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HEALTH RISK ASSESSMENT OF HEAVY METALS FROM PESTICIDES USE IN PLATEAU STATE, NIGERIA

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ABSTRACT
Heavy metals bioaccumulation in agricultural crops fumigated with pesticides has grown into a major concern globally. This study assessed heavy metals concentrations (Cd, Pb, Cr, Cu, Zn) in commonly consumed crops and their corresponding soil from agricultural farm lands in Jos Plateau State, Nigeria. The mean concentrations of heavy metals in the studied crops ranged from 0.17-100.75, 0.17-54.33, 0.83-28.75, 0.17-5.50, 0.5-0.5 mg/kg for Zn, Pb, Cu, Cr, and Cd respectively. The trend of heavy metals in the crops were in decreasing order of Zn>Pb>Cu>Cr>Cd and their concentrations varied in different parts of the crops. The mean concentration of Cd, Pb, and Cr in the studied crops were above the WHO, (2019) permissible limits and therefore a call for concern. The mean concentrations of heavy metals in the soil varied from 0.5-0.5, 2.50-13.83, 3.67-5.75, 11.83-26.33, and 41-89.50 mg/kg for Cd, Pb, Cr, Cu and Zn respectively and were below the UNEP, (2013) permissible limits for agricultural soil. The result showed that Pb had the highest transfer factor (1.91) in (Capsicum annuum) and Zn had the least. Similarly, the result revealed high Pollution index value for Pb compared to other metals. Hazard quotient and Hazard index of all the crops were less than 1; thus the consumption of these crops is unlikely to pose health risks to the target population. However, the result showed health risk from daily intake of some of the studied crops for Pb ((Brassica oleracea, Lactucasativus, Zea mays, Spinaciaoleracea, and Capsicum annuum). Hence, regular monitoring and screening of pesticides for heavy metals should be employed by government agencies.
Key words: Bioaccumulation factor, Heavy metals, Hazard Quotient, Pesticides

INTRODUCTION

Intensification of agricultural activities around the world to meet the ever growing food demand has led to an increase in the use of pesticides particularly in Northern Nigeria. Even though pesticides are beneficial to agricultural production but uncontrolled use can be detrimental, many users especially in northern Nigeria are inadequately informed about potential short and long term risk of pesticides in the environment. According to world Health Organization (WHO), 20% of pesticides are used in the developing countries and the trends of pesticides use is increasing (WHO, 2000). Nigeria has been ranked first among West African countries importing pesticides from the United Kingdom (Okafoagul, *et al*., 2017). However, despite the significant contribution of pesticides to agricultural production, evidences have shown that they could cause detrimental potential health risk to humans and the ecosystem as well (Lou *et al.,* 2009). The use of agro-chemicals such as herbicides, fungicides and insecticides play an important role in the contamination of agricultural crops and the subsequent transfer along food chain to humans (Zhong *et al*., 2017).

Studies have shown the presence of heavy metals in pesticides (Yuguda, *et al*., 2015; Kabata-Pendias and Pendias, 1992; Barau *et al*., 2018). Therefore, continuous and uncontrolled application of these agrochemicals and can potentially exacerbate the accumulation of heavy metals in the agricultural soils over time (Wang *et al*., 2004). Despite the ban of heavy metals in pesticides in developed countries, study by Defarge *et al*., (2018) have revealed for the first time the presence of As, Co, Cr, Ni, Pb as contaminants in 22 pesticides formulations at levels above admissible ones in water at their recommended dilutions rate in Europe.

This trend is worrisome in developing countries particularly in Africa as majority of the pesticides infiltrating the markets have been shown to contain heavy metals (Yaguda, *et al*., 2015; Barau *et al*., 2018). Even though most studies have studied and attributed heavy metals sources in food crops from waste-water irrigation, industrial waste and contaminated waste disposal site. Sources of heavy metals from pesticides in food crops/vegetables and their health hazard in humans should not be overlooked. More so, there are limited information on the heavy metals concentration in food crops from pesticides and their health risk in Northern Nigeria. Hence, this study was designed with the aim of determining the concentration of heavy metals (Cd, Pb, Cr, Cu, Zn) from pesticides in the root, stem, leaf and fruit of some crops, and the respective farmland soil in Jos and their associated human health risk.

