Transfer of Heavy Metals from Soil to Cabbage (*Brassica oleracea*) grown in Irrigated Farmlands of Kaduna Metropolis.

W.L.O Jimoh[1] and M. I. Mohammed[2*]

[1] *Department of Pure and Industrial Chemistry, Bayero University, Kano Nigeria.*
[2] *Department of Applied Science, College of Science and Technology, Kaduna Polytechnic*
E-mail: mmimam9312@gmail.com

ABSTRACT

In this research work the accumulation of heavy metal and its transfer from the growing medium which is soil to the vegetable mainly cabbage was investigated. Twenty sampling sites were selected from irrigated farmlands of Kaduna metropolis were there is intense agricultural practice, and one control site were there is less human activities. The Concentrations of heavy metals (Cd, Fe, Cu, Zn and Pd) for the soil and cabbage were determined with the help of atomic absorption spectrophotometer (AAS) after acid digestion. The results revealed that all transfer factors are below 1 with the exception of samples from Rigasa (18.25 μgg^{-1} for Cd), Kakuri (1.27 μgg^{-1} for Cd), Kawo (2.35 μgg^{-1} for Cd), Unguwan Sanusi (15.66 μgg^{-1} for Cd), Tudunwada (2.95 μgg^{-1} for Cd), Costain (1.00 μgg^{-1} for Cu) and Kurmi mashi (1.07 μgg^{-1} for Cu and 1.15 μgg^{-1} for Pb). The transfer factor values obtained in most of the sampling sites were lower than that obtained from Rigachikun (control site) 0.45 μgg^{-1} for Cd, 0.24 μgg^{-1} for Fe, 0.43 μgg^{-1} for Zn, 0.94 μgg^{-1} for Cu and 0.55 μgg^{-1} for Pb . It was also established that the highest metal transfer from soil to cabbage is cadmium. After this, increasing order of transfer factor in this analysis are lead, copper, iron and zinc. That is, Cadmium > lead > copper > iron > zinc. This is as a result of increasing usage of fertilizers,biosolids and other related amendments to boost agricultural production.

Keywords: Soil, cabbage, transfer factor, heavy metals, atomic absorption spectrophotometer, Kaduna Metropolis, Nigeria.

INTRODUCTION

Heavy metals are among the major contaminant of food supply and are considered as problem to the environment[1]. Heavy metals contamination may occur due to irrigation with contaminated water, the addition of fertilizers, metal based pesticides, industrial emissions, transportation, harvesting process and storage. Advancement in technology has lead to high levels of industrialization leading to the discharge of effluent bearing heavy metals into our environment.Unlike organic waste, heavy metals are non-biodegradable and they can be accumulated in living tissues, causing various diseases and

disorders, therefore, they must be removed before discharge [2].

Heavy metals are among the major contaminant of food supply and are considered as problem to the environment[1]. Heavy metals contamination may occur due to irrigation with contaminated water, the addition of fertilizers, metal based pesticides, industrial emissions, transportation, harvesting process and storage. Advancement in technology has lead to high

levels of industrialization leading to the discharge of effluent bearing heavy metals into our environment.

The main sources of lead pollution in the environment are: Industrial production processes and their emission, road traffic using leaded petrol, the smoke and dust emissions of coal and gas-fired power stations. Lead is very difficult to be excreted if consumed this is because little is known about the excretion of lead, once it has been absorbed. As such lead is not considered to be carcinogen or mutagen.

Most of the people obtained large amount of lead intake from food while other source may be water in areas with lead piping and plumbosolvent water, air, soil, dust, paint flakes in old houses or contaminated land.

Lead affects children by causing poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient (IQ) [3].

Cadmium exists in low concentrations in all soil. It is actively extracted from its ores for commercial purposes and also emitted from industrial processes such as metal melting and refining, coal and oil-fired power stations, electroplating plants etc.

Cadmium is concentrated particularly in the kidneys, liver, blood forming organs and in the lungs. It result to kidney damage (necrotic protein precipitation) and metabolic anomalies caused by enzyme inhibitions. It is now known as *itai – itai* sickness in Japan (with bone damage) which is as a result of the regular consumption of highly contaminated rice [4].

