Arabian Journal of Chemical and Environmental Research

Vol. 10 Issue 2 (2023) 106–122

Environmental Impact Assessment of Toxic Metal and Probabilistic health risk in Phaseolus Vulgaris Dietary intake in Southwest Nigeria

Kayode Idowu Ogungbemi[1]*, Olusola Olurotimi Oyebola[2] and Williams. Igoniye[3]

[1]*Department of Physics, Faculty of Science, University of Lagos, Akoka – Yaba, Lagos, Nigeria,*
email: kogungbemi@unilag.edu.ng
[2]*Department of Physics, Faculty of Science, University of Lagos, Akoka – Yaba, Lagos, Nigeria*
email: ooyebola@unilag.edu.ng
[3]*Dept. of Radiology, University of Port Harcourt Teaching Hospital, River State, Nigeria*
email: willingonhouse@yahoo.com

Received 18 July 2023, Revised 27 December 2023, Accepted 29 December 2023

Cited as: *Kayode Idowu Ogungbem, Olusola Olurotimi Oyebola and Williams Igoniye (2023) Environmental Impact Assessment of Toxic Metal and Probabilistic health risk in Phaseolus Vulgaris Dietary intake in Southwest Nigeria, Arab. J. Chem. Environ. Res. 10(2) (2023) 106-122*

Abstract

This study has quantified selected toxic metals in Phaseolus Vulgaris for the assessment of health risk and environmental pollution effects using Atomic Absorption Spectrophotometer (AAS) for analysis. Mean concentration of metals were obtained from the samples. *Estimated daily intakes* (EDI) of toxic metals highest in Zn. Lowest EDI from As and Hg in samples EPG and SGE respectively. Health risk probability depend on *target hazard quotient* (THQ), the obtained value is far less than unity. Probability of cancer in a lifetime estimated using *target cancer risk* (TCR) with adult, 1.23 x 10^{-6} and 3.33x 10^{-7} as highest and lowest values, while in children the highest value 6.51x10^{-7} and lowest 1.77 x 10^{-7}. *Lifetime cancer risk* (CR) assessed, values in adult and children are less than the permissible limit of 10^{-4}. *Toxic metal pollution index* (TMPI) have been used to assess the environmental pollution level, the highest value is 0.600.

Keywords: environments; carcinogenic; contamination; bioaccumulation; toxicity

*Corresponding author.
E-mail address: kogungbemi@unilag.edu.ng

1. Introduction

Environmental pollution induced by heavy metals have been found to be long –term, persist, and generational. This because metals are non-biodegradable and long half-life; so therefore, they can't be easily decomposed for this reason they remain human body for very long time and become health risk to the body. Several research works have been conducted on various food pollution and many articles have been published on the various works done on heavy metal pollution on consumable items. However, more attentions are still needed on the essential food stuff that has major part in the daily nutrients for a balanced diet. This food stuff is part of major sources of protein, carbonate, and vitamins etc., that are essential to the body. Vegetables are important components of human diets due to their high nutrients content such as vitamins, minerals, foliate, dietary fibre, ascorbic acid, carotene and other nutrients.

