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ENVIRONMENTAL HEALTH RISK INDEX ASSESSMENT IN EDIBLE VEGETABLE OILS WITHIN LAGOS SOUTHWEST NIGERIA

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Abstract

Edible vegetable oils are common in the market and almost every household uses the oils every day. In this study the goal is to measure the concentration of selected toxic metals, obtain information on health risk index and assessment of the environment due to these toxic metals and estimated daily dose intake from the polluted vegetable oils consumed and the impact on the population. Ten different vegetable oils from various manufacturers where collected from department stores in Lagos and processed for toxic metals analysis. A digital analytical balance (Explorer, Ohaus, Model E11140, and Switzerland) with ±0.0001 g precision was used for all measurements. Buck Scientific Atomic Absorption Spectrometer (BSAAS) (Model 210/211 VGP) was used to determine the concentrations of these heavy metals. The concentrations for Zn, Pb, Cu, Mn, Ni, Cd and Fe are in the range of 7.075 – 0.891; 0.032 – 0.008; 1.175 – 0.034; 9.065 – 0.082; 0.073 – 0.013; 0.077 – 0.017 and 6.625 – 0.580 mg\kg respectively. Potential non-carcinogenic health risk was evaluated using the daily estimate intake (DEI) of this metals and the health risk index. In addition, the carcinogenic health risk assessment of lifetime of these metals was evaluated; and health risk indices (HRI) were obtained. $1 > HRI_{(A3)} > HRI_{(A4)} > HRI_{(A7)} > HRI_{(A1)} > HRI_{(A5)} > HRI_{(A6)} > HRI_{(A2)} > HRI_{(A8)} > HRI_{(A9)} > HRI_{(A10)}$. This implies that the edible vegetable oils are safe for consumption since these values are less than 1. The results obtained are comparable with the US Environmental Protection Agency (US EPA) and Joint FAO/WHO Expert Committee on Food Additives (JECFA), thus the results indicate no health risk in the short time.

Keywords: health risk; Carcinogenic; Daily intake, Hazard Quotient, Pollution

Introduction

Vegetable oils are widely used domestically, industrially for this reasons they are commonly available worldwide. They are part of the food necessity for human growth; and are obtained from difference sources, are extracted by various methods thus its production runs to billion liters per year (Thode *et al.*, 2017), the consumption of edible oils in products, including the following; salad, cooking oil, baking and frying fats, and margarine. Some vegetable oils are used in animal feed, and small quantities are also used in the production of inedible products such as inks, diesel fuel, organic chemicals, paints, coatings and varnishes, plasticizers, lubricants, and soap. They are also used in the chemical and pharmaceutical industries (Dugo *et al.*, 2004). The quality of food products has received great attention due to its influence on human nutrition and health. Vegetable oils are beneficial to human health due to the fact that they have low cholesterol when compared to animal fats. Vegetable oils comprised primarily of triacylglycerol's or fatty acids this may be broken down (Bukola *et al.*, 2017) into valuable nutrients.

Toxic metals are an environmental concern and several millions of people worldwide are being affected. Metals are found in plants via deposition as well as bioaccumulation from the soil due to natural metal sources and environmental pollution. Toxic metals get their ways to edible oils through their direct migration from arable

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land to the oil producing plant. Individual plant's properties could also account for the content of heavy metal in edible oil production. Toxic metals in edible oils cause's changes to the oil quality, change to taste, and make them smell with bad odor, theses toxic metals could cause detrimental effects on human health. Toxic metals have harmful effects on human health, and exposure to these metals has been increased by industrial and anthropogenic activities and modern industrialization. Heavy metals are serious inorganic pollutants in food that are of great concern to human health, (Ghorani-Azam *et al.*, 2016; Luo *et al.*, 2021), because of their toxic effects. These heavy metals enter the human body through inhalation and ingestion. The intake via ingestion depends upon food habits. Heavy metals have adverse effects on human health when consumed above the recommended limits.

The reactions of metals both at the cellular and molecular levels may cause problems in the nucleophilic sites of most of the vital tissues in human body thus affecting the different organs (Samuel *et al.*, 2015). Metals such as cadmium, mercury, lead and arsenic etc. causes gastrointestinal disorders, tremors, hemoglobinuria, ataxia, paralysis, vomiting, pneumonia etc. this effect (even in small amount) could be acute or chronic effect (carcinogenic, or mutagenic and neurogenic) (Rajeshkumar *et al.*, 2006). Gastrointestinal and kidney dysfunction, nervous system disorders, skin lesions, vascular damage, immune system dysfunction, birth defects, and cancer are some examples of such effects (Costa *et al.*, 2019; Gazwi *et al.*, 2020; Tsai *et al.*, 2017). All living things rely on major metals such as Ca, Mg, Fe, Cu, Zn and Mn for growth and development, though some metals are beneficiary, while others are toxic, depending on the amount ingested (Sanches-Filho *et al.*, 2017; Ogungbemi *et al.*, 2022) therefor they are very contagious if found in edible oils. Since dietary vegetable oils play an important and essential role during digestion and metabolism they may react with some chemicals in particular with oxygen (Mendil *et al.*, 2009). The concentration levels of metals like Fe, Cu, Ca, Mg, Co, Cd, and Mn are known to increase the rate of oil oxidation while other elements such as Cr, Cd, and Pb at certain levels are toxic (Manjusha *et al.*, 2019). It is well established that Pb and Cd are toxic and children are more sensitive to these metals than adults (Cao *et al.*, 2010; Ogungbemi *et al.*, 2022). Consumption of toxic metals may increase the risk in a particular population, so it is essential to determine the concentration of these metals. Therefore, potential health risk may be estimated based on the risk index for each of the samples collected. Then, the risks from individual metals, which contribute to the population health risk, may be determined (Gan *et al.*, 2019; Li *et al.*, 2020; Monged *et al.*, 2020). This research is aimed at identifying and quantifying heavy metals in various edible oils available in the environment; and the quantitative assessment of environmental potential health risk of these heavy metals through the daily intake. On these bases, the goal is to measure the concentration of selected toxic metals, obtain information on health risk index and assessment of the environment due to these toxic metals and estimated daily dose intake from the polluted vegetable oils consumed.

