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*Original Paper*

# Ecological Risk Assessment of Consuming Vegetables Exposed To Heavy Metals From Hairdressing Salon


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***Abstract*— This study is focused on the impact of improper disposal of hair dressing contaminated water on farmland within different communities. Presence of different heavy metals were detected at Ohofia and Isiukwuto communities while, Talinum triangulare and Telfairer occindentalis were planted in the soil obtained from sampling sites. Health risk, ecological risk and bioaccumulation factor was estimated on the plants. Different heavy metals were accumulated in the plants. However, iron was highest in both T. triangulare and T. occidentalis with value of 109.92 and 48.84 respectively. The bioaccumulation factor of plants was in this order Fe < Cd< Mn < Cr < Zn < Ni < Cu < As < Pb < Hg respectively. Besides, Fe is considered to be of high ecological risk concerns (160 ⩽ Eir < 320). While, the health risk showed that the ten heavy metals detected exceeded the non-carcinogenic risk (I.e. THQ >1) though, in Isiukwuato Fe appears to have highest THQ (target hazard quotient). The ecological risk perceived in the assessment indicates that hair dressing salon waste contamination of arable soil and farmland is unsafe. Therefore, effective and safe method is required for proper discharge.**



***Keywords*— Risk assessment, Bioaccumulation, Risk index and Heavy metals.***


## I. Introduction

Hair dressing saloon are littered everywhere in without proper regulation. The job of hair dressing is a proper skill that can earn a living for an individual. However, the environmental concerns are paramount mostly, because of hair products utilization which contains heavy metals in different quantities while, improper disposal methods pose a problem to the environment and society at large. Heavy metals are chemical compounds that are natural and constitute the structural component of the earth's crust, some of which are persistent and non-degradable in the environment. These heavy metals have been found in trace quantities in most industrial products of which hair dressing salon products are not excluded. This includes shampoos, hair conditioners, hair dyes, hair relaxers creams and curl activator, hair oil treatment, hair sprays, hair styling gels, hair setting lotions, hair mousse, edge control, straightener and bleaches, etc. [10]. Some of the trace metals that are embedded in hairdressing products includes; Cadmium (Cd), mercury (Hg), arsenic (As), nickel (Ni), cobalt (Co), and lead (Pb). These metals are known to be toxic and harmful in low concentrations due to its ability to accumulate in body tissues [20]. However, direct contact with this toxic substance on human's skin may cause it absorption into human body [32]. Thus, the use of trace metals as active ingredient in hair products is prohibited in most developed countries due to the potential health risk associated with it usage. Furthermore, services provided by hairdressing salon has led to increase in the level of environmental contamination as most of the effluents generated are hazardous in nature and are frequently discharged without treatment into water bodies or nearby land locations. The deposition of these metals on soil surface makes it readily available to plant root apoplast which spreads and accumulate in both the edible and non-edible parts thereby affecting the food chain [2,3]. Vegetable plants are important part of the man's diet and are rich in fibers, antioxidants, minerals and vitamins. However, there are some factors affecting heavy metal bioaccumulation in vegetable and these includes; the soil metal concentration, atmospheric depositions, soil type, climate, plant species and plant maturity stage at the time of harvest [7]. As such the impact of the indiscriminate release of heavy metals on vegetable farmland cannot be over emphasized due to their significant in destroying the food. Also, exposure to these metals from contaminated food have been reported to cause severe health damage such as kidney, nervous, cardiovascular system, and bone diseases [22]. In addition, induced health implications such as; high blood pressure, joint/muscle pain, abdominal pain, miscarriages and premature birth, have been recorded from prolong exposure to trace metals irrespective of the route of exposure [30,34]. Hence, the study assessed the ecological risk associated with the ingestion of heavy metal contaminated vegetable grown on hairdressing salon waste products polluted soil.

## II. Ease of Use

### A. Study Area

The study was conducted in Abia state located in southeastern Nigeria. Its latitude and longitude are 4˚49.30'N - 6˚02'N and 7˚08'E - 8° 04'E with a land mass of 5833.77 km2. The state has boundaries with several states such as Enugu, Rivers, Imo, Cross River and Akwa Ibom [16]. Abia State is suitable for the study because of its commercial and agricultural importance. It has a lot of hairdressing salons within the urban and rural areas.