Zinc is essential for growth and has important functional role in cellular immunity, sexual maturation and wound healing [5]. The chief important role of zinc in the body is that, it promotes wound healing, moderate attack of sickle cell anaemia and controls some of the hereditary disease such as acrodermatitis enteropathics.[6].

Adverse effects of zinc toxicity include gastrointestinal problem such as epigastric pain, nausea etc. It also retards growth and enlarges liver[7]. Zinc deficiency also includes hair loss, damaging of body tissues and eventually death while too much of it suppresses copper and iron absorption.

Copper is a very common substance that occurs naturally in the environment and spreads to the environment through natural phenomena. Copper can also be released into the environment through natural sources and human activities, examples of natural sources are dust, decaying vegetation, forest fires and sea spray. Other examples are mining, metal production, wood production and production of phosphate fertilizer.

Copper poisoning results in Wilson's disease characterized by hepatic cirrhosis, brain damage, demyelisation, renal disease and copper deposition in the cornea [8].

Excess accumulation of copper in tissues genetically results in a condition known as hepatolenticular regeneration. It also causes liver cirrhosis and brain disturbance [9].

Iron is widely distributed and is responsible for the colour of most of the soils. Iron is very essential to all organisms, animals and plant. It also functions as a catalyst and is present in amount greater than that of any other trace elements. Excessive iron intake result to a toxic effect. For instance iron acts as catalyst for free radical generating reaction. Consequently, an excess of free iron through the enhancement of cellular oxidative reaction as lipid peroxidation can lead to oxidative damage [10].

Soil is a vital resource for sustaining basic human needs, a quality food supply and a liveable environment [11]. It serves as a sink and recycling factory for both liquid and solid waste. Municipal solid waste has been found to contain appreciable quantity of heavy metals such as Cd, Zn, Pb and Cu all which may eventually end – up in the soil [12]. Other identifiable sources include atmospheric depositions, manure and fertilizers, pesticides and industrial discharge.[13].

Heavy metal in soil is either from pedogenic or anthropogenic sources. Studies of heavy metals in soil have tended to concentrate on sewage sludge and aerosol deposition source with limited attention being given to municipal solid waste source. Most often the levels of heavy metal in soil reflect the level of industrialization of the area [14].

People eat vegetables raw or cooked and use them as part of their meal in the form of salad, soup and snacks. Vegetable is an important part of human diet since they contain carbohydrates, proteins as well as vitamins, mineral and trace elements [15].

Cabbage (*Brassica oleracea)* is an important part of human diet since they contain carbohydrates, proteins as well as vitamins, mineral and trace elements. Human beings are encourage to consume more vegetables especially cabbage and fruits, because they are good source of vitamins, minerals, fibres and also beneficial to their health. However, these plants contain both essential and toxic metals over a wide range of concentrations.

The aim of this research work is to investigate the amount of heavy metals transferred from soil to cabbage so as to know the extent of contamination if found extremely above concentrations stipulated by various agencies

MATERIAL AND METHOD

Sample and Sampling:

Cabbage samples were collected from twenty one (21) different irrigation site of the farmlands of the Kaduna metropolis where they were irrigated with water from the river or pond which are sometimes contaminated. Soil samples were also randomly collected from the farm where these vegetables were grown and irrigated with water. These samples were then stored in polythene bags and taken to the laboratory and dried in an oven at 100^0C.

The dried samples were ground with mortar and pestle and sieved with 2mm sieve.

Sampling Sites and their Codes

Soil samples and Cabbage samples for heavy metal determination were collected from twenty one (21) irrigation sites of the Kaduna metropolis. These sites were shown in the below table

SAMPLE PREPARATION

Cabbage samples

5g of the ground Cabbage samples were ashed in a muffle furnace at a temperature of 550^0c for five hours and digested with 20cm^3 of HNO_3/H_2O_2 (2:1). The digested residues were dissolved with 50cm of distilled water and filtered in 50cm^3 volumetric flask.

