International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 10 Issue 6 Series III || June 2021 || PP 19-26

Transfer Of Heavy Metals from Soil to Tomatoes *(Solanum lycopersium)* Grown In Irrigated Farmlands of Kaduna Metropolis.

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ABSTRACT: *The present investigation deals with the accumulation of heavy metals such as Cd, Fe, Zn,Cu and Pb are accumulated by the soil and transferred to the tomatoes grown in irrigated farmlands of Kaduna metropolis. Twenty sampling sites were selected from different agricultural areas of Kaduna metropolis along with a control site (Rigachikun). Soil and tomatoes samples were acid digested and analysed for heavy metals with the atomic absorption spectrophotometer (AAS). The result of this work showed that Zinc from Kabala sample is absorbed more than all elements analyzed for tomatoes from the irrigation sites of the Kaduna metropolis. The absorption of heavy metal in the present study are arranged in the following increasing series. Zn (KBL) > Fe (TDW) > Cu(KKR) > Pb (KMS) > Cd(NAS and DKA) Most of the transfer factors in the studied samples are below 1 with the exception of samples from Rigasa (17.25 μgg^{-1} for Cd), Kakuri (1.01 μgg^{-1} for Cd), Kawo (1.56 μgg^{-1} for Cd), Unguwan Sanusi (3.00 μgg^{-1} for Cd), Tudunwada (1.60 μgg^{-1} for Cd) , Doka (1.06 μgg^{-1} for Cd), Abakpa (1.00 μgg^{-1} for both Cu and Pb) and Rigachikun (control) (1.00 μgg^{-1} for Cu).The result also revealed that cadmium is highly transferred from the soil to tomatoes. This is because high concentration of heavy metal such as cadmium in tomatoes may occur due to irrigation with contaminated water. Transfer factor in this work is arranged in the following order , Cadmium > copper > lead > zinc and iron. When vegetable accumulates heavy metals at a proportion exceeding the tolerance limit and if consumed may be toxic and causes varieties of illness*

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

Date of Submission: 06-06-2021 Date of Acceptance: 20-06-2021

I. INTRODUCTION

The term "heavy metals" refers to any metallic element that has relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). Heavy metals are general terms, which apply to the group of metals and metalloids with atomic density greater than 4g/cm^3, (Huton and Symon, 1988; Garbarino *et al*., *1995*, Hawkey 1997., Nriagu, 1999).

This classification includes transition metals and higher atomic weight metals of group III to V of the periodic table. Heavy metals include lead cadmium, zinc, copper, iron etc (Duruibe *et al.*, 2007).

The sources of heavy metals in plants are their growth media from which heavy metals are taken up by roots. Although some heavy metals such as Cu, Zn, Mn, Fe etc are essential in plant nutrition, many heavy metals do not play significant role in the plants physiology. Plants growing in a polluted environment can accumulate the toxic metal at high concentration thereby causing serious risk to the human health when consumed (Kabata – Pendias, 1984, Alloway, 1990, Vousta *et al*, 1996). Heavymetals have been excessively released into the environment due to rapid industrialization and have created a major global concern (Wan Ngah and Hanafiah, 2008). 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 (Namasivayam and Ranganathan, 1995).

Industrial products that are used in homes and which have been produced with heavy metals are other sources of human exposure to such heavy metals. Mercury exposure is through disinfectants, antifungal agents, toiletries, creams and organo-metallics (McCluggage, 1991). Cadmium exposure is through nickel/cadmium batteries and artist paints; lead exposure is through wine bottle wraps, mirror coatings, batteries, paints and tiles.

Lead occurs naturally in the environment. Most lead that is found in the environment is as a result of human activities due to the application of gasoline, which is an unnatural lead – cycle consisting of lead salts entering the environment through car exhausts. The larger particles will drop to the ground immediately and pollute soil or surface water while the smaller particles will travel long distance through air and remain in the atmosphere and fall back on earth when it is raining. The lead cycle caused by human production is much more extended than the natural lead-cycle.(Ogwuegbu and Muhanga, 2005)

Lead causes injuries to mental development such as reduction of intelligence and growth disturbances. Children are particularly at risk for lead consumption, both before and after birth as they absorb lead more rapidly than adults. Particularly affected are small children with their habit of placing dirty fingers and objects of all kinds into their mouth (or licking them which is refer to as mouth/hand activity) and in this way, swallowing dust and soil particles containing heavy metals, for example from lead – based paints (Alloway and Ayres, 1997).