MATERIALS AND METHODS

Samples of leaves, stems, roots and fruits of nine selected matured plants were collected by randomly picking from two farm lands. Five (5) replicates from each of the nine (9) plants were collected from Naraguta Farm (A) in Plateau State at coordinates of N09^{0}58.586, E008^{0}53.820 and Naraguta Farm (B) at coordinates of N09^{0}58.562, E008^{0}53.230. At each sampling sites, 20g each of the nine crops namelytomatoes, pepper, onions, cabbage, carrot, cucumber, spinach, lettuce and maize) were collected from three different locations in each farm land to provide replicate samples of each crop. Samples were collected from the roots, stems, leaves and fruits of each of these crops and their corresponding soil. The crops and soil samples were collected in a clean brown paper envelope, labelled and stored at Abubakar Tafawa Balewa University (ATBU) Biology laboratory.

Preparation of Samples

The uneatable portions of the plants were separated from edible portion and chopped into small pieces. The samples were oven dried at 80^{o}C and crushed using a stainless steel blender and passed through a 2mm sieve at Biology laboratory ATBU. The resulting fine powder were kept at room temperature before analysis. The soil samples were air dried in the laboratory, crushed and passed through a 2 mm mesh size sieve and stored at room temperature before analysis.

Heavy Metal Analysis

The non-edible portions of the plants were separated from edible portion and chopped into small pieces. The soil and plant samples were oven dried at 80^{o}C and 1g each was digested separately with a mixture of (Nitric acid) HNO_3, 65% (Per chloric acid) $HClO_4$ and 70% (Sulfuric) H_2SO_4 in 5:1:1 ratio). The samples were analyzed for heavy metals using an Atomic Absorption Spectrophotometer model 210 VGP as described by (Zhong et *al*., 2018).

Health Risk Assessment

Daily intake of metal

The daily intake of metals(DIM) was calculated to determine the health risk from consuming vegetables, with trace of heavy metals concentration using the formula below as described by (Zhong*et al.,* 2017).DIM=$\frac{M \times K \times I}{W}$

Hazard Quotient

The health risks to the local inhabitants from the consumption of vegetables were evaluated based on the Hazard Quotient, which is the ratio between exposure and oral reference dose (R_fD) as described (US-EPA, 2013).Given as;HQ=$\frac{\mathrm{Dim}}{RfD}$

Hazard Index

Potential risk to human health due to more than one heavy metal known as the Hazard index (HI) was calculated as described by US-EPA, (2013), which is the total sum of all the Hazard Quotients as shown in the equation below:

$HI = \sum HQ = HQ_{Cd} + HQ_{Pb} + HQ_{Cr} + HQ_{Cu} + HQ_{Zn}$

Estimated daily Intake (EDI)

The degree of toxicity of heavy metals to human upon their daily intake (mg/kg/day) known as the estimated daily intake was computed for each element as described by US-EPA, (2013).

EDI=$\frac{\mathrm{Cmetal} \times Averagedailyintake}{BA}$ mg/kg/day

Pollution Index (PI)

Pollution index (PI) is the ratio of metal concentration in a biotic or abiotic medium to that of the regulatory Standard of international bodies such as United states Environmental Protection Agency (USEPA) was computed as described by (Chukwuma, 1994).

Mathematically, PI was computed as PI=$C_{plant}/C_{US\text{-}EPA\text{-}STANDARD}$

Statistical Analysis

Analysis of variance ANOVA was used to analyze data using statistical software "R" 2014 version as described by Dytham, (2011).

RESULTS

Heavy metals concentration in crops

The concentration of heavy metals in different parts of crops (root, stem, leaf, and fruit) from the study area is given (Table 1.).

The concentrations of heavy metals ranged from 0.17-100.75 mg/kg, 0.17-54.33, 0.83-28.75, 0.17-5.50, 0.5-0.5 mg/kg for Zn, Pb, Cu, Cr, and Cd respectively.