### B. Waterleaf and Fluted Pumpkin Sample Collection

Samples of matured Talinum triangulare and Telfairer occidentalis plants were harvested near the hairdressing salon locations in Abia State. Several bunches of these leafy vegetables were collected from Ohofia and Isuikwuato communities. Samples were collected aseptically to avoid contamination and were transported on ice chest to the laboratory. Edible portions were used for the analysis. However, unpolluted soil sample was obtained from agricultural farm of Michael Okpara University of Agriculture Umudike.

### C. Waterleaf and Fluted Pumpkin Sample Preparation and Treatment

The obtained samples were washed, shredded, dried with oven and ground with crucible to fine powder. The ground sample were labelled respectively and stored. About 20ml of Nitric and hydrochloric acid in ratio of 3:1 was added to the sample and heated in water bath at 70o C to form a clear brownish solution. Deionized water was added to about 50ml of the solution and filtered with Whatman filter paper and stored in acid rinsed polythene bottle. Varian AA240 Atomic Absorption Spectrophotometer was used for further analysis to obtain the concentration of heavy metals e.g. Ni, Mn, Cd, Hg, Cu, Zn, Cr, Fe, Pb & As [6].

### D. Determination of Bioaccumulation Factor

The bioaccumulation factor of the samples was determined using model described by [17]. The bioaccumulation factor index is the capacity of the plant to store heavy metal compared to the concentration in the soil [29]. The bioaccumulation factor for the samples was obtained by the equation 1 below:

$$BAF = \frac{Concemtration\ of\ heavy\ in\ the\ vegetable}{Total\ concentration\ of\ metal\ in\ the\ soil} \quad (1)$$

Bioaccumulation values greater than one (> 1) was regarded as high-risk value [9,17].

### E. Ecological Potential Risk Index (PRI)

The potential risk index model is used to assess the risk of several heavy metals from soil in terms of metal content, biotoxicity and environmental effect [15]. The risk index was obtained by equation 2 and 3 below:

$$P_x^i = T_r^i\ x\ C_r^i = T_x^i\ x\ {C_5^i}/{C_n^i} \quad (2)$$

$$RI = \sum_{i=1}^{n} \quad E^{I} \quad (3)$$

$P^i_r$ represents the potential ecological risk index, $C^i_s$ is the actual concentration of each heavy metal, the toxic response coefficients ($T^i_r$) values of Ni, Mn, Cd, Hg, Cu, Zn, Cr, Fe, Pb and As are 5, 1, 30, 40, 5, 1, 2, 1, 5 and 10 respectively. The RI classifications are low risk (RI < 150), moderate risk (150 ⩽ RI < 300), considerable risk (300 ⩽ RI < 600), and high risk (RI ⩾ 600). The single element risk degrees ($P^i_r$) are low ecological risk ($P^i_r$ < 40), moderate ecological risk (40 ⩽ $P^i_r$ < 80), considerable ecological risk (80 ⩽ $P^i_r$ < 160), high ecological risk (160 ⩽ $P^i_r$ < 320), and very high ecological risk ($P^i_r$ ⩾ 320).

### F. Health Risk Assessment

The non carcinogenic risk of heavy metal to humans was obtained through evaluating the daily dietary intake (DDI) and target hazard quotient (THQ). Health risk index was used in obtaining the non-carcinogenic hazard exposure of mixture of heavy metals used in this study. The DDI was obtained with the equation 4 below:

$$DDI = \frac{EF\ x\ ED\ x\ Ci\ x\ FIR}{BW\ x\ AT} \quad (4)$$

where Ci is heavy metals concentration in the edible part of vegetables (mg/kg); FIR is the food-intake ratio of for which the value of local children was 94 g/d [10]; EF is exposure frequency (365d/a); DE is duration of exposure (70 years life expectancy) [34]; BM represents the average body mass (70Kg for Adult); average time (AT) exposure for non-carcinogenic

effects (DE x 365 = 25,550 days).