Cadmium contamination cannot be removed from plants by washing them; it is therefore distributed throughout the organism. It is often difficult to mention the cause of a cadmium content found in fruit or vegetables, as cadmium in its natural form exists everywhere in the soil and is absorbed by the roots. The major pathway of lead is through food via the addition of cadmium to agricultural soil from various sources (atmospheric deposition and fertiliser application) and uptake by food and fodder crops.

Depending on the severity of exposure the symptoms of cadmium toxic effects also include nausea, vomiting, abdominal cramps, dysperia and muscular weakness. Severe exposure may result in pulmonary Odema and death. (McCluggage, 1991; INECAR, 2000; E.U, 2002; and Young, 2005).

Zinc can also be present as alloys. It is used in rubber industries, manufacture of dry batteries, roofing and exterior fitting on building and pharmaceutical industries where it is used in ointment, shampoo (Ferner, 2001).

Zinc is essential for growth and has important functional role in cellular immunity, sexual maturation and wound healing (Favier, 1992). 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. (Ferner,2001)

Zinc has similar symptons of illness to that of lead and can easily be mistakenly diagonised as lead poisoning (McCluggage, 1991). Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction (INECAR, 2000; Nolan, 2003). The significant signs of zinc toxicity has been reported as vomiting, diarrhoea, bloody urine, liver failure, kidney failure and anaemia.

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. However excessive iron can damage the cells of the gastrointestinal tract and may also damage the cell in the ear and liver. (Ademoroti, 1996).

Soil is a loose surface of the earth distinguished from rock. It is a medium in which crops grow. But to civil engineer, soil is the material that supports buildings and construction of roads (Zampella, 2003). Soil is a vital resource for sustaining basic human needs, a quality food supply and a liveable environment (Wild, 1995). 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 (Alloway and Aryes 1997). Other identifiable sources include atmospheric depositions, manure and fertilizers, pesticides and industrial discharge. (Holgate, 1979).

The accumulation of trace metals in agricultural and non-agricultural soils poses health hazards (Peplow, 1999). Some of the health effects of trace metals include skin irritation, damage to the liver, kidney circulatory and nerve – tissue resulting from acute or chronic exposure

Pollution of plants is of concern for two major reasons. Firstly, pollutants may have direct or indirect phytotoxic impacts on the plants themselves, leading to a decline in crop yields and threatening our food supply. Secondly the plants may act as a vehicle for transferring pollutants into the food chain. For example, cadmium is readily accumulated by plants and may get to levels which are adverse to the plants themselves, consequently posing a significant threat to animal and human that consumes such plants. Heavy metals and pesticides are major pollutants in this respect (Radojevic and Bashkin 1999).

In municipal sewage, the metallic content are often absorbed on the sewage solids or sewage sludge, if disposed into farmland, the metallic contents are taken up by plants and may have unpleasant effect on the fruits and as such are unsuitable for human consumption. In some cases, they may have adverse effects on plants produced on the farm land, such plants serve as food for man. Heavy metals are passed onto man through the food chain and the cumulative effects of these metals, most of which are toxic.

Actually, some of the toxic metals are being released to the environment in increasing amount and the most commonest element is lead. Infact, heavy metals are daily ingested by human either through air, food, water and soil. Irrespective of their sources, toxic elements can reach the soil when they become part of food chain (Igwe *et al,* 2005) unfortunately, once the elements become part of this cycle, they accumulate in animal and human tissues (Daniel and Edward, 1998). When agricultural soil are polluted, these metals are taken up by plants and consequently accumulate in their tissues (Trueby, 2003). Animals that graze on such contaminated plants and drink from polluted water, as well as marine lives that breed in heavy metals polluted water also accumulate such metal in their tissues, and milk if lactating (Habashi, 1992; Garbarino *et al.*, 1995; Horsfall and Spiff, 1992; Peplow 1999).