The result revealed that there was significant variation ($p<0.05$) in the concentration of heavy metals in different parts the studied crops (Table 1). The trend of heavy metals in the studied crops was in decreasing order of Zn>Pb>Cu>Cr>Cd. The mean concentrations of Cd, Pb, and Cr were above the WHO, (2019) in most of the investigated crops, while the concentrations of Cu and Zn were below the WHO, (2019) permissible limits (Table 1).

Heavy metals concentration in soil

The mean concentration of heavy metals in the corresponding soils of the crops under investigation ranged from 0.5-0.5, 2.50-13.83, 3.67-5.75, 11.83-26.33, and 41-89.50 mg/kg for Cd, Pb, Cr, Cu and Zn respectively (Table 2.). The concentration of cadmium was not detected in all the corresponding soils of the studied crops except in the soils of Carrot (*Daucuscarota)* and Lettuce (*Lactucasativus).* The mean concentration of heavy metals in the corresponding soils of all the studied crops was below the permissible set by UNEP, (2013) and NESREA, (2011) for agricultural soils (Table 2). Analysis of variance (ANOVA) revealed a significant difference in heavy metals concentration in the corresponding soils of most studied crops, however the concentration of chromium in the soils of all the studied crops showed no significant difference except between the soil of carrot (*Daucuscarota*) $P<0.05$ (Table 2).

Transfer factor of metals from soil to crops

The result for heavy metals transfer factor in crops from the study area is given in Table 3. The Bioaccumulation factor (BAF) for crops grown in the study area ranges from 0.19-1.91, 0.25-0.82, 0.23-0.82, 0.08-0.76 for Pb, Cr, Cu, Zn respectively. While BAF was not computed for Cd in all the studied crops. BAF was highest for pepper (*Capsicum annuum*) (1.91), followed by maize (*Zea mays*) (0.95), tomato (*Solanumlycopersicum*) (0.93), Spinach (*Spinaciaoleracea* (0.82) and cabbage (*Brassica oleracea* (0.76) (Table 3.). Zinc BAF was lowest for all the investigated crops compared to other metals and Pb showed the highest BAF than other metals.

Pollution indices

The result of the computed pollution indices (PI) in the edible parts of crops grown in the study area is given in Table 4. The PI value ranges from 2.5-2.5, 0.56-20.00, 0.29-1.59, 0.02-0.34, and 0.19-0.43 for Cd, Pb, Cr, Cu, and Zn respectively. Pollution indices were not detected in the edible parts of all the studied crops for Cadmium, except in lettuce (*Lactucasativus)* and Onion (*Allium cepa*) .Pollution indices value were higher for Pb in all the studied crops compared to other metals. PI was highest 20.00 in pepper (*Capsicum annuum*), followed by lettuce (*Lactucasativus)* 18.89, cabbage (*Brassica oleracea)* 13.89, maize (*Zea mays*) 12.22, Spinach (*Spinaciaoleracea)* 10.83. The high PI values greater than 1 indicates that these crops are contaminated and are therefore consider unsafe for human consumption. The trend of pollution indices in the edible parts of the studied crops was in the order of Pb>Cd>Cr>Zn>Cu.

Health risk assessment

Estimated daily intake of metal (EDI)

The result of the estimated daily intake of metals for adults (average age 60 years), are presented in Table 5. The result showed that the values of daily intake for Pb through the consumption some of the studied the crops (*Brassica oleracea)* (0.00597),(*Lactucasativus*) (0.00812), (*Zea mays*) (0.00526), *Spinaciaoleracea* (0.00466), *Capsicum annuum* (0.00860) had exceeded the oral reference dose (the daily exposure of individual to toxins or pollutants that can pose no appreciable hazard over life time) and are likely to cause human health risk. The estimated daily intake for Cd, Cr, Cu, and Zn through the consumption of all the studied crops were below the oral reference dose (RFD) and are therefore considered safe for consumption (Table 5).