Target hazard quotient (THQ) is used to obtain the risk of non-cancerous heavy metals through regular intake of vegetables contaminated with heavy metals. THQ values of <1 have no non-carcinogenic risks. While, THQ >1, have substantial health hazards. Increase in THQ increase the health risk hazard [5]. THQ was determined by equation 5 below:

$$THQ = \frac{DDI}{RfD} \quad (5)$$

RfD is the daily reference dose of heavy metals (μg/(kg·d)), the values of RfD for Ni, Mn, Cd, Hg, Cu, Zn, Cr, Fe, Pb and As were 2.0 x $10^{-2}$, 4.6 x $10^{-2}$, 1.0 x $10^{-3}$, 1.0 x $10^{-2}$, 4.0 x $10^{-1}$, 3.0 x $10^{-1}$, 3.0 x$10^{-4}$, 7.0 x $10^{-3}$, 3.5 x $10^{-3}$, 3.0 x $10^{-4}$ respectively [31]. Although Pb element had not been required in USEPA, Pb could exert a bad influence on the central nervous system of adolescents. Thus, the RfD for Pb was 3.5 μg/(kg·d) in present study [17].

## III. RESULTS AND DISCUSSIONS

### A. Heavy Metals Concentration in Soil around Hairdressing Salon Areas

Heavy metals concentration in soil around hairdressing salon is presented on table 1. The result showed the detection of ten (10) heavy metals in the soil samples from the two study areas except mercury from Ohofia. This includes Nickel (Ni), Manganese (Mn), Cadmium (Cd), mercury (Hg), Copper (Cu), Zinc (Zn), Chromium (Cr), Iron (Fe), Lead (Pb) and Arsenic (As). Iron (Fe) had the highest concentration values of 192.33 (Isuikwuato) while, the least was mercury (0.002). However, in Ohafia study site, concentration of iron was revealed to be the highest at 136.53 and the lowest was Chromium (0.04). Furthermore, the hierarchy of heavy metals concentrations from the study areas in descending order is as follows Fe>Cd>Mn>Zn>Pb>Ni>Cu>As>Cr>Hg. However, of all the heavy metals detected, mercury (Hg) had the least concentration values of 0.002 (Isuikwuato) and non-detected in Ohafia site.

TABLE I. THE HEAVY METALS CONCENTRATION IN SOIL AROUND HAIRDRESSING SALON STUDY AREA

| Heavy Metals (mg/g) | Isuikwuato Mean ± SD | Ohafia Mean ± SD | Distance Hairdressing (50m) | Away from Salon (200m) | The Facilities Control (400m) |
|---|---|---|---|---|---|
| Nickel (Ni) | 0.14 ± 0.03[c] | 0.23 ± 0.04[b] | 0.03 ± 0.02 | 0.01 ± 0.00 | 0.01 ± 0.00 |
| Manganese (Mn) | 1.22 ± 0.03[a] | 1.05 ± 0.10[b] | 0.24 ± 0.60 | 0.19 ± 0.01 | 0.19 ± 0.00 |
| Cadmium (Cd) | 0.39 ± 0.05[b] | 2.17 ± 0.05[b] | 0.02 ± 0.01 | 0.01 ± 0.01 | 0.01 ± 0.00 |
| Mercury (Hg) | 0.002 ± 0.00[a] | - | - | - | - |
| Copper (Cu) | 0.15 ± 0.05[a] | 0.09 ± 0.03[a] | 0.029 ± 0.00 | 0.01 ± 0.00 | 0.01 ± 0.00 |
| Zinc (Zn) | 0.71 ± 0.11[a] | 0.42 ± 0.28[a] | 0.26 ± 0.03 | 0.24 ± 0.06 | 0.21 ± 0.03 |
| Chromium (Cr) | 0.07 ± 0.01[a] | 0.04 ± 0.01[a] | 0.01 ± 0.01 | 0.01 ± 0.01 | 0.01 ± 0.01 |
| Iron (Fe) | 192.33 ± 70.05[a] | 136.53 ±37.37[a] | 54.81 ± 3.34 | 29.59 ± 0.31 | 12.34 ± 0.02 |
| Lead (Pb) | 0.37 ± 0.11[a] | 0.21 ± 0.06[a] | 0.1 ± 0.01 | 0.01 ± 0.00 | 0.01 ± 0.00 |
| Arsenic (As) | 0.075 ± 0.002[a] | 0.067 ± 0.001[a] | 0.013 ± 0.001 | 0.011 ± 0.00 | - |

Legend: (-) not detected; Mean; Means with same alphabet/superscript are not significantly different at P<0.05.