In Northern Nigeria and Kaduna metropolis in particular there is no adequate rainfall for the planting season. In order to complement the water need for farming, irrigation with available river is performed. This occurs with reasonable frequency throughout growing season.

Irrigation is the artificial means of water supply to the agricultural crops ranging from surface irrigation, micro sprayer and low-head barber irrigation. Irrigation is design to permit farming in arid regions and offset drought in semi-arid or semi humid regions.

The purpose of irrigation is to introduce water into the part of the soil profile that serves as the root zone, for the subsequent uses of the crop. (Zapella, 2003).

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. Excessive amount of fertilizers are applied to crops, considering that they are reasonable insurances against yield losses and their economic consequences. Fertilizers contain not only major elements necessary for plant nutrient and growth but also trace metal impurities such as Cd, Pb, or Ni (Zhan and Shan 2001). The uptake of these heavy metals by plants especially leafy vegetables is an avenue of their entry into the human food chain with harmful effects on health (Uwah *et al.*, 2009).

Vegetables are nutritious food that comes from the leaves, roots, seeds, stem and other parts of certain plants (Cheah, 1969). 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 (Dastane, 1987).

Tomatoes is the edible often red fruit of the plant (Solanum lycopersium), commonly known as a tomato plant. It belong to the nightshade family. The plants typically grown to 1-3 meters (3-10ft) in height and have a weak stem that often sprawls over the ground and vines other plant. It is grown in temperate climates as an annual. Tomato is consumed in diverse way, including raw, as an ingredient in many dishes,sauces,salad and drinks.

The aim of this research work is to investigate the amount of heavy metals transferred from soil to tomatoes so as to ascertain the extent of contamination if found extremely above the limit given by various health organisations.

II. MATERIAL AND METHOD

Sample and Sampling:

Tomatoes 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 tomatoes 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

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

SAMPLE PREPARATION

Cabbage samples

5g of the ground tomatoes 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 & Pb) were determined using bulk scientific model VPG 210 model atomic absorption spectrophotometer (AAS).

Transfer of Heavy metals from soil to tomatoes

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 Oyedele et al, 1995 and Harrison and Chirgawi, 1989).

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

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

According to Rasheed and Awadallah (1998) 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.

III. RESULTS AND DISCUSSION

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

Table 1.0: Heavy metals in tomatoes 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	0.42	±	0.68	8.98	±	1.12	19.69	±	27.17	ND		ND	3.63	±	1.54
DMN	0.1	±	0.1	7.78	±	3.69	ND		ND	ND		ND	4.26	±	2.67
RGS	0.69	±	0.66	6.45	±	1.19	3.63	±	3.39	2.07	±	1.96	4.19	±	2.45
BNW	0.59	±	0.48	5.09	±	1.41	1.46	±	2.37	2.33	±	2.08	3.99	±	1.72
MKR	0.87	±	0.61	6.67	±	1.51	4.53	±	1.40	4.53	±	1.95	2.13	±	0.81
KKR	0.74	±	0.84	9.2	±	0.92	6.03	±	0.85	5.8	±	1.51	1.88	±	0.61
BDK	0.36	±	0.26	5.99	±	0.40	ND		ND	0.27	±	0.31	0.92	±	0.08
NAS	1.33	±	0.12	7.47	±	1.62	9.6	±	2.86	2.9	±	0.3	3.27	±	1.70
MAL	0.67	±	0.50	8.2	±	2.46	8.87	±	3.72	4.27	±	2.25	3.07	±	1.94
KUD	0.77	±	0.51	9.93	±	4.88	6.33	±	1.53	4.47	±	0.64	2.44	±	0.67
KKN	1	±	0.53	8.43	±	3.21	6.77	±	0.80	4.87	±	2.12	2	±	0.6
KWO	0.84	±	0.63	5.4	±	1.22	7.34	±	1.01	3.33	±	0.81	1.93	±	1.10
URM	0.93	±	0.31	8.4	±	1.2	7.33	±	1.31	2.77	±	0.51	1.87	±	0.81
UNS	0.15	±	0.22	6.33	±	0.76	5.33	±	0.61	3.16	±	0.74	1.93	±	0.50
TDW	0.32	±	0.21	12.44	±	10.95	0.53	±	0.35	ND		ND	3.53	±	3.25
DKA	1.33	±	0.23	3.33	±	2.14	7.27	±	1.10	4.73	±	1.65	2.32	±	0.30
UDS	0.93	±	0.46	7.73	±	3.35	9.73	±	4.64	3.57	±	2.54	4.6	±	2.42
CTA	0.6	±	0.53	6.93	±	3.56	7.93	±	4.35	3.77	±	1.25	3.4	±	1.56
KMS	0.87	±	0.58	9.6	±	3.12	7.9	±	2.01	3.13	±	2.97	4.67	±	1.29
ABK	0.93	±	0.23	6.4	±	1.71	7.7	±	2.45	3.53	±	0.58	2.4	±	0.53
RCK	1	±	0.35	9.2	±	3.50	6.17	±	1.75	3.53	±	0.95	3.27	±	1.70