Estimated Hazard Quotient (HQ) and Hazard index (HI)

The result of the estimated hazard quotient and hazard index through the consumption of the studied crops are presented in Table 6. The estimated hazard quotient values for all the investigated crops ranged from 0.0602-0.0602, 0.00508-0.18275, 5.41E-05-0.00029, 0.00254-0.04112, 0.00081-0.01046, for Cd, Pb, Cr, Cu, and Zn respectively. The result revealed that HQ value was highest (0.18275) in *Capsicum annuum* and least (5.41E-05) in (*Daucuscarota*). The HQ values of all the studied crops are the following order of health risk Pb (0.18275)>Cd (0.0602)>Cu (0.04112)>Zn (0.01046)> Cr (0.00029).

Table 1. Mean Concentrations of Heavy Metals (Mg/Kg) in Crops Grown in Jos (2017)

Name of Sample	Botanical Name	Hausa Name	Heavy metals mg/kg				
			Cd	Pb	Cr	Cu	Zn
Cabbage	*Brassica oleracea*	Kabeji					
Root			ND	5.67b	1.92a	2.50a	18.00a
Stem			ND	2.67a	1.17a	5.67ab	100.75b
Leaf			ND	4.17ab	3.67b	8.67b	11.50a
Carrot	*Daucuscarota*	Karas					
Root			ND	ND	ND	ND	ND
Stem			ND	7.17c	0.92ab	5.50ab	18.17a
Leaf			ND	4.50ab	2.67b	7.67b	19.50a
Taproot			ND	2.17a	0.67a	4.67a	17.00a
Cucumber	*Cucumissativus*	Kokwamba					
Root			ND	0.67a	2.00ab	11.17b	4.00b
Stem			ND	3.33b	1.58a	5.33a	32.00d
Leaf			ND	1.67ab	1.50a	8.50ab	0.67a
Fruit			ND	2.83ab	3.00b	5.25a	23.33c
Lettuce	*Lactuca sativa*	Salad					
Root			0.5a	15.16b	2.67b	11.16b	9.67a
Stem			0.5a	3.00a	3.00b	4.75a	12.67b
Leaf			0.5a	5.67a	1.25a	7.33a	14.25b
Maize	*Zea mays*	Masara					
Root			ND	54.33b	4.67c	15.33b	32.33ab
Stem			ND	5.33a	0.17a	7.83a	41.33b
Leaf			ND	4.50a	1.50b	7.00a	25.00a
Fruit			ND	3.67a	1.75b	4.25a	18.50a
WHO (2019)			0.2	0.3	2.3	40	60

Limits: FAO/WHO(2019)
Mean followed with same letter across the column are not significantly different p>0.05 using Duncan test
N=6 replicates

Table 1. Contd.

Name of Sample	Botanical Name	Hausa Name	Heavy metals mg/kg				
			Cd	Pb	Cr	Cu	Zn
Spinach	*Spinaciaoleracea*	Alayyaho					
Root			ND	4.58a	4.08b	6.25a	19.42a
Stem			ND	4.67a	2.58a	9.67b	23.67a
Leaf			ND	3.25a	2.33a	7.25a	25.75a
Onion	*Allium cepa*	Albasa					
Root			ND	4.33a	5.50c	17.33c	79.83d
Stem			ND	6.17c	1.83a	ND	24.50c
Leaf			ND	5.83c	2.50b	1.50a	5.50a
Bulb			0.5	0.17a	1.50a	13.50b	12.83b
Pepper	*Capsicum annuum*	Barkono					
Root			ND	4.67a	1.50a	7.50b	0.17a
Stem			ND	ND	ND	ND	ND
Leaf			ND	3.67a	2.83b	8.50b	1.00a
Fruit			ND	6.00b	3.00b	0.83a	21.00b
Tomato	*Solanumlycopersicum*	Tomatur					
Root			ND	5.67a	3.75a	28.75b	10.00a
Stem			ND	6.50a	1.67a	8.42a	ND
Leaf			ND	6.17a	2.17a	7.75a	11.58a
Fruit			ND	2.42a	2.58a	7.25a	6.66a
WHO(2019)			0.2	0.3	2.3	40	60

Limits FAO/WHO (2019)
Mean followed with same letter across the column are not significantly different p>0.05 using Duncan test
N=6 replicates