*B. The Heavy Metals Concentration in T. triangulare and T.occindentalis from Hairdressing Salon*

Heavy metals concentrations in T. triangulare and T.occidentalis are presented on Table 2. The results displayed that a total number of ten (10) heavy metals were detected in plants samples. This includes Nickel (Ni), Manganese (Mn), Copper (Cu), Zinc (Zn), Chronium (Cr), Iron (Fe), lead (Pb), and Arsenic (As). However, Ni, Hg, Cr and Pb were not detected in the unpolluted plant samples of T. triangulare. However, T. triangulare, Cr and Pb was not detected in Isuikwato study site. Also, it was observed that the concentration of iron in the two study areas were higher in both T.triangulare and T. occidentalis respectively. However T. triangulare had higher concentrations values of 109.92 (Ohafia) compared to those of T.occidentalis values of 48.84 (Isuikwuato). Furthermore, it was observed that Ni, Cd, Hg, Pb and As concentration exceeded the standard limits given by FAO and WHO.

TABLE II. THE HEAVY METALS CONCENTRATIONS IN T. TRIANGULARE AND T. OCCIDENTALIS FROM HAIRDRESSING SALON STUDY AREA

| Heavy Metals (mg/g) | T. triangulare UPPS | Ohafia | Isuikwuato | T. occidentalis UPPS | Ohafia | Isuikwuato | FAO & WHO (2011) |
|---|---|---|---|---|---|---|---|
| Nickel (Ni) | - | 0.89 ± 0.00[g] | 0.17 ± 0.00[d] | - | 0.41 ± 0.00[e] | 0.09 ± 0.00[c] | 0.1 |
| Manganese (Mn) | 0.05 ± 0.02 | 10.52 ± 0.00[g] | 1.16 ± 0.00[c] | 0.02 ± 0.18 | 13.95 ± 0.00[h] | 1.75 ± 0.00[f] | 5 |
| Cadmium (Cd) | 0.01 ± 0.00 | 2.01 ± 0.00[g] | 0.26 ± 0.00[b] | - | 1.72 ± 0.00[f] | 0.14 ± 0.00[a] | 0.02 |
| Mercury (Hg) | - | 1.01 ± 0.00[f] | 0.58 ± 0.00[d] | - | 1.98 ± 0.01[g] | 0.87 ± 0.00[e] | 0.03 |
| Copper (Cu) | 0.04 ± 0.03 | 0.84 ± 0.00[g] | 0.64 ± 0.00[c] | 0.04 ± 0.03 | 0.82 ± 0.00[d] | 0.69 ± 0.00[a] | 10 |
| Zinc (Zn) | 0.002 ± 0.01 | 2.87 ± 0.00[d] | 2.60 ± 0.00[a] | 0.01 ± 0.06 | 2.90 ± 0.00[f] | 2.64 ± 0.00[b] | 60 |
| Chromium (Cr) | - | 0.38 ± 0.00[f] | - | - | 0.52 ± 0.00[g] | 0.05 ± 0.00[d] | 1.3 |
| Iron (Fe) | 1.2 ± 2.77 | 109.92 ± 0.00[g] | 104.38 ± 0.00[d] | 1.0 ± 1.89 | 58.13 ± 0.00[h] | 48.84 ± 0.00[c] | 425.5 |
| Lead (Pb) | - | 7.26 ± 0.00[a] | - | 0.01 ± 0.00 | 5.01 ± 0.01[a] | - | 0.3 |
| Arsenic (As) | 0.01 ± 0.00 | 0.01 ± 0.00[a] | - | - | - | - | 0.5 |

Legend: (-) not detected, mean ±, Means with same alphabet/superscript are not significantly, different at P<0.05