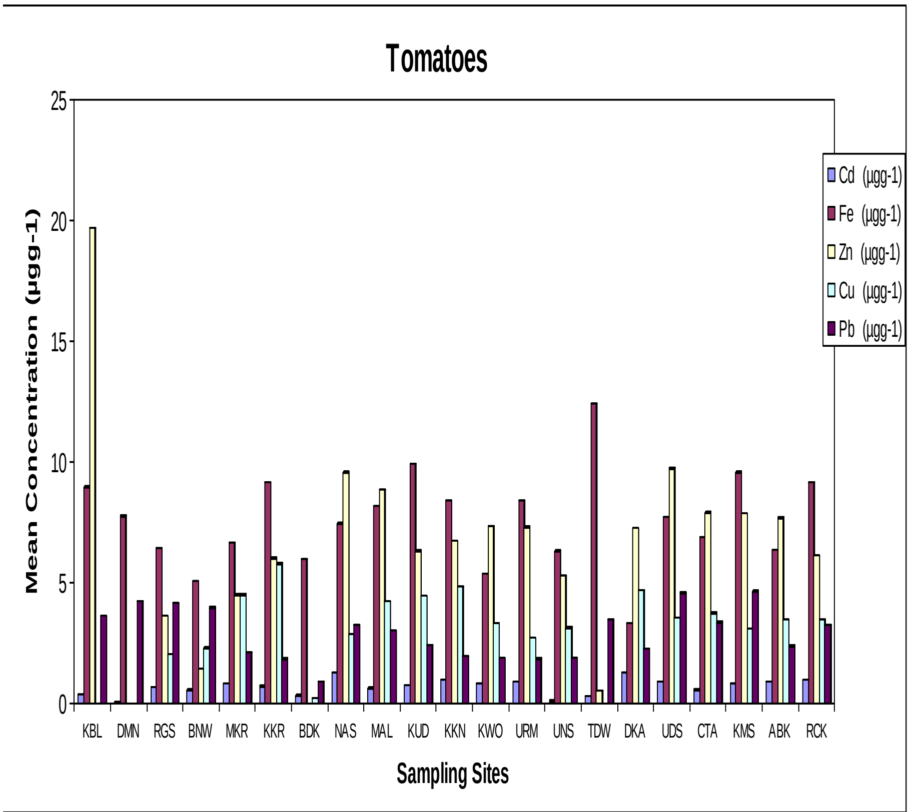

Fig 1.0: Heavy metal in Tomatoes sample from different irrigation sites of the Kaduna Metropolis