Table 2. Mean Concentrations of Heavy Metals (Mg/Kg) in Soils of Corresponding Crops Grown in Jos (2017)

Soil from the land of	Botanical Name	Hausa Name	Heavy metals mg/kg				
			Cd	Pb	Cr	Cu	Zn
Cabbage	*Brassica oleracea*	Kabeji	ND	8.50a	3.75a	11.83a	83.58b
Carrot	*Daucuscarota*	Karas	0.5	4.00a	5.75b	26.33d	63.25ab
Cucumber	*Cucumissativus*	Kokwamba	ND	11.00ab	3.83a	18.92abcd	68.17ab
Lettuce	*Lactuca sativa*	Salad	0.5	9.17ab	4.25a	21.33bcd	70.58ab
Maize	*Zea mays*	Masara	ND	13.83b	5.08a	19.67cd	89.50b
Spinach	*Spinaciaoleracea*	Alayyaho	ND	7.33ab	3.67a	17.25abc	50.25ab
Onion	*Allium cepa*	Albasa	ND	7.50ab	3.67a	16.33abc	41.67a
Pepper	*Capsicum annuum*	Barkono	ND	2.50a	4.00a	21.67bcd	78.83ab
Tomato	*Solanumlycopersicum*	Tomatur	ND	5.58ab	3.92a	15.92ab	60.50ab
UNEP, (2013)			10	200	200	50	250
NESREA			3	NIL	100	100	NIL

Limits:UNEP, 2013
Mean followed with same letter across the column are not significantly different p>0.05 using Duncan test
N=6 replicates

Table 3. Bioaccumulation Factor (BAF) of Heavy Metals in the Edible Parts of Crops Grown in Jos (2017)

Name of Sample	Botanical Name	Hausa Name	BAF				
			Cd	Pb	Cr	Cu	Zn
Cabbage	*Brassica oleracea*	Kabeji	ND	0.45	0.60	0.48	0.76
Carrot	*Daucuscarota*	Karas	ND	0.58	0.25	0.23	0.29
Cucumber	*Cucumissativus*	Kokwamba	ND	0.19	0.53	0.40	0.22
Lettuce	*Lactuca sativa*	Salad	ND	0.56	0.56	0.31	0.08
Maize	*Zea mays*	Masara	ND	0.95	0.50	0.36	0.33
Spinach	*Spinaciaoleracea*	Alayyaho	ND	0.57	0.82	0.45	0.46
Onion	*Allium cepa*	Albasa	ND	0.55	0.77	0.49	0.74
Pepper	*Capsicum annuum*	Barkono	ND	1.91	0.61	0.26	0.09
Tomato	*Solanumlycopersicum*	Tomatur	ND	0.93	0.65	0.82	0.16

BAF value greater than >1 is indicating high uptake of metal

Table 4. Pollution Indices of Heavy Metals in the Edible Parts of Crops Grown in Jos (2017)

Sampling Site	Name of Sample	Botanical Name	Hausa Name	Pollution index				
				Cd	Pb	Cr	Cu	Zn
Jos	Cabbage	*Brassica oleracea*	Kabeji	00	13.89	1.59	0.22	0.19
	Carrot	*Daucuscarota*	Karas	00	7.22	0.29	0.12	0.28
	Cucumber	*Cucumissativus*	Kokwamba	00	9.44	1.30	0.13	0.39
	Lettuce	*Lactuca sativa*	Salad	2.5	18.89	0.54	0.18	0.24
	Maize	*Zea mays*	Masara	00	12.22	0.76	0.11	0.31
	Spinach	*Spinaciaoleracea*	Alayyaho	00	10.83	1.01	0.18	0.43
	Onion	*Allium cepa*	Albasa	2.5	0.56	0.65	0.34	0.21
	Pepper	*Capsicum annuum*	Barkono	00	20.00	1.30	0.02	0.35
	Tomato	*Solanumlycopersicum*	Tomatur	00	8.06	1.12	0.18	0.03