*C. Heavy Metals Bioaccumulation in Talinum triangulare and Telfairia occidentalis*

The heavy metals bioaccumulation in Talinum triangulare and Telfairia occidentalis is presented in table 3. It was observed that lead (Pb) was not detected in Isuikwuato site in both plants' species. Also, Arsenic was not detected in Isuikwuato in T. triangulare as well as in Ohafia and Isuikwuato in T. occidentalis. Mercury (Hg) was observed to be more accumulated in both plant species with Isiukwuato site having the highest accumulation value of 435 in T. occidentalis. Although, no detection was observed in Ohafia sites in both plants' species. Furthermore, the bioaccumulation values in the sampling sites were greater than one (>1) except for iron (Fe) and cadmium (Cd). The rise in heavy metals bioaccumulation of of the vegetables plant of T. triangulare and T. occidentalis are arrange in ascending order of Fe < Cd< Mn < Cr < Zn < Ni < Cu < As < Pb < Hg respectively.

TABLE III. BIOACCUMULATION FACTOR OF HEAVY METALS IN TALINUM TRIANGULARE AND TELFAIRA OCCIDENTALIS

| Heavy Metals | UPPS | Ohafia | Isuikwuato | UPPS | Ohafia | Isuikwuato | FAO & WHO (2011) |
|---|---|---|---|---|---|---|---|
| Nickel (Ni) | - | 3.87 | 1.21 | - | 1.78 | 0.64 | 0.1 |
| Manganese (Mn) | - | 10.02 | 0.95 | - | 13.29 | 1.43 | 5 |
| Cadmium (Cd) | - | 0.93 | 0.1 | - | 0.79 | 0.36 | 0.02 |
| Mercury (Hg) | - | nd | 290 | - | - | 435 | 0.03 |
| Copper (Cu) | - | 9.33 | 4.27 | - | 9.11 | 4.6 | 10 |
| Zinc (Zn) | - | 6.83 | 3.66 | - | 6.9 | 3.71 | 60 |
| Chromium (Cr) | - | 9.5 | nd | - | 13 | 0.71 | 1.3 |
| Iron (Fe) | - | 0.81 | 0.54 | - | 0.42 | 0.25 | 425.5 |
| Lead (Pb) | - | 34.57 | nd | - | 23.86 | - | 0.3 |
| Arsenic (As) | - | 0.15 | nd | - | - | - | 0.5 |
| $BAF_{(TOTAL)}$ | | 76.01 | 300.73 | - | 69.15 | 446.7 | - |

Legend: (-) not detected

### D. *Ecological Potential Risk Associated with Heavy Metals in the Soils of the Study Sites*

Table 4 reports the heavy metals ecological potential risk index in the soils of the study sites. It was observed that of all the heavy metals Iron (Fe) posed the most ecological potential risk. It presents considerable potential ecological risk in Ohafia and Isuikwuato with value ranges of 136.53 and 192.33 respectively. This was followed by the value of cadnium (Cd) in Ohafia (65.1) which is considered to be of moderate risk. Furthermore, iron (Fe) showed high ecological potential risk concern ($160 \leqslant P^i_r < 320$) in Isuikwuato. However, it poses a moderate ecological potential risk ($80 \leqslant P^i_r < 160$) in Ohafia. In addition, the values of the other heavy metals where of low ecological potential risk ($P^i_r < 40$) concern in the study sites.

TABLE IV. HEAVY METALS ECOLOGICAL POTENTIAL RISK INDEX IN THE SOILS OF THE STUDY SITES (MG/KG).