***Soil sample*:**

20g of the finely ground soil samples was mixed with 60cm^3 (5:5:1) $H_2SO_4/HNO_3/HCl$ acid mixtures and the content were refluxed for 12 hours. The sample was washed with 1M HNO_3 and 100cm^3 of deionized water was also added and centrifuged. The elements (Fe, Zn, Cu, Cd and Pb) were determined using bulk scientific model VPG 210 model atomic absorption spectrophotometer (AAS).

Transfer of Heavy metals from soil to cabbage

In order to determine the ratio of the concentration of heavy metal in a plant to the concentration heavy metal in soil, the transfer factor was calculated based on the method described by[16 and 17]

$$TF = Ps\ (\mu gg^{-1}/ St\ (\mu gg^{-1})$$

Where Ps is the plant metal content originating from the soil and St is the total metal content in the soil.

According to [18] plant uptake is one of the major path ways by which metal in soil enter the food chain. The food chain plants might absorb enough amounts of heavy metals to become a potential health hazard to consumers.

The transfer factor is an index for evaluating the transfer potential of a metal from soil to plant.

Table of the sampling sites and their codes

S/NO	Sampling Sites	Codes
1.	Kabala	KBL
2.	Danmani	DMN
3.	Barnawa	BNW
4.	Makera	MKR
5.	Badiko	BDK
6.	Nasarawa	NAS
7.	Malali	MAL
8.	Kudenda	KUD
9.	Kinkinau	KKN
10.	Kawo	KWO
11.	Unguwan Rimi	URM
12.	Unguwan Sanusi	UNS
13.	Tudun Wada	TDW
14.	Doka	DKA
15.	Unguwan Dosa	UDS
16.	Costain	CTA
17.	Kurmin Mashi	KMS
18.	Abakpa	ABK
19.	Kakuri	KKR
20.	Rigasa	RGS
21.	Rigachikun (Control)	RCK

RESULTS AND DISCUSSION

The mean concentration of some heavy metals and that of the transfer factor from soil to cabbage were shown in the below table 1.0 and 2.0 respectively

Table1.0: Heavy metals in cabbage samples from different irrigation sites of the Kaduna Metropolis

Sampling sites	Cd (μgg^{-1})			Fe (μgg^{-1})			Zn (μgg^{-1})			Cu (μgg^{-1})			Pb (μgg^{-1})		
KBL	0.04	±	0.02	1.85	±	1.80	0.46	±	0.30	ND		ND	2.67	±	0.84
DMN	0.38	±	0.23	0.51	±	0.78	14.29	±	3.75	ND		ND	3.34	±	2.02
RGS	1.1	±	0.14	6.39	±	0.96	ND		ND	ND		ND	0.61	±	0.20
BNW	0.89	±	0.72	8.06	±	1.52	3.67	±	3.19	1.7	±	1.51	2.73	±	0.42
MKR	0.27	±	0.12	8.67	±	3.21	8.67	±	1.51	3.3	±	1.45	2	±	0.6
KKR	0.93	±	0.31	9.26	±	4.63	7.3	±	4.35	3.3	±	1.15	1.28	±	0.79
BDK	0.03	±	0	4.02	±	3.17	0.73	±	0.64	ND		ND	1.16	±	0.14
NAS	1.27	±	0.31	5.53	±	2.19	7.53	±	1.50	3.33	±	1.11	2.87	±	0.31
MAL	0.87	±	0.42	7.27	±	3.10	6.63	±	2.31	3.03	±	1.06	2.93	±	1.42
KUD	1.07	±	0.50	7.47	±	3.45	7.1	±	3.12	4.73	±	1.80	3.43	±	1.36
KKN	0.6	±	0.4	12.4	±	4.2	5	±	2.03	3	±	0.35	1.73	±	0.46
KWO	1.27	±	0.12	7.33	±	2.08	8.03	±	1.78	3.47	±	1.62	1.73	±	0.76
URM	0.93	±	0.42	12.13	±	3.44	7.2	±	2.31	5.17	±	1.82	2.67	±	1.50
UNS	0.53	±	0.31	11.53	±	7.02	7.23	±	0.29	5.01	±	2.75	2.5	±	0.5
TDW	0.59	±	0.56	10.93	±	2.20	2.72	±	3.63	1.73	±	3.00	2.88	±	0.29
DKA	1	±	0.2	10	±	5.19	9.63	±	0.71	3.6	±	2.52	3.88	±	2.01
UDS	0.8	±	0.2	8.67	±	3.70	6.73	±	1.97	3.17	±	0.74	3.73	±	3.06
CTA	0.6	±	0.35	11.67	±	5.52	6.63	±	0.51	4	±	3.55	2.07	±	1.33
KMS	0.87	±	0.31	7.73	±	4.16	6.57	±	2.69	5.83	±	0.85	3	±	1.97
ABK	0.87	±	0.58	8.67	±	0.61	4.93	±	3.71	3.32	±	1.29	3.4	±	1.56
RCK	0.6	±	0.2	5.28	±	3.61	7.4	±	4.46	3.33	±	1.37	2.03	±	0.45