Materials and Methods

Sample Collection and Preparations

Ten different brands (these brands are the most common brands in the markets, they are everywhere) of vegetable oils in plastic containers (Samples A1, A2, A3, A4, A5, A6, A7, A8, A9, and A10) were purchased from various popular markets in Lagos and taken to the research laboratory for heavy metal analysis. Five milliliters of each of the oil samples were randomly collected and digested with 10 ml of acid nitric-hydrochloric acids (HNO_3-HCl) in a ratio 1:3 and distilled water was added to each sample collected to make a total volume of 50 ml each. The oil samples were digested with nitric acid HNO_3 because it serves as

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both acid and oxidizing agent. Nitric acid does not form any insoluble compounds with metals and non-metals, whereas H_2SO_4 and HCl would. Each digested samples was carefully placed in the Flame Atomic Absorption Spectrophotometer (Model 210/211 VGP Buck Scientific Atomic Absorption Spectrometer (BSAAS)) for the detection of metals. A digital analytical balance (Explorer, Ohaus, Model E11140, and Switzerland) with ±0.0001 g precision was used for all measurements of samples and chemicals. Flame Atomic Absorption the BSAAS was used to determine the concentrations of Cu, Zn, Cd, Pb, Fe, Mn, and Ni. This section should include apparatus and equipment setup, work materials, design, experimental methods, as applicable.

Health Risk Analysis

Potential Health Risk Assessment

The potential non-carcinogenic health risk by metals intake can be assessed by the characterization of the following (Men *et al.*, 2018; Pourramezani *et al.*, 2019):

i. Daily Estimated Intake of metals (DEI),

ii. Hazard Quotient (HQ) and

iii. Health Risk index (HRI)

Daily Estimated intake (DEI) of metals*: Pb, Zn, Fe, Cd, Cu, Ni, Mn*

The DEI of metals was evaluated with consideration for the daily consumption of 25 g for vegetable oil as recommended World Health Organization (WHO). The body weight of an individual adult was set to a standard of 70 kg for this study. The equation to compute DEI (Zhu *et al.*, 2011) is given by

$$DEI = \frac{ED \times FI \times EF \times MC}{BW \times AT} \times 10^{-3} \quad (1)$$

DEI = daily estimated Intake of individual element (mg/kg/day)

EF = exposure frequency of each element (365day/year)

ED = exposure duration for an adult (70 years)

FI = daily consumption of the vegetable oil (25 g/day) WHO recommendation

MC = mean concentration of each element in the oil (mg/kg)

BW = mean body weight of an adult (70 kg)

AT = average life time (70 years x 365 days)

Target Hazard Quotient (THQ)

For non-carcinogenic, the estimated health risk level can be obtained using THQ (USEPA, 2008), THQ is estimated by the following equation

$$THQ = \frac{DEI}{RfD} \quad (2)$$

DEI = daily estimated Intake of individual element (mg/kg/day)

RfD = oral reference dose (mg/kgBw/day)

Table 1: RfD Values for the Metals in This Study (Harmanescu *et al.*, 2011; USEPA, 2014; USEPA, 2017; UUSEPARA, 2005; Cao *et al.*, 2010)

Element	RfD ((mg\kgBw\day)
Zn	3×10^{-1}
Fe	0.7
Mn	0.046

Pb	3.5×10^{-3}
Ni	2×10^{-2}
Cd	1×10^{-3}
Cu	4×10^{-2}

Potential Carcinogenic Risk Assessment (PCRA)

The Potential Carcinogenic Risk Assessment (PCRA) has been used to indicate carcinogenic health risk assessment of lifetime of metals. This is obtained by the use of the equation of Incremental Lifetime Cancer risk (ILCR) as indicated below (Sultana *et al*., 2017; USEPA, 2017).

DEI = daily estimated Intake of individual element (mg/kg/day)

CPSo =carcinogenic potency slope for oral route (mg/kg bw/day)$^{-1}$

Health Risk Index (HRI)

HI from THQs is expressed as the sum of the hazard quotients (UUEPA, 2010).

$$ILCR = DEI \times CPSo \quad (3)$$

$$HI = THQ(Pb) + THQ(Mn) + THQ(Fe) + THQ(Cd) + THQ(Zn) + THQ(Cu) + THQ(Ni) \quad (4)$$

THQ (Pb) is the Targeted Quotient for Pb, where HI < 1 is safe and HI > 1 is hazardousThe mathematical principles or theories used should be included as appropriate.

Table 2: CPSo value for the metals in this study (Sultana *et al*., 2017; USEPA, 2017; Cogliano *et al*., 2003)

Elements	CPSo (mg\kg\day)
Zn	----
Fe	----
Mn	----
Pb	0.0085
Ni	0.91
Cd	15
Cu	----

Results

The metals in each of the samples are Zn, Fe, Mn, Pb, Ni, Cd and Cu. For these elements, the concentrations (mg\kg) per sample are stated (Table 3). Fe, Mn, Cu and Zn are essential for metabolism in their lower concentrations, whereas; Cd, Pb, and Ni are potentially hazardous to human health. These obtained concentrations were used to estimate the daily intake of these metals per sample and hence the potential risk assessments were estimated from the values.