| Metals | Ohofia | Isiukwuato | Toxic Response | Ohofia($P^i_r$) | Isiukwuato ($P^i_r$) |
|---|---|---|---|---|---|
| Ni | 0.23 ±0.04 | 0.14 ±0.03 | 5 | 1.15 | 0.7 |
| Mn | 1.05 ±0.10 | 1.22 ±0.03 | 1 | 1.05 | 1.22 |
| Cd | 2.17 ±0.05 | 0.39 ±0.05 | 30 | 65.1 | 11.7 |
| Hg | - | 0.002 ±0.00 | 40 | - | 0.08 |
| Cu | 0.09 ±0.03 | 0.15 ±0.05 | 5 | 0.45 | 0.75 |
| Zn | 0.42 ±0.28 | 0.71 ±0.11 | 1 | 0.42 | 0.71 |
| Cr | 0.04 ±0.01 | 0.07 ±0.01 | 2 | 0.04 | 0.14 |
| Fe | 136.53 ±37.37 | 192.23 ±70.05 | 1 | 136.53 | 192.33 |
| Pb | 0.21 ±0.06 | 0.37 ±0.11 | 5 | 1.05 | 1.85 |
| As | 0.067 ±0.001 | 0.075 ±0.002 | 10 | 0.67 | 0.75 |

Legend: (-) not detected

### E. *Health hazards linked with food intake of Heavy Metals from T. triangulare and T. occidentalis in Ohafia Site*

The health risk of heavy metal exposure on T. triangulare and T. occidentalis in Ohofia sites on consumption is presented on table 5. The result showed that Fe had a high EDI and THQ value of T. triangulare 147.60 and 42.171 while, in T. occidentalis the values were 78,06 and 22,302.86 respectively. This was followed by the THQ values of Pb 2,785.71 and 1,922.86. However, Cd maintained these values in 2,690 and 2,310 in both T. triangulare and T. occidentalis. Furthermore, it was also observed that within all the sites, the target hazard quotient of the ten heavy metals detected exceeded the non-carcinogenic risk (I.e THQ >1). Though, Arsenic (As) was completely not detected in T.occidentalis.

TABLE V. HEALTH RISK ASSOCIATED WITH CONSUMPTION OF T. TRIANGULARE AND T.OCCIDENTALIS EXPOSED TO HEAVY METALS IN OHAFIA SITES

| T. triangulare | | | | | T.occidentalis | | |
|---|---|---|---|---|---|---|---|
| METALS | RfD | MEAN ± SD (mg/ml) | EDI | THQ | MEAN ± SD (mg/ml) | EDI | THQ |
| Ni | $2.0 \times 10^{-2}$ | 0.89 ± 0.00 | 1.19 | 59.5 | 0.41 ± 0.00 | 0.55 | 27.5 |
| Mn | $4.6 \times 10^{-2}$ | 10.52 ± 0.00 | 14.13 | 307.17 | 13.95 ± 0.00 | 17.73 | 385.43 |
| Cd | $1.0 \times 10^{-3}$ | 2.01 ± 0.00 | 2.69 | 2,690 | 1.72 ± 0.00 | 2.31 | 2,310 |
| Hg | $1.0 \times 10^{-3}$ | 1.01 ± 0.00 | 1.36 | 1,360 | 1.98 ± 0.01 | 2.66 | 2,660 |
| Cu | $4.0 \times 10^{-1}$ | 0.84 ± 0.00 | 1.13 | 2.83 | 0.82 ± 0.00 | 1.1 | 2.75 |
| Zn | $3.0 \times 10^{-1}$ | 2.87 ± 0.00 | 3.85 | 12.8 | 2.90 ± 0.00 | 3.89 | 12.97 |
| Cr | $7.0 \times 10^{-4}$ | 0.38 ± 0.00 | 0.51 | 728.57 | 0.52 ± 0.00 | 0.69 | 985.71 |
| Fe | $3.5 \times 10^{-3}$ | 109.92 ± 0.00 | 147.6 | 42,171 | 58.13 ± 0.00 | 78.06 | 22,302.86 |
| Pb | $3.5 \times 10^{-3}$ | 7.26 ± 0.00 | 9.75 | 2,785.71 | 5.01 ± 0.01 | 6.73 | 1,922.86 |
| As | $3.0 \times 10^{-4}$ | 0.01 ± 0.00 | 0.01 | 33.33 | - | - | - |

Legend: Legend: (-) not detected, mean ±

### F. *Health hazards linked with food intake of Heavy Metals from T. triangulare and T. occidentalis in Isuikwuato Site*

The results of the health risk associated with the consumption of T. triangulare and T. occidentalis exposed to heavy metals in Isuikwato sites are presented in table 6. It showed that Fe had a high EDI and THQ value in T. triangulare 1,483.02 and 423,720 whereas, T. occidentalis had 65.59 and 18,740 respectively. This was tailed by the values of Hg 780 and 1,170 in both T. triangulare and T. occidentalis. It was also observed that the target hazard quotient (THQ) of the ten heavy metals detected exceeded the non-carcinogenic risk (I.e. THQ >1). However, Cr was not detected in T. triangulare besides, Pb and As were not also detected in both vegetables. In addition, of all the study sites Fe THQ was observed to be highest in Isuikwuato in T. triangulare.