Heavy metal contamination of soil is one of the most pressing concerns in the world and this is about food safety and food security (Toth *et al*., 2016)**.** Soil pollution has become a serious global environmental problem. In this era, of pollution everywhere, human has always been the receiving end of it all. This is one of the major sources of health problems to the society. Recently, adverse effects of unexpected contaminants on crop quality have threatened both food security and human health (Prabhat *et al*., 2016**)** in some studies. Contaminations crops or food items are at the different levels depending on the rate and sources of the contaminants, nevertheless, they are still very hazardous to human begin in a long-term base. The organization responsible for toxic substances and disease, Agency for Toxic Substances and Disease Registry (ATSDR), Atlanta, GA, USA, lists Cd as the sixth most toxic substance that endangers human health. The United Nations Environment Program (UNEP) and the international committee on trace metals in occupational health also listed some toxic metals as an environmental pollutant as reported (USEPA, 2002**).** Heavy metals and metalloids (e.g., Hg, As, Pb, Cd, and Cr) in any amount greater that the permissible amount can cause disturbance in human metabolomics, or contributing to morbidity and even mortality in one's life time. At higher concentrations, metals such as chromium (Cr), mercury (Hg), arsenic (As), lead (Pb), and cadmium (Cd) are toxic to most plants and human begin. Toxic metals contamination is a vital concern in human health, especially in densely populated agro ecology areas (Kui *et al*., 2016**).** Materials contaminated with toxic metals may increase human health risks when inhaled or ingested, there is also the risk of potential levels of heavy metals entering the food chain via absorption by crops from contaminated soil and water (Štofejová *et al*., 2021; Ogungbemi *et al*., 2022; Bazzi *et al*., 2016)**.** Major sources of heavy metals in the soil environment and agriculture are atmospheric deposition, livestock manure, irrigation with wastewater or polluted water, metallo-pesticides, fertilizers that are phosphate based (Bazzi *et al*., 2016). Toxic metals find their ways into the ecosystem usually may lead to bioaccumulation in the system (Karim *et al*., 2016). Several techniques have been developed for the remediation of heavy metal-contaminated sediments and soils, as well as water, including physicochemical and biological methods (Álvarez *et al*., 2023; El Hammari *et al*., 2022). Plants take up heavy metals by absorbing them from contaminated soils, as well as from deposits on parts such as stem, root, fruits, and leaves exposed to the air from polluted environments; for these reasons, they are therefore important components of ecosystem as they transfer elements from abiotic to biotic environments. Ingestion of contaminated food such as beans with toxic metals may cause serious human health problems ranging from malnutrition, gastrointestinal cancer, fragile immunological problems, headache and liver disease etc. (El-Kady *et al*., 2018; Dickin *et al*., 2016; Gress *et al*., 2015). Essential or non-essential trace elements that may be present in excess of the recommended dose levels may result in physiological or morphological abnormalities or genetic mutations etc. (Khan *et al*., 2010; Li *et al*., 2010; Luo *et al*., 2011). Food safety is a major public concern worldwide, thus production of safe food is vital to human health and safe environments.

This study therefore is aimed at evaluating the concentration levels of selected heavy metals; Zinc (Zn), Arsenic (As), Copper (Cu), Mercury (Hg), Lead (Pub), Nickel (Ni),Cadmium (Cd) and Chromium (Cr) in Pharsalus Vulgaris popularly consumed in southwest Nigeria; determine the potential health risks of the heavy metals as carcinogenic and non-carcinogenic risks in both adults and children via route of ingestion and diet from Pharsalus Vulgaris, and provide suggestions as to the safety of Pharsalus Vulgaris Consumption.

2. Materials and methods

2.1. Study location

Odan market in Oja-Odan situated in Egbado North, Ogun on latitude 6^{o}59'36"N and longitude 2^{o}37'30"E is one of the largest Agricultural produce market in Southwest Nigeria. All kinds of agricultural produce are sold in the market, thus a place for sampling in this study. The collection points were reference to the gates of the market as indicated in **Table 1** below:

Table 1. Showing points of sampling and the coding

Gates Directions	Coded As
Northern Gate point 1	NOA
Northern Gate point 2	NOB
Western Gate point 1	WPC
Western Gate point 2	WPD
Southern Gate point 1	SGE
Southern Gate point 2	SGF
Eastern Gate point 1	EPG
Eastern Gate point 2	EPH

2.2 Sample collection and preparation

Phaseolus Vulgaris used in this study were strictly based on the popularity in consumption of the bean in the region nearly 98.75% of the population consumed the beans every day. The reason may be due to it one of the cheapest sources of protein and commonly loved by every age group in the society. Thus, it is common house food stuff everywhere. About five kilogram (5 kg) of Phaseolus Vulgaris samples were collected from each of the eight (8) sources and dried to a constant weight in an oven at 105^{o}C, ground and sieved using a less than 2mm nylon sieve. Digestion was carried by weighing 0.75g into an acid washed porcelain crucible placed in a muffle furnace and heated for about 2 hours at 250^{o}C. When cooled 10ml of 6M HCl was added and heated again for about twenty minutes (20 mins). The acid was added drop by drop and gently with continuous stirring and heating to dryness. 10 ml of distilled water was added and heated using steam bath to dissolve it completely. This mixture was then allowed to cool and filtered through a Whitman. filter paper into a 50ml volumetric flask (Radojevic *et al*., 1999**);** and then made up to the mark with additional distilled water Atomic Absorption Spectrophotometer (AAS) model Perkin-Elmer 306 was used to determine the concentration levels of the selected metals in the samples.

