of humus soil sample was collected from the same source. 2kg of the soil was poured into six pots labeled A to F. The salts used to contaminate the soil were  $\text{CuSO}_4 \cdot 8\text{H}_2\text{O}$ ,  $\text{PbO}$ ,  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ,  $\text{CdSO}_4 \cdot 8\text{H}_2\text{O}$  and  $\text{NH}_4\text{SO}_4 \cdot \text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ . A separate homogenous mixture of 1g of each salt, 2g of each salt, 3g of each salt, 4g of each salt and 5g was prepared. Each of the mixture was poured into 1000cm<sup>3</sup> volumetric flask, deionized water added, stirred and made up to the mark.

The concentration per 1000cm<sup>3</sup> solution of the heavy metal in 1g mixture of salts was 0.40g Cu, 0.20gFe, 0.16gNi, 0.87gPb and 0.32gCd. The standard solutions containing mixtures of 1g, 2g, 3g, 4g and 5g salts were poured into soil sample pots labeled A to E respectively. Pot F had no salt added to it. The

standard solutions of heavy metals and the soil samples were mixed thoroughly using a hand trowel. Four pumpkin seeds were planted in each of the pots. The seeds germinated and stopped growing at different dates. It was observed that the pumpkin leaves had varying degrees of yellowish - green color, and they were harvested on the 30<sup>th</sup> day from the date of germination. The plants in pot F had normal growth and the color of the leaves remained green. The harvested leaves were wrapped in polythene bag and taken to the laboratory. In the laboratory, the leaves were removed from the stem, washed in water, drained in a colander, shredded and dried. The dried leaves were ashed in a furnace of 600<sup>o</sup>C.

The ashed samples were allowed to cool and then stored in air-tight plastic containers ready for elemental analysis.

In the determination of the levels of heavy metal in the sample, the digestive method as recommended by A.O.A.C. (1975) was used. 1g of each of the ashed sample was transferred to separate beakers, 10ml aqua-regia was added. The beakers were swirled gently and the content digested slowly in an electro thermal heater (250<sup>o</sup>C) for 15minutes. The temperature was controlled and allowed to increase gradually. The digest was cooled, filtered and diluted to 50ml with deionized water. The concentration of the heavy metals were determined by using atomic absorption spectrophotometer, model 205.

## RESULTS:

The results of the pot experiment carried out with pumpkin leaves harvested from different soil samples contaminated with varying levels of heavy metals are shown in table 1 and in figures 1 to 5 while Table 2 is for the uncontaminated soil sample.

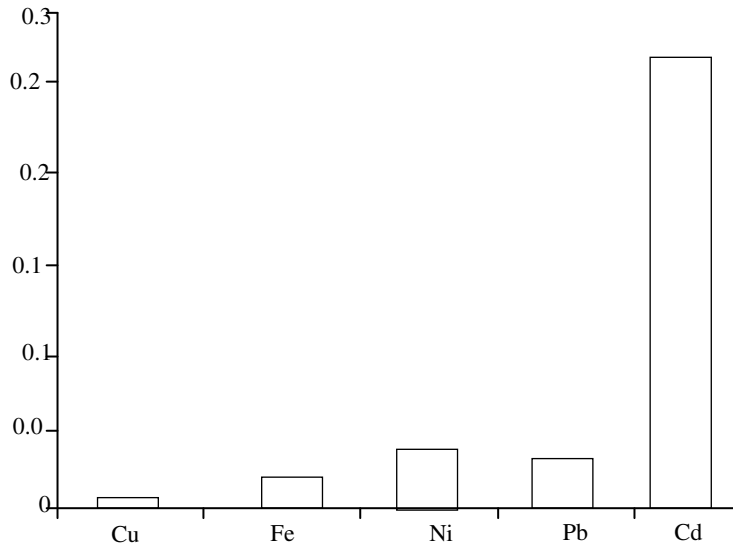
**Table1:** Levels of heavy metal ingested by pumpkin leaves in different contaminated soils.