N.B PI value greater than >1 is indicating high pollution load

Table 5. Estimated Daily Intake of Metals (EDI) (Mg/Kg/Bw/Day) Through Consumption of Crops Grown in Jos (2017)

Botanical Name	Hausa Name	Estimated daily intake				
		Cd	Pb	Cr	Cu	Zn
Brassica oleracea	Kabeji	ND	0.00597	0.00526	0.01242	0.01648
Daucuscarota	Karas	ND	0.00311	0.00096	0.00669	0.02437
Cucumissativus	Kokwamba	ND	0.00406	0.00430	0.00753	0.03344
Lactuca sativa	Salad	0.0007	0.00812	0.00179	0.01051	0.02043
Zea mays	Masara	ND	0.00526	0.00251	0.00609	0.02652
Spinaciaoleracea	Alayyaho	ND	0.00466	0.00334	0.01039	0.03691
Allium cepa	Albasa	0.0007	0.00024	0.00215	0.01935	0.01839
Capsicum annuum	Barkono	ND	0.00860	0.00430	0.00119	0.03010
Solanumlycopersicum	Tomatur	ND	0.00346	0.00370	0.01039	0.00287
RfD[a]		0.001	0.004	1.5	0.04	0.30

RFD: USEPA, (2013)

Table 6. Estimated Hazard Quotient and Hazard Index for Adult Population through the Consumption of Crops Grown in Jos (2017)

Name of Sample	Botanical Name	Hausa Name	Hazard Quotient(HQ)					Hazard Index(HI)
			Cd	Pb	Cr	Cu	Zn	
Cabbage	*Brassica oleracea*	Kabeji	ND	0.12691	0.00029	0.02640	0.00467	0.15828
Carrot	*Daucuscarota*	Karas	ND	0.06599	5.41E-05	0.01421	0.00690	0.08716
Cucumber	*Cucumissativus*	Kokwamba	ND	0.08630	0.00024	0.01599	0.00948	0.11201
Lettuce	*Lactuca sativa*	Salad	0.0609	0.17260	0.00010	0.02234	0.00579	0.26174
Maize	*Zea mays*	Masara	ND	0.11168	0.00014	0.01294	0.00751	0.13228
Spinach	*Spinaciaoleracea*	Alayyaho	ND	0.09899	0.00019	0.02208	0.01046	0.13172
Onion	*Allium cepa*	Albasa	0.0609	0.00508	0.00012	0.04112	0.00521	0.11245
Pepper	*Capsicum annuum*	Barkono	ND	0.18275	0.00024	0.00254	0.00853	0.19406
Tomato	*Solanumlycopersicum*	Tomatur	ND	0.07361	0.00021	0.02208	0.00081	0.09671

DISCUSSION

In this study, the concentrations of heavy metals in the investigated crops fumigated with pesticides ranged from 0.17-100.75, 0.17-54.33, 0.83-28.75, 0.17-5.50, 0.5-0.5 mg/kg for Zn, Pb, Cu, Cr, and Cd respectively. The present study indicated that most of the investigated crops had exceeded the WHO, (2019) permissible limits for Cd, Pb and Cr, while the concentration of Zn and Cu in the studied crops were below WHO permissible limits. The result revealed that there were significant variation ($p<0.05$) in the concentration of heavy metals in different parts of the studied crops, with no clear trend.

The mean Zn content in the studied crops (0.17-100.75 mg/kg) was significantly higher compared to (19.36-37.76 mg/kg) reported for crops irrigated with waste water in Pakistan (Mahmood and Malik, 2014), and (1.88 mg/kg) Zn content in crops from Saudi Arabia (Balkhair and Ashraf, 2016). The mean concentration in this study (0.17-100.75 mg/kg) was similar to the Zn concentration reported in Indonesia (5.12-90.69 mg/kg) from waste water irrigation (Siaka *et al.,*2014) and (32.01-69.26 mg/kg) Zn concentration in vegetables from Beijing, China (Liu *et al.,* 2005).