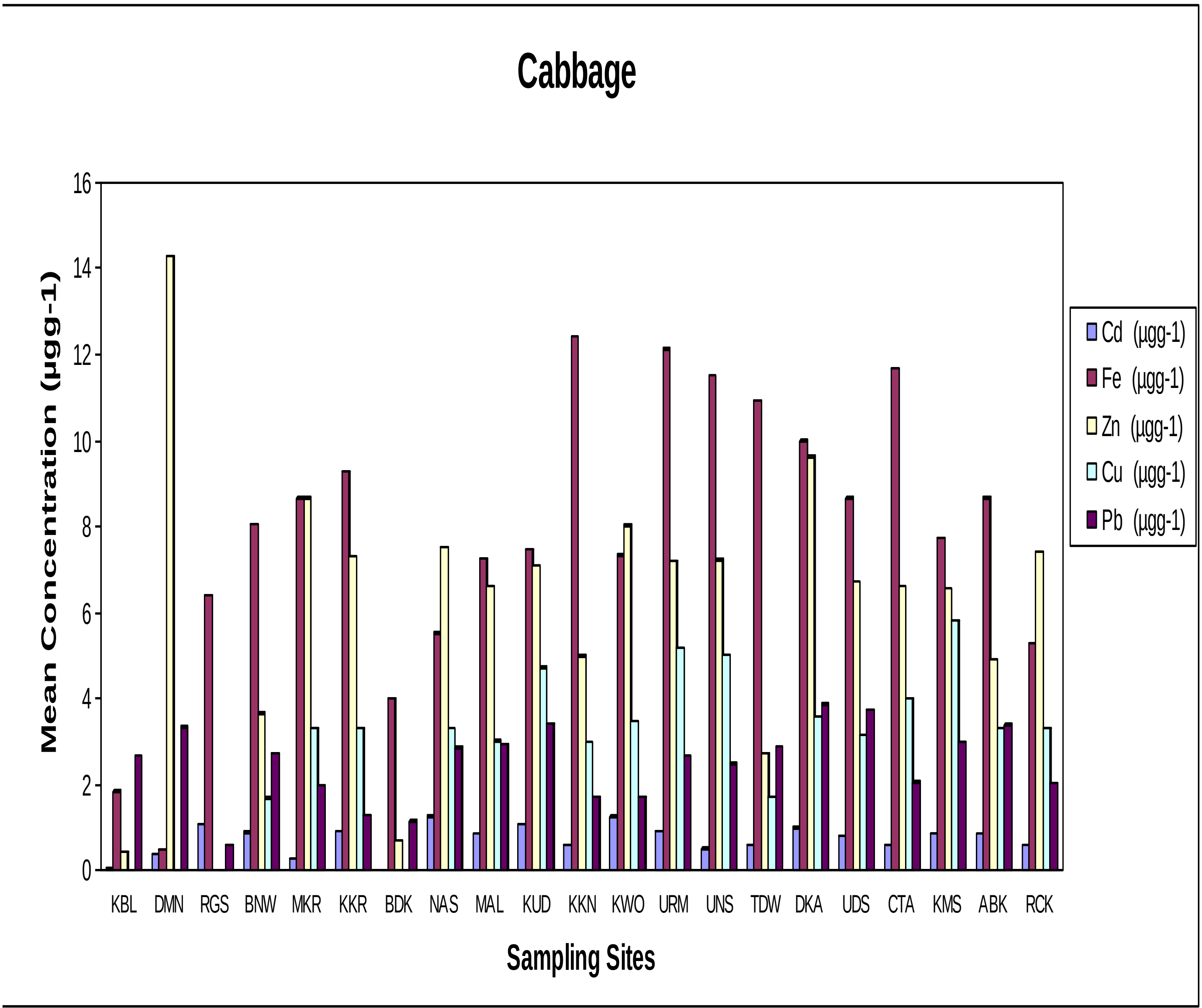

Fig. 1.0: Heavy metal in Cabbage sample from different irrigation sites of the Kaduna Metropolis

Figure1.0 showed that in the Cabbage samples analyzed for heavy metal, Zinc from DMN is being absorbed more than the other element. This is because it had 14.29 ± 3.75µgg^{-1} and Iron from KKN with 12.4 ± 4.2µgg^{-1}. However, Copper from KMS sample with 5.83 ± 0.85µgg^{-1} and Pb (DKA) had 3.88 ± 2.01µgg^{-1} were next in this series. Cadmium from Cabbage sample had their concentration in NAS and KWO as 1.27 ± 0.31µgg^{-1} and 1.27 ± 0.12µgg^{-1} respectively.

Therefore, the absorption of these heavy metals are in the following increasing order

Zn (DMN) > Fe (KKN) > Cu (KMS) > Pb (DKA) > Cd (NAS & KWO).

Table 2.0 :Transfer factor (TF) for each metal from soil to Cabbage

Sampling Sites	Cd (μgg^{-1})	Fe (μgg^{-1})	Zn (μgg^{-1})	Cu (μgg^{-1})	Pb (μgg^{-1})
Kabala	0.03	0.04	0.01	0.00	0.64
Danmani	0.37	0.01	0.46	0.00	0.84
Rigasa	18.25	0.06	0.00	0.00	0.05
Barnawa	0.39	0.08	0.11	0.04	0.08
Makera	0.14	0.19	0.21	0.40	0.63
Kakuri	1.27	0.09	0.14	0.19	0.04
Badiko	0.02	0.09	0.03	0.00	0.53
Nasarawa	0.71	0.13	0.24	0.44	0.62
Malali	0.69	0.58	0.24	0.74	0.77
Kudenda	0.49	0.16	0.18	0.59	0.69
Kinkinau	0.39	0.35	0.17	0.47	0.50
Kawo	2.35	0.07	0.17	0.17	0.04
Unguwan Rimi	0.93	0.12	0.11	0.25	0.16