Figure 1.0 showed that Zinc from KBL tomatoes sample has the highest concentration of 19.69 ± 27µgg^{-1} follow by Iron which had 12.44 ± 10.95µgg^{-1}. copper and lead had concentrations of 5.8 ± 1.51µgg^{-1} (KKR) and 4.67 ± 1.29µgg^{-1} (KMS) respectively. Cadmium had 1.33 ± 0.12µgg^{-1} (NAS) and 1.33 ± 0.23µgg^{-1} (DKA). This implies that Zinc from KBL sample is absorbed more than all elements analyzed for tomatoes from the irrigation sites of the Kaduna metropolis.
The absorption of heavy metal in the present study are arranged in the following increasing series.
Zn (KBL) > Fe (TDW) > Cu(KKR) > Pb (KMS) > Cd(NAS and DKA)

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

Sampling Sites	Cd (µgg^{-1})	Fe (µgg^{-1})	Zn (µgg^{-1})	Cu (µgg^{-1})	Pb (µgg^{-1})
Kabala	0.31	0.20	0.60	0.00	0.87
Danmani	0.09	0.17	0.00	0.00	0.80
Rigasa	17.25	0.06	0.05	0.65	0.12
Barnawa	0.26	0.31	0.04	0.05	0.05
Makera	0.47	0.15	0.11	0.53	0.50
Kakuri	1.01	0.11	0.11	0.34	0.14
Badiko	0.29	0.13	0.00	0.38	0.63
Nasarawa	0.74	0.17	0.31	0.57	0.00
Malali	0.52	0.65	0.31	0.56	0.48
Kudenda	0.35	0.21	0.15	0.55	0.31
Kinkinau	0.65	0.24	0.23	0.77	0.56
Kawo	1.56	0.05	0.16	0.16	0.07
Unguwan Rimi	0.93	0.08	0.12	0.13	0.23
Unguwan Sanusi	3.00	0.06	0.11	0.39	0.23
Tudunwada	1.60	0.12	0.01	0.00	0.34
Doka	1.06	0.05	0.24	0.35	0.13
Unguwan Dosa	0.59	0.48	0.38	0.70	0.85
Costain	0.39	0.24	0.28	0.95	0.75
Kurmi mashi	0.56	0.24	0.35	0.58	0.97
Abakpa	0.78	0.33	0.30	1.00	1.00
Rigachikun	0.76	0.42	0.36	1.00	0.67