The mean concentration of Pb in the investigated crops (0.17-54.33 mg/kg) was higher compared to (0.23-0.64 mg/kg) in India from crops irrigated with waste water (Kulkarni 2017), and in China (1.82 mg/kg) in vegetables collected from market (Hongwen, *et al*., 2017). The Pb concentration in this study was also higher compared to (0.26-0.54 mg/kg) in Ethiopia (Eliku and Leta, 2017) and (1.42-2.76 mg/kg) in Pakistan (Khannum, *et al*., 2017) in crops irrigated with waste-water.

The mean concentration of Cu in this study varied from (0.83-28.75 mg/kg) was comparatively higher than (0.56 mg/kg) in Saudi Arabia (Balkhair and Ashraf, 2016), and (1.1-2.3 mg/kg) in India (Kulkarni *et al*., 2017). However, Cu contents in this study were significantly lower than (4.34-150.5 mg/kg) in Indonesia (Siaka*et al*., 2014) and (12.6-82.1 mg/kg) in Nigeria (Oti, 2015).

The mean level of Cr (0.17-5.50 mg/kg) in crops in this study were significantly higher than (0.16-0.32 mg/kg) reported in India (Kulkarni *et al*., 2017), and higher than (0.37-0.60 mg/kg) in Pakistan (Khannum, *et al*., 2017). However, the Cr contents in this study was similar to the result (0.84-2.4 mg/kg) obtained by Iwuanyanwu and Chioma, (2017) in Nigeria and within the range of (0.51-1.73) reported in Ethiopia (Eliku and Leta, 2017).

The mean concentrations of Cd (0.5-0.5 mg/kg) reported only in (*Lactuca sativa*) in this study was comparatively similar to (0.30-0.62 mg/kg) reported in India (Kulkarni *et al*., 2017), and also (0.6 mg/kg) obtained in China by (Hongwen*, et al*., 2017). The mean Cr concentrations in the present study was also significantly lower than the result obtained in China (0.1-900 mg/kg) (Zhong *et al*., (2014) and also less than (0.10-12.4 mg/kg) reported in Nigeria by (Oti, 2015).

Results of this study indicate that the accumulation of certain metals Cd, Pb, Cr above the permissible limits is a serious health risk for human population. Cd have been shown to hinders sulfhydryl enzymes and interacts with other cell ligands, disrupting oxidative phosphorylation pathways (Jomova and Valko, 2011; Waisberg *et al*., 2003). It accumulates in the human bones, lungs, liver, kidneys, and nerve tissues, leading to their damage and malfunction (Tsutsumi*et al*., 2014). It affects the respiratory system and enhances the development of kidney stones (Hambach, 2013). Exposure of Cd to the liver induces hepatocellular injuries to humans through the synthesis of metallothionein (Kang *et al*., 2013).Cadmium also interferes with transport across cell membranes and epithelia which eventually affect cell function and homeostasis (Van Kerhove *et al*., 2010). This study has shown that the concentration of heavy metals in crops fumigated with pesticides as the only source of metal contamination are equal or several folds higher than metals contents in crops reported from other sources like waste water irrigation, mine sites, and hence sources of heavy metals from pesticides should not be overlooked.

The mean concentration of heavy metals in the corresponding soils of the crops under investigation ranged from 0.5-0.5, 2.50-13.83, 3.67-5.75, 11.83-26.33, and 41-89.50 mg/kg for Cd, Pb, Cr, Cu and Zn respectively. The mean concentration of heavy metals in the corresponding soils of all the studied crops was below the permissible set by UNEP, (2013) and NESREA, (2011) for agricultural soils. This could be due to the higher uptake of heavy metals by the crops. The mean soil concentration of Cd in this study, were lower than the soil concentration of 0.93 mg/kg reported in Ethiopia (Eliku and Leta, 2017) and substantially lower compared to (126mg/kg) in Nigeria ((Oti, 2015).Lead (Pb) concentration in soil were also lower compared to (70.36 mg/kg) in China (Liu *et al*., (2013) and higher than (2.31 mg/kg) in India (Kumar *et al*., 2017). While the soil concentration of Cu and Zn in the present study were both similar to 30.3 mg/kg, 88.5 mg/g for Cu, Zn obtained in Ethiopia (Eliku and Leta, 2017).