Unguwan Sanusi	15.66	0.11	0.06	0.62	0.26
Tudunwada	2.95	0.11	0.32	0.07	0.56
Doka	0.80	0.13	0.27	0.25	0.13
Unguwan Dosa	0.51	0.54	0.24	0.63	1.01
Costain	0.39	0.40	0.30	1.00	0.82
Kurmi mashi	0.59	0.20	0.30	1.07	1.15
Abakpa	0.72	0.45	0.19	0.94	0.98
Rigachikun	0.45	0.24	0.43	0.94	0.55

Table 2.0 shows transfer factor for heavy metal from soil to Cabbage. All transfer factor are below 1 with the exception of samples from Rigasa (18.25 for Cd), Kakuri (1.27 for Cd), Kawo (2.35 for Cd), Unguwan Sanusi (15.66 for Cd), Tudun wada (2.95), Costain (1.00 for Cu) and Kurmi mashi (1.07 for Cu and 1.15 for Pb).

The transfer factor values obtained in most of the sampling sites were lower than that obtained in Rigachikun (control site).

Transfer factors of 0.15, 0.85, and 0.63 for Fe, Zn and Pb respectively has been reported[19]. These values were lower than that obtained in this research work. Also[20] recorded 2.5 TF for Cd. This is Figure 2.0 revealed transfer factor from soil to cabbage. This shows that, the highest metal transfer from soil to cabbage is also cadmium. This showed that cadmium is more mobile than other metals[20] have reported that Cd is retained less strongly by the soil and hence it is more mobile than other metals. higher than most of the value obtained for Cadmium in the present study.