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Table 3: Mean Concentration of the Elements in the Vegetable Oils (mg\kg)

Elements	Mean Concentrations(mg\kg)									
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
Zn	6.20±0.10	4.55±0.01	7.08±0.23	8.20±0.37	4.38±0.23	1.32±0.01	2.56±0.43	0.89±0.05	1.09±0.55	2.11±0.42
Fe	4.93±0.21	5.05±0.61	6.63±0.16	3.95±0.11	4.89±0.87	0.66±0.05	4.05±0.09	1.09±0.23	0.79±0.16	0.58±0.11
Mn	1.50±0.14	2.28±0.03	6.58±0.71	9.05±0.01	2.33±0.63	1.08±0.87	4.00±0.05	2.42±0.47	0.87±0.31	0.08±0.69
Pb	0.03±0.17	0.01±0.01	0.01±0.11	0.01±0.05	0.02±0.95	0.02±0.09	0.04±0.03	0.01±0.04	0.02±0.17	0.02±0.03
Ni	0.16±0.07	0.04±0.03	0.07±0.03	0.04±0.61	0.07±0.00	0.04±0.07	0.04±0.01	0.07±0.02	0.03±0.42	0.01±0.51
Cd	0.04±0.01	0.01±0.02	0.08±0.42	0.02±0.12	0.04±0.12	0.07±0.51	0.08±0.17	0.03±0.22	0.05±0.01	0.03±0.09
Cu	0.75±0.09	0.70±0.15	1.18±0.21	0.48±0.16	0.53±0.08	0.67±0.36	0.03±0.09	0.06±0.17	0.07±0.04	0.14±0.25

The concentration of each element per sample is illustrated (Fig. 1). From sample A1, Zn has 6.200mg\kg while Fe has 4.925 mg\kg both being the highest, sample A2, Zn has 4.550mg\kg followed by Fe with 5.050mg\kg, sample A3 has its highest in Zn is 7.075mg\kg, Fe is 6.625mg\kg and Mn has 6.575mg\kg while the rest are lower than those values.

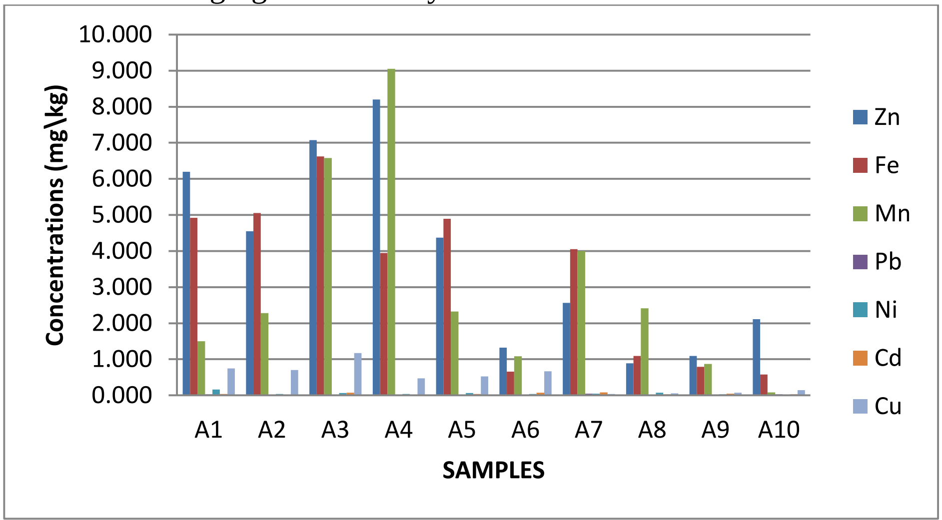

Figure 1: The mean concentrations of each element across samples A1-A10.

A4 has highest concentrations in Mn and Zn both of values 9.050mg\kg and 8.200 respectively. Sample A5 has it highest value in Fe followed by Zn they both have 4.890mg\kg and 4.375mg\kg respectively. In samples A6, A8, A9 and A10 almost all the elements recorded very low concentration values expects in A8 with Mn concentrations value of 2.415mg\kg; A10 with Zn recording 2.107mg\kg the rest elements have lower concentrations than that, however; in sample A7 both Fe and Mn have the same value of 4.002mg\kg.

Discussion

Quantification of the samples shows that most of the samples are polluted to certain extend with heavy metals. So therefore, to estimate the potential health risk assessments in these samples; the following must be evaluated: Daily Estimated Intake of metals (DEI), Hazard Quotient (HQ) and Health Risk index (HRI) as previously described above (Men *et al.*, 2018; Pourramezani *et al.*, 2019; Zhu *et al.*, 2011). Using the parameters provided in health risk analysis session above the values of the DEI in each sample were obtained as shown (Figures 2a – 2j).