Samples	Heavy Metals Ingested	Heavy Metals Ingested				
		Cu	Fe	Ni	Pb	Cd
1	Heavy metal concentration(g) in contaminated soil	0.404	0.235	0.160	0.880	<b>0.370</b>
	Levels of heavy metals ingested by leaves(g/kg) (Pot A)	0.003	0.025	0.040	0.033	<b>0.268</b>
2	Heavy metal concentration(g) in contaminated soil	0.804	0.435	0.320	1.74	<b>0.690</b>
	Levels of heavy metals ingested by leaves(g/kg) (Pot B)	0.006	0.091	0.118	0.058	<b>0.406</b>
3	Heavy metal concentration(g) in contaminated soil	1.204	0.635	0.480	2.609	<b>1.000</b>
	Levels of heavy metals ingested by leaves(g/kg) (Pot C)	0.029	0.311	0.116	0.204	<b>0.380</b>
4	Heavy metal concentration (g) in contaminated soil	1.604	0.835	0.640	3.469	<b>1.320</b>
	Levels of heavy metals ingested by leaves(g/kg) (Pot D)	0.004	0.101	0.070	0.007	<b>0.087</b>
5	Heavy metal concentration (g) in contaminated soil	<b>2.004</b>	<b>1.035</b>	<b>0.800</b>	<b>4.340</b>	<b>1.640</b>
	Levels of heavy metals ingested by leaves(g/kg) (Pot E)	<b>0.004</b>	<b>0.266</b>	<b>0.122</b>	<b>0.017</b>	<b>0.135</b>

Note : Heavy metal in contaminated soil = heavy metal in natural soil sample + added heavy metal from salt.

**Table 2:** Levels of heavy metal ingested by pumpkin leaves in uncontaminated soils.

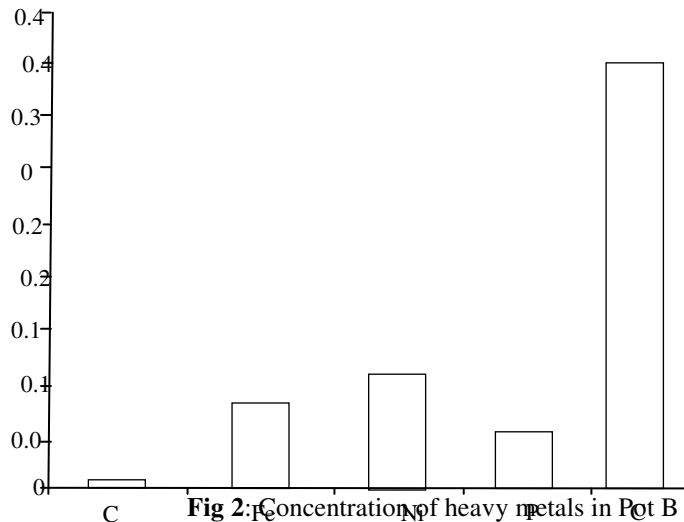
Soil sample	Concentration (g/kg) of Heavy metal ingested				
Uncontaminated soil	Cu	Fe	Ni	Pb	Cd
	0.003	0.035	0.008	0.008	0.050



**Fig 1:** Concentration of heavy metals in Pot A

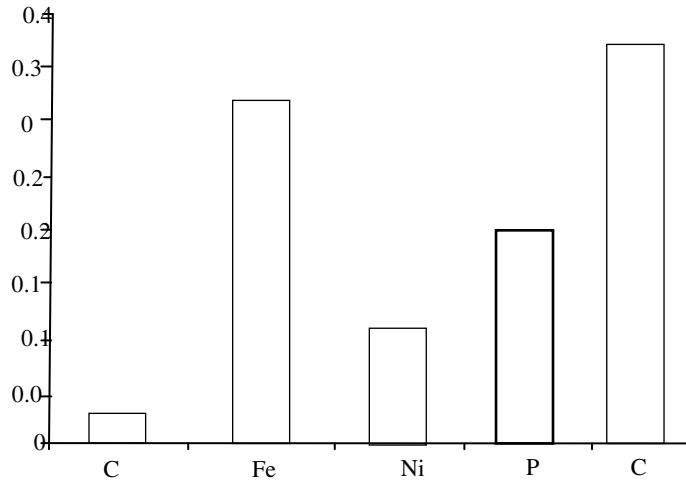
The concentration (g/kg) of the various heavy metals ingested by the pumpkin leaves in pot A were iron (0.025), nickel (0.040), lead (0.033), copper (0.003)

and cadmium (0.268). The results, showed that the order of ingestion was Cd> Ni>Fe> Pb> Cu



The concentration (g/kg) of the various heavy metals ingested by the pumpkin leaves in pot B were iron (0.091), nickel (0.118), lead (0.058), copper (0.006)