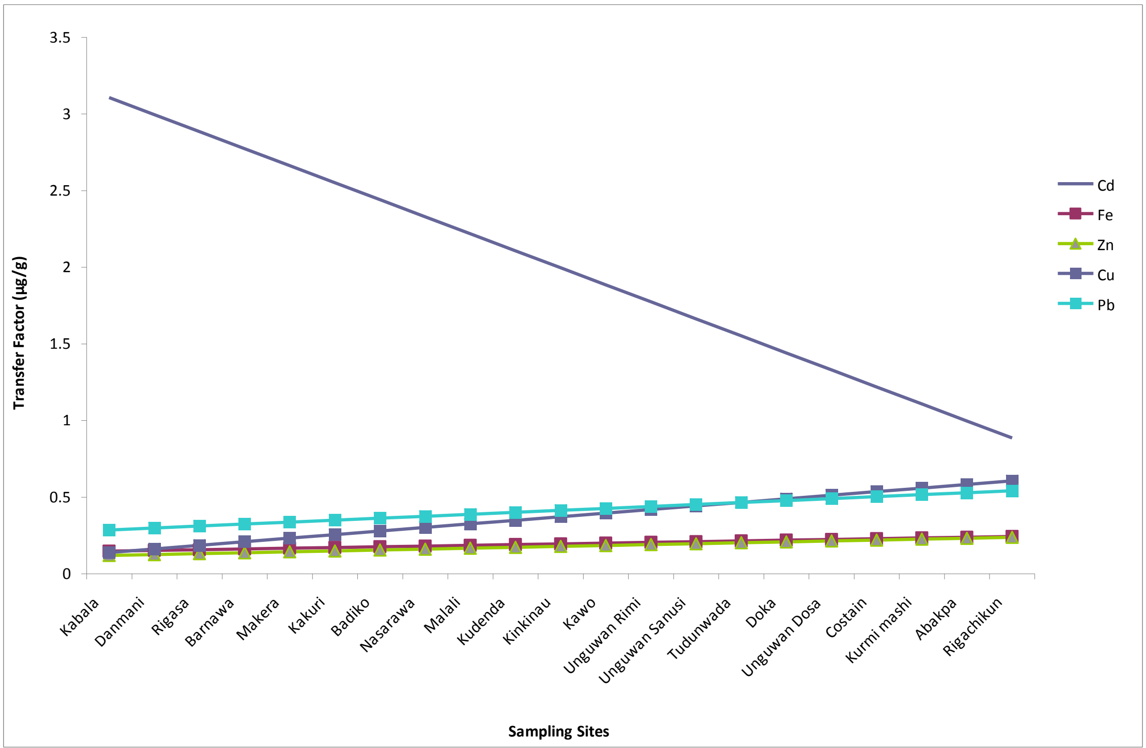

Fig.2.0: A plot of transfer factor from soil to tomatoes

Table 2.0 shows transfer factor for heavy metal from soil to tomatoes. Most of the transfer factors in the studied samples are below 1 with the exception of samples from Rigasa (17.25 for Cd), Kakuri (1.01 for Cd), Kawo (1.56), Unguwan Sanusi (3.00), Tudunwada (1.60) , Doka (1.06), Abakpa (1.00 for both Cu and Pb) and Rigachikun (control) (1.00 for Cu).

The transfer factor reported by Oyedele et al., (2005) were 0.75, 0.86, 0.40, 1.42 for the Zn, Cd, Cu and Pb respectively in vegetable. Infact these values were higher than the obtained in the present study.

Figure 2.0 shows mean plot of transfer factor from soil to tomatoes in which the transfer factor is highest with cadmium follow by copper and lead. Next in the series are zinc and iron.

That is, in tomatoes samples analyzed, cadmium is highly transferred from the soil. This is because high concentration of heavy metal such as cadmium in the vegetables like tomatoes may occur due to irrigation with contaminated water (Singh *et al* 1989, Sharma *et al.*, 2009, Singh and Kumar 2006), as well as other contaminant such as domestic and industrial waste.

Transfer factor in this work is summarized in the below series:-
Cadmium > copper > lead > zinc and iron.

IV. CONCLUSION

The result obtained in this analysis revealed that heavy metals such as cadmium, zinc, copper, iron and lead were absorbed and accumulated by the soil and transfer to the tomatoes samples grown in the irrigated farmlands of Kaduna metropolis. In this analysis it is clearly showed that cadmium had the highest transfer factor follow by copper and lead. Next in the series are zinc and iron. That is, Cadmium > copper > lead > zinc and iron. This is because the accumulation of trace metals in agricultural and non-agricultural soils poses health hazards. Some of the health effects of trace metals include skin irritation, damage to the liver, kidney circulatory and nerve – tissue resulting from acute or chronic exposure. As the result is showing cadmium is very much available in the analyzed tomatoes sample and as such consumers are face with danger of cadmium toxicity since Cadmium is toxic even at extremely low concentration. At the same time cadmium is associated with bone defects, viz; Osteomalacia, Osteoporosis and Spontaneous fractures, increased blood pressure and myocardic dysfunction. Other elements obtained from this research work if present above the regulated limit given by the various health agencies may lead to toxicity and polluting the soil as well as reducing its ability in the production of crops and vegetables in the irrigation sites of Kaduna metropolis.

ACKNOWLEDGEMENT

The Authors are grateful to the assistance rendered by the technologist in the Chemistry laboratory of the Applied Chemistry Department, Kaduna Polytechnic Kaduna.

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Mahmud Mohammed Imam, et. al, "Transfer Of Heavy Metals from Soil to Tomatoes (Solanum lycopersium) Grown In Irrigated Farmlands of Kaduna Metropolis." *International Journal of Engineering Science Invention (IJESI)*, Vol. 10(06), 2021, PP 19-26. Journal DOI- 10.35629/6734