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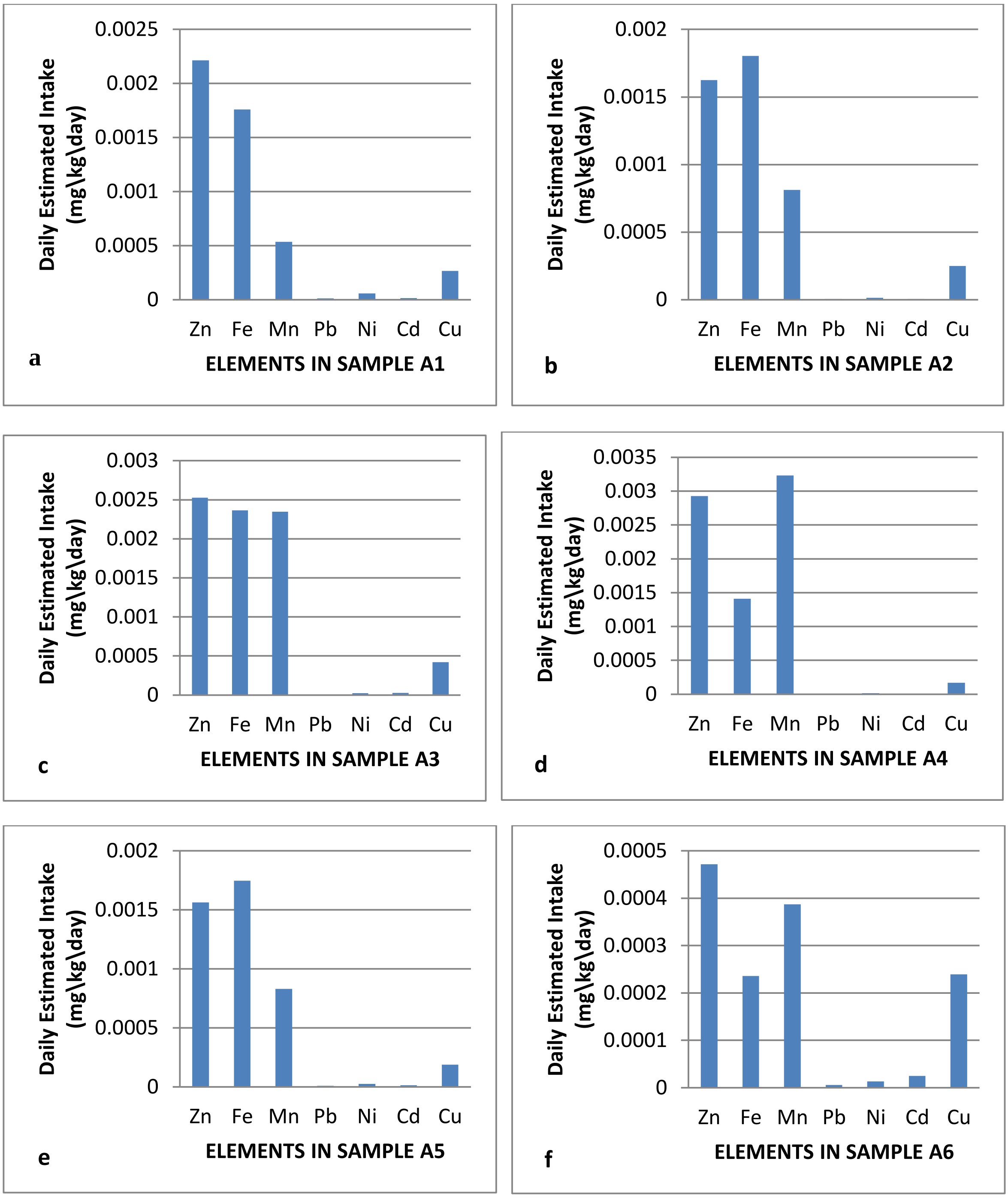

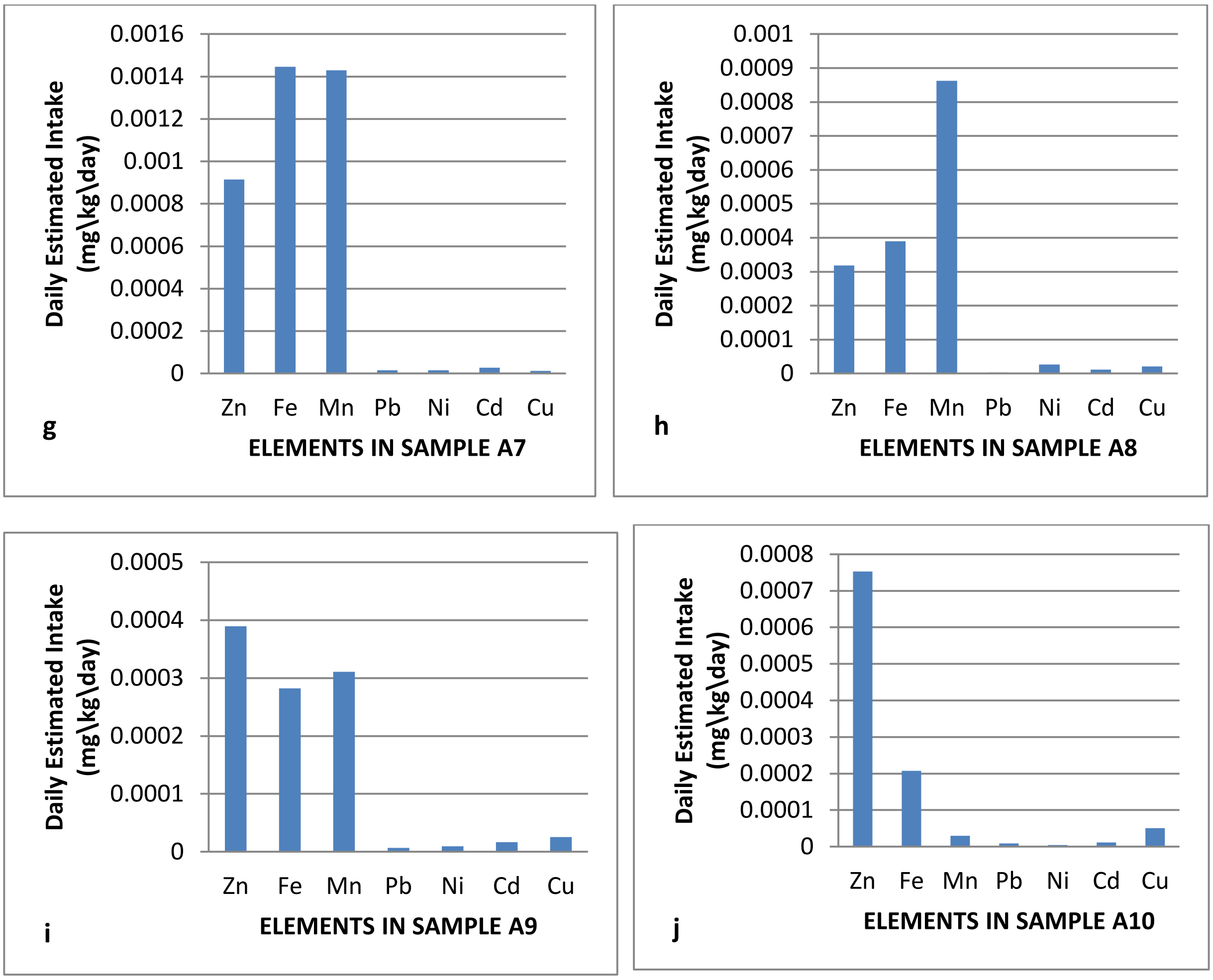

Figure 2: Comparison of DEI of each metal in samples a)A1, b)A2, c)A3, d)A4, e)A5, f)A6 ,g)A7, h)A8, i)A9, and j)A10.