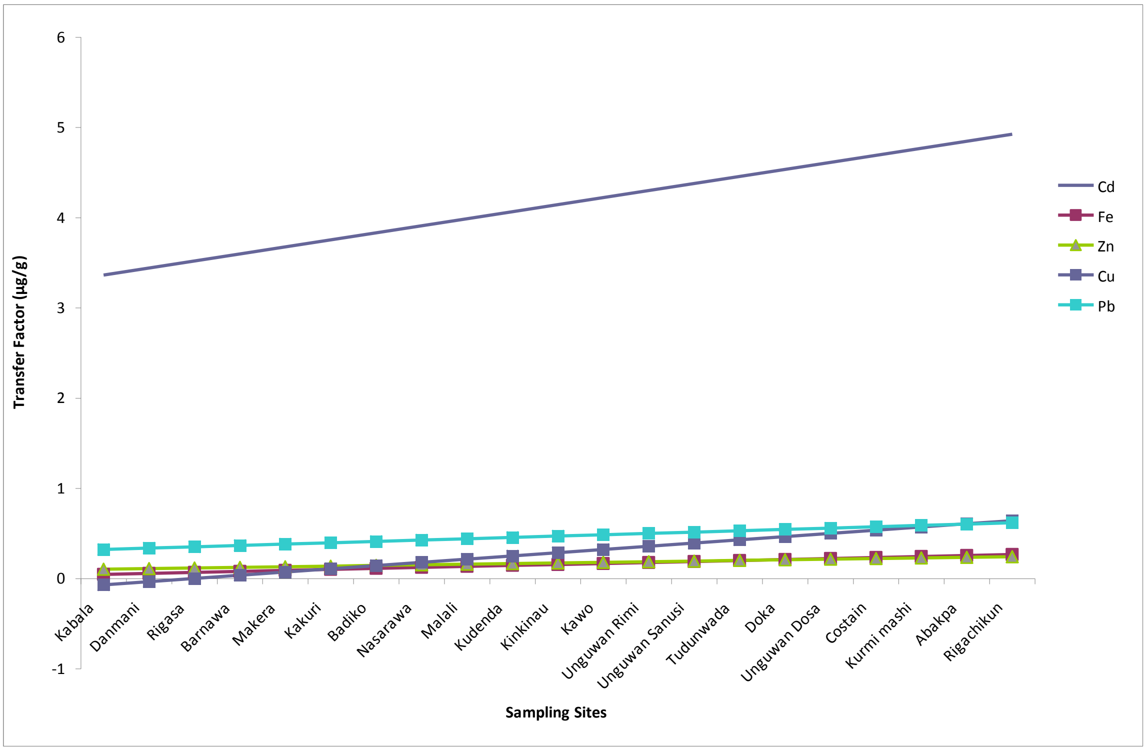

Fig. 2.0: A plot of transfer factor from soil to cabbage

After this, increasing order of transfer factor in this analysis are lead, copper, iron and zinc. This is as a result of increasing use of fertilizers, biosolids and other related amendments to boost agricultural production and increasing reuse of treated and untreated wastewater as irrigation water and also due to plant – human transfer and biomagnifications of trace metal contamination.

This is summarized in below series:-Cadmium > lead > copper > iron > zinc

CONCLUSION

Based on the results obtained this analysis, the transfer of heavy metal from the soil to the cabbage is in the following increasing order:- Cadmium > lead > copper > iron > zinc This also showed that cabbage samples absorbed much cadmium metal than any of the analyzed metals. This is because cadmium is retained less strongly by the soil and hence it is more mobile than other metals.It is very important to know that Cadmium if absorbed is concentrated particularly in the kidneys, liver, blood forming organs and in the lungs. It also result to kidney damage (necrotic protein precipitation) and metabolic anomalies caused by enzyme inhibitions. It is now known as *itai – itai* sickness as it occurs in Japan (with bone damage) which is as a result of the regular consumption of highly contaminated rice

The transfer factor values obtained in most of the sampling sites were found to be lower than that obtained in Rigachikun (control site). This is as a result of increasing use of fertilizers and reuse of treated and untreated wastewater in irrigation and also due to plant – human transfer and biomagnifications of trace metal contamination. The result also revealed other analyzed heavy metals were also accumulated in the cabbage samples and hence toxic for human consumption if found above stipulated limit imposed by various health organizations.