In this study bioaccumulation factor (BAF) varied significantly in different crops and the trend of metal transfer (BAF) from soil to crops were in the order of Pb>Cr>Cu>Zn which were similar to the result reported by Kumar, *et al*, (2017) Chotanagpur in India, and in Ehiopia by (Gebreyohannes and Gebrekidan, 2018). The BCF for Cr in this study were lower compared with (1.82) reported in Saudi Arabia by Balkhair and Ashraf (2016) and higher than (0.16) in green pepper in Ethiopia by (Eliku and Leta, 2017). Kumar *et al*. (2017) also reported closely similar (1.03) for Cu in India in comparison to

BAF obtained in this study. Most of the crops under investigation showed higher metals concentration in their corresponding soil than plant tissues, and hence this could be responsible for the transfer of the heavy metals to their edible parts. The variation in the BAF in different crops were due to the metal concentration in the soil, bioavailability of metals, their chemical forms, difference in uptake capability and growth rate of different plant species and heavy metal contents in pesticides (Singh *et al.*, 2010).

The result showed that the values of daily intake for Pb through the daily adult consumption of the studied crops (*Brassica oleracea)* (0.00597), (*Lactucasativus*) (0.00812), (*Zea mays*) (0.00526), *Spinaciaoleracea* (0.00466), *Capsicum annuum* (0.00860) had exceeded the oral reference dose and are likely to cause severe human health risk. This could be attributed to the use of lead based pesticides indiscriminately by farmers in the study area. Study by Defarge*et al.*, (2018), Barau*etal.*, (2018), Yaguda*et al.*, (2005) have revealed the presence of heavy metals in pesticides. Lead has been shown to interrupt enzyme activation, inhibit trace mineral absorption, stop structural protein synthesis by binding to sulfhydryl protein, and lower the availability and levels of sulfhydryl antioxidant reserves in the body (Ercal *et al.*, 2001; Patrick (2006). Lead also has been linked to incidence of neurological disorders, hypertension and cognitive impairment(Patrick2006).

The potential health risk through the consumption of the metal contaminated crops was calculated using the hazard quotient (HQ). The result of this study indicated that the adult consumption of all the studied crops are unlikely to pose health risk to human as the HQ values was less than 1 for all heavy metals. In this study, the estimated hazard index shown that the consumption of all the investigated crops for all metals will not pose health risk to human as the HI<1. Lower HQ and HI < 1 have been reported in India by Kumar *et al.*, (2017), in Ethiopia by Eliku and Leta, (2017) and Gebreyohannes and Gebrekidan (2018). Higher (>1) HQ and HI values were also reported in different crops by Barau*et al.*, (2018) and Patrick and Chioma (2017) in Nigeria.

CONCLUSION

The present study revealed that most of the agricultural crops fumigated with pesticides were enriched with metals Cd, Pb, and Cr at concentrations above the WHO permissible limits. While the concentration of Zn and Cu in all the studied crops were below the WHO permissible limits. The mean concentration of heavy metals in the corresponding soils of all the studied crops was below the permissible set by UNEP(2013) and NESREA (2011) for agricultural soils. Heavy metals concentrations varied in different parts of the plants and in their corresponding soil. The Bioaccumulation factor shown higher (>1) for Pb only in *Capsicum annuum* (1.91) indicating low retention rate of the metal in the soil. The estimated daily intake revealed that the daily adult consumption of some crops *Brassica oleracea* (0.00597), *Lactucasativus* (0.00812), *Zea mays* (0.00526), Spinacia*oleracea* (0.00466), *Capsicum annuum* (0.00860) had exceeded the oral reference dose (RFD). This shown that the daily intake of these crops contaminated with heavy metals from pesticides in the study area could pose potential health risk to human. However, the estimated hazard quotient (HQ) and hazard index (HI) in this study were lower (<) 1 in all the studied crops and therefore unlikely to posed health risk through the consumption of these crops. Regular monitoring and screening of pesticides for heavy metals contents should be employed by concerned authorities.

Conflict of interest

The authors declare that they do not have conflict of interest.

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