DEI for the Zn is the highest with 2.21 x10^{-3} mgkg^{-1}day^{-1} while Pb is the lowest with 1.14 x10^{-5} mgkg^{-1}day^{-1}, while Fe, Mn, Cu, Cd and Ni have 1.76 x10^{-3}, 5.36 x10^{-5}, 2.68 x10^{-4}, 1.46 x10^{-5}, 5.75 x10^{-5} mgkg^{-1}day^{-1} respectively (Figure 2a). Iron has the highest DEI of 1.80 x10^{-3}mgkg^{-1}day^{-1} and Zn, Mn, Pb, Ni, Cu and Cd have 1.63 x10^{-3}, 8.13 x10^{-4}, 4.29 x10^{-6}, 1.29 x10^{-5}, 0.25 x10^{-3}, 4.64 x10^{-6} mgkg^{-1}day^{-1} respectively (Figure 2b). The DEI values obtained for the third sample A3, for Zn, Fe, Mn, Pb, Ni, Cd and Cu were 2.53 x10^{-3}, 2.37 x10^{-3},2.35 x10^{-3},2.86 x10^{-6},2.39 x10^{-5} 2.71 x10^{-5} ,4.20 x10^{-4} mgkg^{-1}day^{-1} respectively (Figure 2c). DEI for Zn, Fe, Mn, Pb, Ni, Cd and Cu are 2.93 x10^{-3}, 1.41 x10^{-3}, 3.23 x10^{-3}, 4.64 x10^{-6}, 1.46 x10^{-5}, 6.07 x10^{-6}, 1.70 x10^{-4} mgkg^{-1}day^{-1} (Figure 2d). While for Sample A5, the DEI obtained for Zn, Fe, Mn, Pb, Ni, Cd and Cu are 1.56 x10^{-3},1.75 x10^{-3}, 8.30 x10^{-4},7.86 x10^{-6},2.39 x10^{-5},1.32 x10^{-5} ,1.88x10^{-4} mgkg^{-1}day^{-1} respectively Figure 2e). The DEI for each metal Zn, Fe, Mn, Pb, Ni, Cd and Cu in sample A6 are 4.71x10^{-4}, 2.36 x10^{-4}, 3.87x10^{-4}, 5.71x10^{-6}, 1.36x10^{-5}, 2.46x10^{-5}, 2.39x10^{-4} mgkg^{-1}day^{-1} respectively (Figure 2f). For Sample A7, the DEI values for Zn, Fe, Mn, Pb, Ni, Cd and Cu are 3.18 x10^{-4}, 3.89 x10^{-4}, 8.63 x10^{-4}, 2.86 x10^{-6}, 2.61x10^{-5}, 1.11 x10^{-5}, 2.11 x10^{-5} mgkg^{-1}day^{-1} (Figure 2g). DEI values for each metal in sample A8, Zn, Fe, Mn, Pb, Ni, Cd and Cu are 3.18 x10^{-4}, 3.89 x10^{-4}, 8.63 x10^{-4}, 2.86 x10^{-6}, 2.61 x10^{-5}, 1.11 x10^{-5}, 2.1 x10^{-5} mgkg^{-1}day^{-1} (Figure 2h). The DEI values for each metal in sample A9, Zn, Fe, Mn, Pb, Ni, Cd and Cu are 3.90 x10^{-4}, 2.82 x10^{-4}, 3.11 x10^{-4}, 6.79 x10^{-6}, 9.29 x10^{-6}, 1.68 x10^{-5} and 2.54x10^{-5} mgkg^{-1}day^{-1}respectively (Figure 2i). In sample A10, the obtained DEI values in each of the identified metals Zn, Fe, Mn, Pb, Ni, Cd and Cu are 7.53 $x10^{-4}$,2.07 $x10^{-4}$,2.93 $x10^{-5}$,8.57 $x10^{-6}$,4.64 $x10^{-6}$,1.45 $x10^{-5}$,5.07 $x10^{-5}$ mg $kg^{-1}day^{-1}$ respectively (Figure 2j)

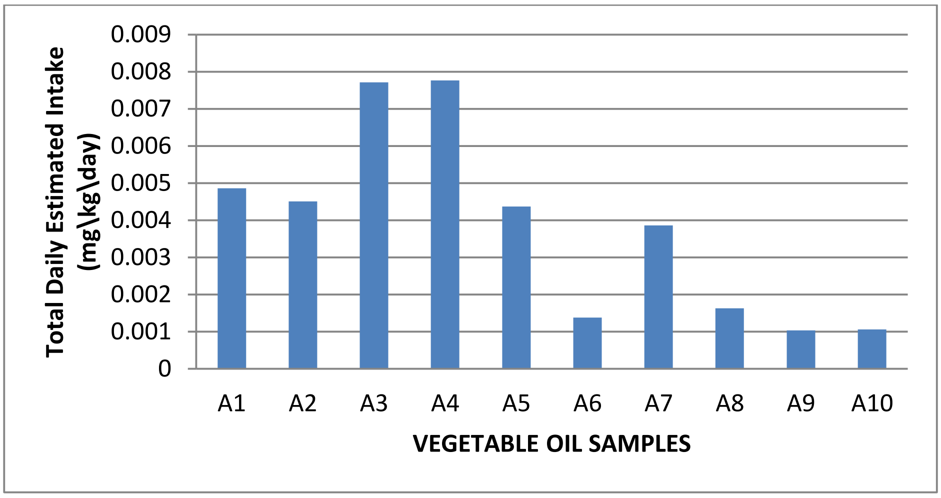

Figure 3: DEI Comparisons of Ten (10) Samples Collected from Different Manufacturers