ACKNOWLEDGEMENT

The Authors were grateful to the management of Kaduna Polytechnic for sponsoring this research

REFERENCES

1. Zaidi M.I.; Asrar A; Mansoor, A; Farooqu, M.A (2005): The heavy metal concentration along roadside trees of Quetta and its effects on public health. *J. Appl. Sci.* 2 (4), 708 – 711.

2. Namasivayam, C. and Ranganathan, K. (1995). Removal of Pb(II), Cd(II) and Ni (II) and mixture of metal ions by absorption onto waste Fe (III)/Cr (III) hydroxide and fixed bed studies. *Environ. Tecnol.* 16, 851- 860.

3. Udedi, S.S., (2003). From Guinea worm scourage to metal toxicity in Ebonyi State, *Chemistry in Nigeria*. 2(2): 13-14.

4. Duruibe J.O, Ogwuegbu, M.O.C and Egwurugwu J.N. (2007): Heavy metal pollution and human biotoxic effects. *International journal of physical sciences* . 2 (5) 112 – 118.

5. Favier, A.E., (1992). Hormonal effect of zinc on growth in children. *Bio Trace Elements Res.* 32:383-398.

6. Ferner D.J. (2001): Toxicity HeaGvy Metals.*emed. J.* (2) 5:1.

7. Bettelheim, F.A. and March, J. (1991). *Introduction to General Organic, and Biochemistry. 3rd Edition.* Harcourt Brace Jovavich Press Australia. Pp 727.

8. Lenntech ,(2004). *Water treatment,* published by the Bird Hospital, Co, U.S.A (http://www.cockatiels. Org/articles/diseases/metals.htm).

9. Bridge, R. F. (1972). *The Encyclopedia of Geochemistry and Environment Science.* Vanmoster and Reinhold W. London Pp 319-321.

10. McCluggage D. (1991): Heavy metal poisoning, NCS magazine, published by the Bird Hospital, Co, USA www.cockatiel.org/articles/diseases/metals:html).Retrieved on 15th June,2009

11. Wild A. (1995). *Soil and the Environment*: An introduction. Cambridge University Press 1st edition pp 109-165.

12. Alloway, B.J, Ayres, D.C, (1997). *Chemical principles of environmental pollution,* Blackie Academic and professional 2nd.edition Blackie press UK pp190 – 220.

13. Holgate M W (1979): *A perspective of Environmental pollution,* Cambridge University Press, Cambridge UK 3th edition pp 55 – 65.

14. Ferlex incorporated (2005). Definition: Environment, *the Free Dictionary,*

Farlex Inc. Publishing, U.S.A (www.thefreedictionary.com/) .Retrieved on 5th October, 2010.

15. Dastane, N. G. (1987). Use of Brackish water in horticulture. *Water Quality Bull.* 12:64-71.

16. Oyedele, D.J. Obioh, I.B, Adejumo J.A, Oluwole A.F, Aina, P.O, Aubiojo, O.I (1995); Lead contamination of soils and vegetation in the vicinity of a lead smelter in Nigeria. *The Sci. of the total Environ*. 1732: 189 – 195.

17. Harrison R.M and Chirgawi M.B, (1989). The assessment of air and soil as controbutor of some trace metal to vegetable plants III-experiment with field-grown plants.*Sci Total Environ*, 83:47-63.
work.

18. Rasheed, M.N. and Awadallah (1998). Trace element in Faba (Vica Faba L) plant and soil as determined by atomic absorpeion spectrophotometer and iron select vie electrode/. *J.Sci Total Environ* 172, 18-24.

19. Francis, O.A. (2005). Trace metal contamination of soil and vegetation in the vicinity of livestock in Nigeria. *Electronic Journal of Environment, Agricultural and food chemistry.* 4(2):863-870.

20. Lokeshwari, H. and Chandrappa, G.T. (2006). Impacts of heavy metals contamination of Bellandar Lake on Soil and Cultivation vegetation. Current Science, *Research Articles*. Vol 91(5): 622-627