TABLE VI. HEALTH RISK ASSOCIATED WITH CONSUMPTION OF T. TRIANGULARE AND T.OCCIDENTALIS EXPOSED TO HEAVY METALS IN ISUIKWUATO SITES

| *T. triangulare* | | | | | *T.occidentalis* | | |
|---|---|---|---|---|---|---|---|
| METALS | RfD | MEAN ± SD (mg/ml) | EDI | THQ | MEAN ± SD (mg/ml) | EDI | THQ |
| Ni | $2.0 \times 10^{-2}$ | 0.17 ± 0.00 | 0.23 | 11.5 | 0.09 ± 0.00 | 0.12 | 6 |
| Mn | $4.6 \times 10^{-2}$ | 1.16 ± 0.00 | 1.56 | 33.91 | 1.75 ± 0.00 | 2.35 | 51.09 |
| Cd | $1.0 \times 10^{-3}$ | 0.26 ± 0.00 | 0.35 | 350 | 0.14 ± 0.00 | 0.19 | 190 |
| Hg | $1.0 \times 10^{-3}$ | 0.58 ± 0.00 | 0.78 | 780 | 0.87 ± 0.00 | 1.17 | 1,170 |
| Cu | $4.0 \times 10^{-1}$ | 0.64 ± 0.00 | 0.86 | 2.15 | 0.69 ± 0.00 | 0.93 | 2.33 |
| Zn | $3.0 \times 10^{-1}$ | 2.60 ± 0.00 | 3.49 | 11.63 | 2.64 ± 0.00 | 3.55 | 11.83 |
| Cr | $7.0 \times 10^{-4}$ | nd | nd | nd | 0.05 ± 0.00 | 0.07 | 100 |
| Fe | $3.5 \times 10^{-3}$ | 104.38 ± 0.00 | 1,483.02 | 423,720 | 48.84 ± 0.00 | 65.59 | 18,740 |
| Pb | $3.5 \times 10^{-3}$ | - | - | - | - | - | - |
| As | $3.0 \times 10^{-4}$ | - | - | - | - | - | - |