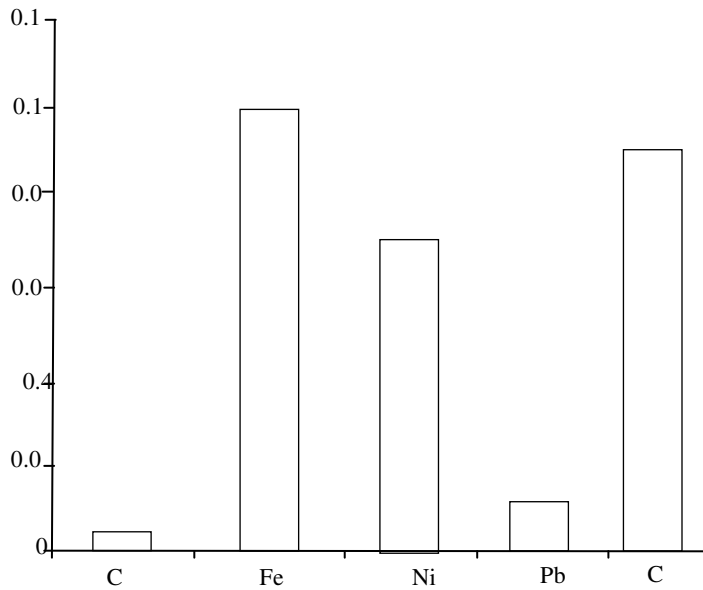
and cadmium (0.406). The results, showed that the order of ingestion was Cd>Fe> Ni> Pb> Cu



**Fig 3:** Concentration of heavy metals in Pot C

The concentration (g/kg) of the various heavy metals ingested by the pumpkin leaves in pot B were iron (0.311), nickel (0.116), lead (0.204), copper (0.029)

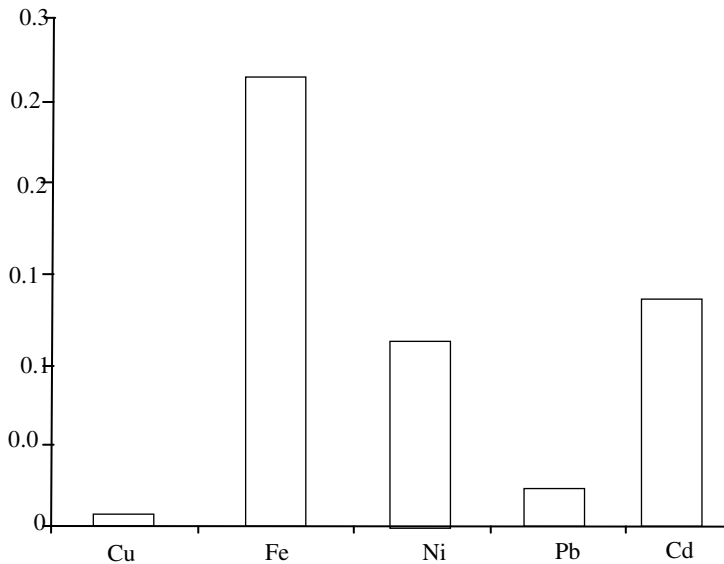
and cadmium (0.380). The results, showed that the order of ingestion was Cd>Fe>Pb>Ni> Cu



**Fig 4:** Concentration of heavy metals in Pot D

The concentration (g/kg) of the various heavy metals ingested by the pumpkin leaves in pot B were iron (0.101), nickel (0.070), lead (0.007), copper (0.004)

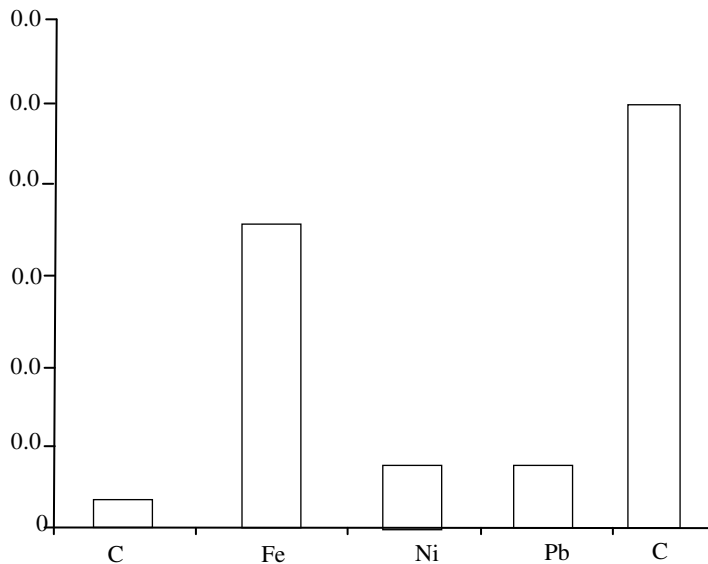
and cadmium (0.087). The results, showed that the order of ingestion was Fe> Cd> Ni> Pb> Cu



**Fig 5:** Concentration of heavy metals in Pot E

The concentration (g/kg) of the various heavy metals ingested by the pumpkin leaves in pot B were iron (0.266), nickel (0.122), lead (0.017), copper (0.004)

and cadmium (0.135). The results, showed that the order of ingestion was Fe > Cd > Ni > Pb > Cu



**Fig 6:** Concentration of heavy metals in Pot F

**DISCUSSION**

The pot experiments were under taken to investigate how the content of heavy metals in plants depended on the concentration of these elements in the soil. Different concentration levels of copper, iron, nickel, lead and cadmium were applied into the soil in liquid form to get the current concentration, this is because free metal ion activity ( $M^{2+}$ ) is often considered to be the most bioavailable species (Sauve *et al.* 1998).

