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 annum) and Zn had the least. Similarly, the result revealed high Pollution index value for Pb compared to other metals. Hazard quotients 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, Lactuca sativus, Zea mays, Spinacia oleracea, and Capsicum annum)). 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 (Okagalogu, 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°58.586, E008°53.820 and Naraguta Farm (B) at coordinates of N09°58.562, E008°53.230. At each sampling sites, 20g each of the nine crops namely tomatoes, 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°C and 1g each was digested separately with a mixture of (Nitric acid) HNO₃, 65% (Per chloric acid) HClO₃ and 70% (Sulfuric) H₂SO₄ 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).

\[
DIM = \frac{M \times R \times J}{W}
\]

**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 (RfD) as described (US-EPA, 2013). Given as:

\[
HQ = \frac{DIM}{RfD}
\]

**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).

\[
EDI = \frac{C_{metal} \times \text{averaged daily intake}}{BA} \text{mg/kg/day}
\]

**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-EPA-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 \((Daucus carota)\) and Lettuce \((Lactuca sativa)\). 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 \((Daucus carota)\) \(P<0.05\) (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, and 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 \((Solanum lycopersicum)\) (0.93), Spinach \((Spinacia oleracea)\) (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 \((Lactuca sativa)\) 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 \((Lactuca sativa)\) 18.89, cabbage \((Brassica oleracea)\) 13.89, maize \((Zea mays)\) 12.22, Spinach \((Spinacia oleracea)\) 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 crops of \((Brassica oleracea)\) \((0.00597),(Lactuca sativa)\) \((0.00812),(Zea mays)\) \((0.00526),(Spinacia oleracea)\) \((0.00466),(Capsicum annuum)\) \((0.00860)\) 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 0.0602-0.18275, 0.00580-0.18275, 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 \((Daucus carota)\). The HQ values of all the studied crops are the following order of health risk Pb \((0.18275)>Cd\) \((0.0602)>Cr\) \((0.04112)>Zn\) \((0.01046)>\) \((0.00029)\).
### 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  | 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
| Name of Sample | Botanical Name | Hausa Name | Heavy metals mg/kg | Cd | Pb | Cr | Cu | Zn |
|----------------|----------------|------------|-------------------|----|----|----|----|----|
| Spinach        | *Spinaciaoleracea* | Alayyaho   |                   | ND | 4.58a | 4.08b | 6.25a | 19.42a |
| Root           |                |            |                   | ND | 4.67a | 2.58a | 9.67b | 23.67a |
| Stem           |                |            |                   | ND | 3.25a | 2.33a | 7.25a | 25.75a |
| Leaf           |                |            |                   | ND | 3.25a | 2.33a | 7.25a | 25.75a |
| Onion          | *Allium cepa*  | Albasa     |                   | ND | 4.33a | 5.50c | 17.33c | 79.83d |
| Root           |                |            |                   | ND | 6.17c | 1.83a | ND | 24.50c |
| Stem           |                |            |                   | ND | 5.83c | 2.50b | 1.50a | 5.50a |
| 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   |                   | ND | 4.67a | 1.50a | 7.50b | 0.17a |
| Root           |                |            |                   | ND | 3.67a | 2.83b | 8.50b | 1.00a |
| Stem           |                |            |                   | ND | 6.00b | 3.00b | 8.83a | 21.00b |
| Leaf           |                |            |                   | ND | 6.00b | 3.00b | 8.83a | 21.00b |
| Fruit          |                |            |                   | 0.2 | 0.3  | 2.3   | 40   | 60 |

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

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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 |
|----------------------|----------------|------------|--------------|
|                      |                |            | 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 | Cd    | Pb    | Cr    | Cu    | Zn    |
|---------------|----------------|----------------------|------------|-------|-------|-------|-------|-------|
| Jos           | Cabbage        | Brassica oleracea    | Kabeji     | 00    | 13.89 | 1.59  | 0.22  | 0.19  |
|               | Carrot         | Daucus carota        | Karas      | 00    | 7.22  | 0.29  | 0.12  | 0.28  |
|               | Cucumber       | Cucumis sativus      | 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        | Spinacia oleracea    | 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         | Solanum lycopersicum | 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 |
| Daucus carota        | Karas      | ND                     | 0.00311 | 0.00096 | 0.00669 | 0.02437 |
| Cucumis sativus      | 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 |
| Spinacia oleracea    | 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 |
| Solanum lycopersicum | Tomatur    | ND                     | 0.00346 | 0.00370 | 0.01039 | 0.00287 |
| RFD                  |            |                        | 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) |
|----------------------|----------------------|------------|---------------------|------------------|
| Cabbage              | Brassica oleracea    | Kabeji     | ND                  | 0.12691           |
| Carrot               | Daucus carota        | Karas      | ND                  | 0.06599           |
| Cucumber             | Cucumis sativus      | Kokwamba   | ND                  | 0.08630           |
| Lettuce              | Lactuca sativa       | Salad      | 0.0609              | 0.12760           |
| Maize                | Zea mays             | Masara     | 0.11168             | 0.11688           |
| Spinach              | Spinacia oleracea    | Alayyaho   | 0.09899             | 0.12929           |
| Onion                | Allium cepa          | Albasa     | 0.0609              | 0.18275           |
| Pepper               | Capsicum annuum      | Barkono    | ND                  | 0.18275           |
| Tomato               | Solanum lycopersicum | Tomatur    | ND                  | 0.07361           |

**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 of Pb in this study was also 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 (Hongwen et al., 2017). 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 was significantly lower than the result obtained 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, 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 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 Ethiopia 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
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The result showed that the values of daily intake for Pb through the daily adult consumption of the studied crops (Brassica oleracea) (0.00597), (Lactuca sativa) (0.00812), (Zea mays) (0.00526), Spinacia oleracea (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.

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), Lactuca sativa (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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