The total daily estimate index is the sum total of the DEI per element in each of the samples. This might give an insight to the potential health hazards of each of the collected samples and could also serve as an indicator for health reason(s) to the consumers in the locality. Samples A3 and A4 have the highest total DEI of 7.71 $x10^{-3}$and 7.77 $x10^{-3}$ $mgkg^{-1}day^{-1}$espectively. For the other samples in descending order of DEI values mg $kg^{-1}day^{-1}$ are A1(4.83 $x10^{-3}$), A2(4.51 $x10^{-3}$), A5(4.37 $x10^{-3}$) and A7(3.86 $x10^{-3}$), A6(1.38 $x10^{-3}$), A8(1.63 $x10^{-3}$), A9(1.04 $x10^{-3}$), A10(1.06 $x10^{-3}$) (Figure 3).

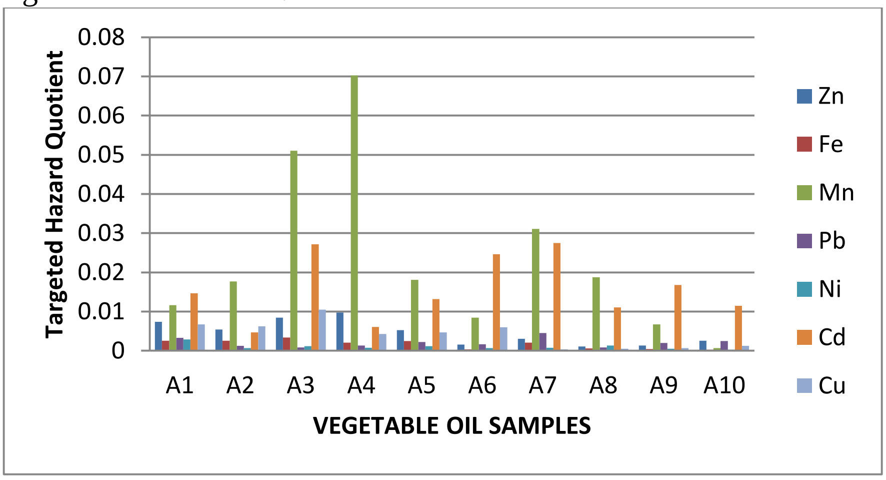

Figure 4: Comparison of the Targeted Hazard Quotients per sample

Therefore, the THQ of Mn in both the sample A3 and A4 shows the highest values of $0.51x10^{-1}$ and $0.70x10^{-1}$. It is noteworthy that the Cd THQ spike cuts across the entire sample with the maximum values of $0.28x10^{-1}$, and $0.27x10^{-1}$ and the lowest values of $0.61x10^{-2}$ and $0.46x10^{-2}$; whereas, for the other elements the THQ all falls below $0.01x10^{-2}$. The risks from individual metals in each sample, may contribute to the ecological risk [b], thus, the potential ecological risk can be estimated based on the risk index (RI) for each sample.

Table 4: Potential Carcinogenic Risk Assessment

Elements	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
	Incremental lifetime Cancer risk (ILCR)									
Pb	9.714×10^{-8}	3.642×10^{-8}	2.428×10^{-8}	3.946×10^{-8}	6.678×10^{-8}	4.857×10^{-8}	1.335×10^{-7}	2.428×10^{-8}	5.767×10^{-8}	7.285×10^{-8}
Ni	2.616×10^{-3}	0.585×10^{-3}	1.089×10^{-3}	0.666×10^{-3}	1.089×10^{-3}	6.175×10^{-4}	0.715×10^{-3}	1.186×10^{-3}	4.225×10^{-3}	2.113×10^{-4}

The incremental lifetime cancer risk (ILCR) for both Pb and Ni as identified in the samples A1 – A10 (Table 4). ILCR is another factor used to estimate the potential health risk assessments for carcinogenic elements to ascertain the health risk level in the samples, Even though these values are small they could be significant in a life time as a result of bioaccumulation of this elements in the body system as acquired from food rich in the oils studied. The ILCR of Ni is generally higher in each sample when compared sample by sample for Pb and Ni.

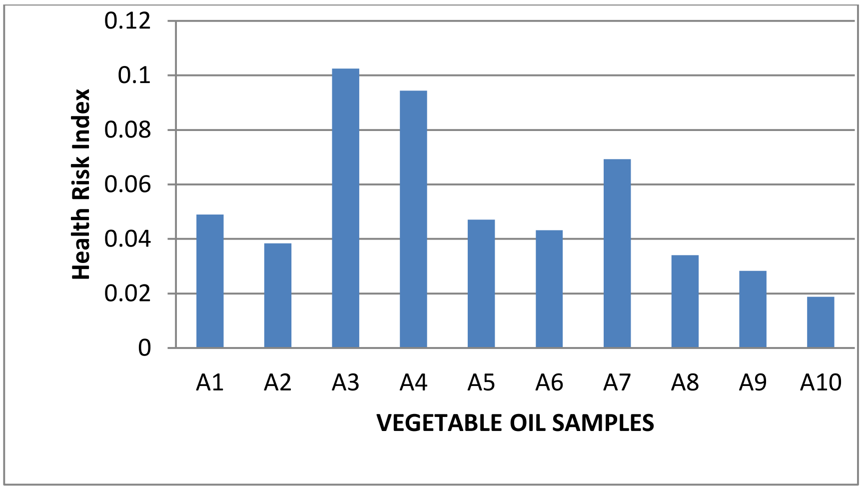

Figure 5: Comparison of the Health Risk Indices of the Vegetable Oils

The Health risk index (HRI) is an important parameter in assessing the potential health risk in the sample; parameter is a function of all the parameters highlighted in this work. Thus, the level of safety of the vegetable edible oil in each sample A1 – A10 is evaluated with the obtained values of HRI per sample as indicated in the figure 5 above. For safety the value of the HRI most the less than unity and if greater than unity it becomes hazardous and unsafe to consumed. However, from figure 5 above all the evaluated values of the HRI are less than unity. From figure 5 it is true that;

$$1 > HRI_{(A3)} > HRI_{(A4)} > HRI_{(A7)} > HRI_{(A1)} > HRI_{(A5)} > HRI_{(A6)} > HRI_{(A2)} > HRI_{(A8)} > HRI_{(A9)} > HRI_{(A10)}$$