The results showed that applying these heavy metals in different amounts into the soil increases the concentration of these elements both in soils and plants. It was obtained that the pumpkin plant assimilated more of Cd in its leaves more than any other heavy metal added. This finding is in agreement with the results of a similar study carried out by Kanger and Kaerblane(1995).

The concept of growing plants in different soils containing moderate to high amounts of heavy metals in a pot experiment as a way of determining the phytoremediation capability of some plant species has been reported (McGrath *et al.* 1997).

Excessive heavy metal concentrations in the contaminated soil is responsible for the observed retarded growth, different growth rate and the yellowish - green color of the leaves (McGrath *et al.* 1997). Studies had shown that two basic strategies exist by which plants respond to elevated concentrations of heavy metals in the environment: exclusive mechanisms, whereby plants avoid excessive uptake and transport of metals, and accumulation and sequestration mechanisms, whereby large amounts of metals are taken up and transported to the plant roots (McGrath *et al.* 1997). Table 1 showed that pumpkin leaves in Pot A to C ingested Cd more than any other studied heavy metals. The hyper accumulation of Cd by plants more than other metals has been reported as in *Thlaspi caerulescens* (McGrath *et al.* 1997), lettuce tissue (Schauer *et al.* 1980), and the highly nutritious leafy palak (*Beta vulgaris*) vegetable widely cultivated and consumed in urban India, particularly by the poor (Sharma *et al.* 2007). Studies have also revealed that Carrot roots accumulate Ni preferentially while tomatoes accumulate Cu more (Schauer 1980). A research on heavy metal uptake from greenhouse border soils for edible vegetables carried out by Zurera – Cosano *et al.* (1989) showed that green beans has a greater capacity of concentration of heavy metals such as Cd and Pb more than Cu. Also, *Cardaminopsis halleri* plant hyperaccumulates Cd in its leaves (Dahmani-Muller 2000). From figure 1 to 5, the concentrations of Cu is the least among others, this confirms the earlier findings of Zurera-Cosano *et al.* (1989). Although Cu is essential for plant growth, a very small amount of Cu is required by plants, for example, 5 to 20mg/g (dry weight) in plant tissue (Jung 2008). The range of the heavy metals ingestion from the pot experiment were: 0.006 – 0.029g/kg Cu, 0.025 – 0.311g/kg Fe, 0.040 – 0.122g/kg Ni, 0.033 – 0.204g/kg Pb and 0.087 – 0.406g/kg Cd. However, the allowable WHO tolerance limit of heavy metals for vegetables are 0.003g/kg Cu, 0.01 – 0.02g/kg Fe 0.001g/kg Ni, 0.002g/kg Pb and 0.001g/kg Cd comparing the pot experiment concentration levels of the heavy metals in the leaves with the WHO, EPA and EEC standards, it is observed that the leaves of pumpkin have the capacity to ingest high concentrations of heavy metals far above tolerable limit if cultivated in contaminated soils.

The implications of this study is that since excessive metal concentrations in contaminated soils can result in decreased soil microbial activity, soil fertility, yield and coupled with the difficulty associated with the removal of heavy metals from the soil, high cost of existing physical or chemical methods of soil clean-up which often results in destruction of soil structure, the use of bioaccumulation in specialized plant species may provide an effective and in situ way of removing heavy metals from contaminated soils (McGrath *et al.* 1997). Secondly, consuming pumpkin leaves cultivated on contaminated soil poses potential health problems to both animal and human.

**Conclusion:** The use of Pot experiment to investigate the dependency of heavy metal concentration levels of pumpkin leaves, the retardation of growth of plant and yield on the degree of contamination of the soil, has been demonstrated and confirmed to be positively related. It is suggested that further research of this nature should be carried out with other plant species as to determine their phytoremediation value on one hand and the need to educate urban dwellers to stop the practice of cultivating vegetables on any available land space without carrying out heavy metal concentration levels of the soil sample vis-à-vis the plant species to be cultivated.

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