Legend: Legend: (-) not detected, mean ±

## IV. DISCUSSION

The heavy metals absorbed by the vegetable plant is reflected in their concentrations. However, the plant samples were able to take up more of some of the heavy metals than others. In the two study sites, iron (Fe) content was observed to be more abundant in the leaf of the two plants (T. triangulare and T. occidentalis) this might be due to the participation of green vegetables in the synthesis of ferrodoxin which make them useful source of Fe. However, this reveals that the significant concentration of Fe from the study sites cannot be conclusively attributed to the hairdressing salon but other source of Fe must be put into consideration. Moreover, continuous cropping or surface runoff from wastewater, effluent etc. could increase Fe concentrations in the soil [1]. Also, higher concentrations of mercury (Hg) were detected in the leaf of the vegetable plants when compared to those found in the soil. This result is in consonance with Liu Shaode and Changle [19] who also reported higher concentrations of Hg in the leafy parts of pepper when compared to their root, this maybe contributed the the atmosphere as plants breathe through their pores and are able to absorb elemental Hg and methyl Hg in the atmosphere. In addition, the result of the contamination of heavy metals; Ni, Mn, Cd, Hg, Zn, Cr, Cd and As, from the study sites might be of possible lethal effect as their concentrations exceeded the permissible limits of FAO and WHO [13] except for iron and copper. Plants have shown the ability to bioaccumulate heavy metal especially leafy vegetables which can be of consequence on the food chain. This is because heavy metals are not only toxic to human health but are potential carcinogen. However, the result revealed that Mercury (Hg) accumulated more in both vegetables than the other heavy metals. This could be from the atmosphere as plant has the ability to absorb Hg through the leaf and stem. Furthermore, plant enzymes are capable of reducing plant uptake of organic mercury, which is then released in to the atmosphere. According to Yu et al., [35], leafy vegetables when treated in low pressure the (Hg) present in the leafy parts had higher values when compared to those found in the root. This may be attributed to the atmosphere as plants breathe through their pores and are able to absorb metallic mercury and CH3Hg in the atmosphere. Increase mercury content in food can damage the digestive tract, kidney as well as cause stillbirth in pregnant women. The result in this study showed increase bioaccumulation value of Ni, Mn, Cd, Hg, Cr, Pb and As against the above recommended maximum limit for vegetable by WHO and FAO [13] indicating that consumption of this vegetable grown from farmland along hairdressing salon could cause adverse health effect on human when consumed. Eteng et al., [12] reported that high intake of Cr contaminated vegetables is associated with allergic dermatoid, ulceration, kidney and liver damage in humans; while Ni and As can increase cancer risk. In addition, Osundiya et al., [24] reported lead (Pb) to be a serious cumulative body poison which penetrates into the body system via food, air and water respectively and cannot be removed by washing the vegetables. The elevated levels of metals in the vegetables could be attributed to excessive usage of fertilizers and other agro-chemicals, as well as runoff from hairdressing salon and other industrial waste water.

The ecological potential risk index (Pir) shows the vulnerability of biological ecosystems to harmful contaminants and thus, the possibility of potential risk posed by harmful metals in the environment and living organisms [20, 26]. From the values recorded of Pir, except for Cd, which had a moderate in Ohafia site, Eir indices of Ni, Mn, Hg, Cu, Zn, Cr, Pb and As were all < 40 showed low risk concern. While that of Fe across the study sites were relatively high ecological potential risk. According to Amusan et al., [4], Fe has been reported to be the most abundant heavy metal in Nigeria soil. High soil Fe concentrations can lead to impediment of nutrient uptake by plants [8]. Furthermore, Cd was observed to be of moderate ecological risk in Ohafia site. The continuous exposure of soil to Cd can be detrimental as it is a bio-toxic heavy metal and can serve as a potential threat to soil, food quality and human health [23].

The dietary daily intake (DDI) of heavy metals was used to determine its impact on human health. The dietary daily plant metal intake of Fe, Mn and Zn from both T. triangulare and T. occidentalis in Ohafia and Isuikwato were observed to exceed the recommended upper tolerable daily intake level (45.0, 11.0 and 0.24 mg day-1 person-1) of metals when compared to the other two study sites as established by institute of medicine for 19 - >70 years adults [14]. The results of the dietary intakes of metals Ni, Mn, Cd, Hg, Cu, Zn, Cr, Fe, Pb and As, from vegetables grown in contaminated study sites exceeded the dietary intakes of metals, but below the lower tolerable limits, with some exceptions.

Target Hazard Quotients (THQ) are parameter used for the determination of potential health risks associated with long term exposure to chemical pollutants [25,31]. This defines the exposure duration and the risk of exposure period. The THQs for heavy metals in all the study site for both T. triangulare and T. occidentalis samples were > 1. This is a clear signal that the ingestion of these vegetables grown on these study sites is not free from risk and therefore could bring about health risk of public concern.

## V. Conclusion

The contamination of edible vegetables in the Nigeria has been an issue that cannot be over looked due to its important in the food chain. Due to the cultivation method of vegetables in gardens and places that are not really farm, the chances of contamination are increased. This study focused on the vegetable contamination from hairdressing salon and its effect on humans as a result of consumption. The study shows that iron content is highest at the study sites. The hairdressing salon waste not properly discarded can contaminate the soil with heavy metals as well as the vegetables planted in such soil and this can result in human health risk. This study reveals that leafy parts of the vegetables usually consumed can accumulate heavy metals at high amount. Therefore, the study highlights the risks of consuming vegetables planted near hairdressing salon as they have high tendency of bioaccumulating heavy metals which can cause environmental and health risk.

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