Conclusion

Heavy metals intake through the consumption of edible vegetable oils and successive accumulation in human tissues and bio-magnification through the food chain cause both human health and environment concerns. Although the sources of Ni, Mn, Cd, Cu, Pb, Fe and Zn contamination in these samples might not be known, it is very important to evaluate the potential health risk that caused by these metals in these different edible vegetable oils analyzed.

This study also revealed that nearly all the collected edible vegetable oils were contaminated by the identified metals Ni, Mn, Cd, Cu, Pb, Fe and Zn to certain degree.

Furthermore, the small DEI values of the heavy metals obtained from the evaluation of these edible vegetable oils provides evidence for the safety of consumers of these oils.

The potential carcinogenic risk assessment performed for the targeted elements Pb and Ni, showed that Nickel's ILCR was significant in all the collected samples when compared to that of Pb. However, the long-term bioaccumulation of the metal may be a concern over a long period of time in the biota. The Health risk index (HRI) performed in this study shows that

$1 > HRI_{(A3)} > HRI_{(A4)} > HRI_{(A7)} > HRI_{(A1)} > HRI_{(A5)} > HRI_{(A6)} > HRI_{(A2)} > HRI_{(A8)} > HRI_{(A9)} > HRI_{(A10)}$;this implies that the edible vegetable oils investigated are safe for consumption since these values are less 1.

Authors Contributions

Ogungbemi I. Kayode conceptualized, investigated and analysed the data. He also wrote the manuscript proof reading with grammatical Applications.

Uba Blessing Uchenna contributed in administrative support, collected samples and draft the first document.

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Ethical Approval Statement

Since this research work is not involved with life of human begin or Animals directly, there is no need of Ethical Approval for the work.

Funding Information

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Conflict of Interest Statement

It should be on record that there is no conflict of interest.

Data Availability Statement

All data generated or analysed during this study are included in this published article.

References

Bukola Margaret Popoola, A. A. Onilude (2017). Microorganisms associated with Vegetable oil polluted; *Advances in Microbiology*, Vol.7 No.5 pg 377-386, DOI: 10.4236/aim.2017.75031

Cao H, Chen J, Zhang J, Zhang H, Qiao L, Men Y., (2010). Heavy metals in rice and garden vegetables and their potential health risks to inhabitants in the vicinity of an industrial zone in Jiangsu, China. *Journal of Environmental Sciences*. 22(11),1792-1799. https://doi.org/10.1016/S1001-0742(09)60321-

Cogliano, V. J., Barton H. A., Cogliano V. J., Flowers, L., Valcovic, L., Setzer, R. W., Woodruff, T. J., (2003) Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens. *Environmental Health Perspect*.113 (9), 1125-1133. DOI: 10.1289/ehp.7667

Costa M. (2019). Review of arsenic toxicity, speciation and polyadenylation of canonical histones. *Toxicology and Applied Pharmacology* 375, 1–4. *Doi:10.1016/j.taap.2019.05.006*

Dugo G, la Pera L, La Torre GL, Giuffrida D. (2004). Determination of Cd (II), Cu (II), Pb (II), and Zn (II) content in commercial vegetable oils using derivative potentiometric stripping analysis. *Food Chemistry*. 87, 639-645 DOI:10.1016/j.foodchem.2003.12.035

Gan, Y., Huang, X., Li, S., Liu, N., Li, Y. C., Freidenreich, A. Wang, W., Wang , R., Dai, J . (2019). Source quantification and potential risk of mercury, cadmium, arsenic, lead, and chromium in farmland soils of Yellow River Delta. *Journal of Cleaner Production*. 221, 98–107. doi: 10.1016/j.jclepro.2019.02.157

Gazwi H. S. S., Yassien E. E., Hassan H. M. (2020). Mitigation of lead neurotoxicity by the ethanolic extract of Laurus leaf in rats. *Ecotoxicology and Environmental Safe* 192. 2020 Apr 1;192:110297. doi: 10.1016/j.ecoenv.2020.110297. Epub 2020 Feb 13. PMID: 32061979

Ghorani-Azam A., Riahi-Zanjani B., Balali-Mood M. (2016). Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of Research in Medical Sciences*, 21, 65.
DOI: 10.4103/1735-1995.189646

Harmanescu M., Alda L. M., Bordean D.M., Gogoasa I.,Gergen I. (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: Banat County. *Romania Chemistry Central Journal*. 5(1), 64-73. DOI: 10.1186/1752-153X-5-64

Kayode Idowu Ogungbemi, Williams Igoniye, Ibitoye Ayo Zaccheaus, Margret Abosede Adedokun. (2022). Radiation Doses in fishing Water and Coast Soil in Lagos State South West Nigeria. *Communication in Physical Sciences*, 8(4): 456-464 https://www.journalcps.com

Li, J., Wang, G., Liu, F. Cui L., Jiao Y., Source Apportionment and Ecological-Health Risks Assessment of Heavy Metals in Topsoil Near a Factory, Central China. *Exposure and Health* **13**, 79–92 (2021). https://doi.org/10.1007/s12403-020-00363-8

Luo, L., Wang, B., Jiang, J., Fitzgerald, M., Huang, Q., Yu, Z., Li, H., Zhang, J., Wei, J., Yang, C., Zhang, H., Dong, L., Chen, S,. (2021). Heavy Metal Contaminations in Herbal Medicines: Determination, Comprehensive Risk Assessments, and Solutions. *Frontiers in pharmacology*, 11, 595335.
https://doi.org/10.3389/fphar.2020.595335

Manjusha R., Shekhar R. and Kumar S.J. (2019). Ultrasound-assisted extraction of Pb, Cd, Cr, Mn, Fe, Cu, Zn from edible oils with tetra methyl ammonium hydroxide and EDTA followed by determination using graphite furnace atomic absorption spectrometer. *Food Chemistry*. 294, 384-389. https://doi.org/10.1016/j. foodchem.2019.04.104

Men, C., Liu, R., Xu, F., Wang, Q., Guo, L., Shen, Z., (2018). Pollution characteristics, risk assessment, and source apportionment of heavy metals in road dust in Beijing. China. Sci. *Total Environmental*. 612, 138–147. DOI: 10.1016/j.scitotenv.2017.08.123

Mendil D, Uluozlu ÖD, Tüzen M, Soylak M.(2009). Investigation of the contents of some element in edible oil samples produced in turkey by atomic absorption spectrometry. *Jour. Hazard. Mater*. 165, 724-728.
DOI: 10.1016/j.jhazmat.2008.10.046

Monged, M. H. E., Hassan, H. B., and El-Sayed, S. A. (2020). Spatial Distribution and Ecological Risk Assessment of Natural Radionuclides and Trace Elements in Agricultural Soil of Northeastern Nile Valley, Egypt. Water. *Air. Soil Pollution* 231; 338. doi: 10.1007/s11270-020-04678-9

Ogungbemi, K. I., Y. Nsa, L. R. Owoade (2022). Investigation of Estimated Daily Intake of Toxic Metals and Potential Health Risks in Oreochromis noliticus (Tilapia Fish); *Bulgarian Journal of Physics* vol. 49 (2022) 386–398 doi:
https://doi.org/10.55318/bgjp.2022.49
https://www.bjp-bg.com/accepted.php

Pourramezani, F., Mohajeri, A. F., Salmani, M. H., Tafti A. D., Sadrabad E. K., (2019). Evaluation of heavy metal concentration in imported black tea in Iran and consumer risk assessments. *Food Science & Nutrition,* 7, 4021–4026. DOI: 10.1002/fsn3.1267

Rajeshkumar S., Liu Y., Ma J., Duan H.Y. and Li X. (2017). Effects of exposure to multiple heavy metals on biochemical and histopathological alterations in common carp, Cyprinus carpio L. *Fish Shellfish Immunology*. 70, 461-472. https://doi.org/10.1016/j.fsi.2017.08.013

Sanches-Filho P.J., Caldas J.S., da Rosa N.N. and Pereira F.O.P. (2017). Toxicity test and Cd, Cr, Pb and Zn bioaccumulation in Phalloceros caudimaculatus. *Egyptian Journal of Basic Applied Sciences*. 4 (3), 206-211. https://doi. org/10.1016/j.ejbas.2017.06.001

Samuel J Cobbina , Yao Chen , Zhaoxiang Zhou , Xueshan Wu , Ting Zhao , Zhen Zhang , Weiwei Feng , Wei Wang , Qian Li , Xiangyang Wu , Liuqing Yang. (2015). Toxicity assessment due to sub-chronic exposure to individual and mixtures of four toxic heavy metals. *Journal of Hazard Materials.* 294, 109–120. DOI: 10.1016/j.jhazmat.2015.03.057

Sultana M.S., Rana S., Yamazaki S., Aono T., Yoshida S. (2017). Health risk assessment for carcinogenic and noncarcinogenic heavy metal exposures from vegetables and fruits of Bangladesh. *Cogent Environmental Sciences.* 3(1), 129 1107. doi:10.1080/23311843.2017.1291107

Thode Filho, Sergio, Paiva, Julieta Laudelina de, Heider Alves Franco, Daniel Vidal Perez, Monica Regina da Costa Marques. (2017). Environmental impacts caused by residual vegetable oil in the soil-plant system. *Journal Ciência e Natura* Vol 39 pp 748, DOI 10.5902/2179460X27645

Tsai M.T., Huang S.-Y., Cheng S.Y. (2017). Lead poisoning can be easily misdiagnosed as acute porphyria and nonspecific abdominal pain Case reports in emergency medicine. Case Rep. *Emergency Medicine* Vol 2, pg. 1– 4. DOI: 10.1155/2017/9050713

USEPA, (2008). Environmental Protection Agency. Integrated Risk Information System. CRC. 2008.

USEPA. (2014). United States Environmental Protection Agency Washington (DC).

USEPA I.R.I.S.I., (2017). United States Environmental Protection Agency. Appendix A to, 40.
U.U.S.E.P.A.R.A. Forum, (2005) Guidelines for carcinogen risk assessment.

U.U.E.P. (Agency) (2010) Toxicological Review of 553 Hexavalent Chromium. CAS No. 1840-29-9.

Zhang, J., Yang, R., Chen, R., Peng, Y., Wen, X., Gao L., (2018) Accumulation of heavy metals in tea leaves and potential health risk assessment: a case study from Puan County, Guizhou Province, China. *International Journal of Environmental Research and Public Health,* 15(1), 133. DOI:10.3390/ijerph15010133

Zhu, F., Fan, W., Wang, X., Qu, L., & Yao, S. (2011). Health risk assessment of eight heavy metals in nine varieties of edible vegetable oils consumed in China. *Food and Chemical Toxicology*, 49, 3081–3085. DOI: 10.1016/j.fct.2011.09.019