2.3 Environmental Impact and Health risk assessment

The following parameters are used in this study for environmental impact and health risk assessment: Toxic Metal pollution index (TMPI), Estimated daily intake (EDI), Target hazard quotient (THQ), Health risk index (HI), Target hazard quotient (THQ) and Lifetime cancer risk (CR).

2.3.1 Toxic metal pollution index (TMPI), have been used to assess the total metal content of the Phaseolus Vulgaris because this is one of the effective tool for assessing metal pollution in consumable stuff as an agent in predicting the environmental impact.

$$TMPI = \left(C_{f1} \times C_{f2} \times C_{f3} \times .... \times C_{fn}\right)^{1/n} \quad (1)$$

where C_{fn} Concentration of nth metal in the sample.

2.3.2 Estimated daily intake (EDI), this parameter is determined using the average value of the heavy metal concentrations in the beans consumed by both the adult and the children as indicated in the equation 2 below. The descriptions of these quantities used in the computation are given in **Table 2** below:

$$EDI = \frac{E_f \times E_D \times F_{IR} \times C_M \times C_f}{B_W \times T_A} \times 0.001 \quad (2)$$

Table2. Shows the descriptions, values with unit of all the parameters used in this study (USEPA, 2015; Verma *et al*., 2016; Antoine et al., 2017; Gebeyehu *et al*., 2020).

Parameter	Description	Value		Unit
		Children	Adults	
E_f	Exposure rate	365	365	Days\year
E_D	Exposure Period	10	70	years
F_{IR}	Average ingestion rate	150	350	g\day
C_M	Average Metal Concentration	----	----	mg\kg
B_W	Average body weight	15	65	kg
T_A	Average exposure time (non-cancer risk)	6 x 365	30 x 365	days
	Average exposure time (cancer risk)	35 x 365	70 x 365	days

2.3.3 Target hazard quotient (THQ); The health hazard from non-cancer metals due to the consumptions of beans is generally computed as target hazard quotient as found in the literatures and this computation is as describe in equation 3. It is normally accepted to be safe from the risk of non-carcinogenic effects if the value of THQ is <1. If THQ >1 there is possibility of non-carcinogenic effects, with an increasing possibility as the value increases (Verma *et al*., 2021).

$$THQ = \frac{EDI}{RfD} \qquad (3)$$

Where EDI (mg\day\kg bodyweight) = estimated daily metal intake of the population and

R*f*D = oral reference dose (mg/kg/day) values for all metals determined as in **Table 3** below.

Table3. Shows the reference dose (RfD) and Cancer Slope factor (CPSo) values used for different metals (Verma *et al*., 2016; Antoine *et al*., 2017; Gebeyehu *et al*., 2020)

Element	Reference dose (RfD) (mg\kgBw\day)	Cancer Slope Factor (CPSo) (mg\kgbw\day)$^{-1}$
Zn	0.300	------
As	0.0003	1.5
Cu	0.040	-----
Hg	0.0003	-------
Pb	0.0035	8.5 x 10^{-3}
Ni	0.02	1.7
Cd	0.001	0.38
Cr	1.5	0.5

2.3.4 Hazard risk Index (HI); It a known fact from different studies that the specific health risk of the heavy metals due to consumption of contaminated beans are accumulative, hence, HI of the individual metals sought in this work is computed using equation 4. If HI value obtained is less than 1, it seems no health effect through the exposure to the heavy metals sought. However, HI value greater than one designates probable health effect implication, and higher values indicates serious chronic health impact:

$$HI = \sum_{i=1}^{k} THQ_i \, ; i = 1, 2, 3, ... k \qquad (4)$$

Where HI is hazard index and THQ is the target hazard quotient due to the intake of individual metals through beans consumption (Tepanosyan *et al*., 2017).

2.3.5 Target Cancer risk (TCR)

2.3.5.1 Incremental lifetime cancer risk (CR) this is the possibility of cancer risk in a given population owing to the intake of specific potentially cancer causing metals were appraised by the equation 5. In the range of 10^{-6} and < 10^{-4} are the permissible limits for a single carcinogenic metals and multi-carcinogenic metals.

$$CR = EDI \times CPSo \qquad (5)$$

Where CR = cancer risk over lifetime due to specific heavy metal intake, EDI = estimated daily metal ingestion of the populace in mg\day\kg body weight; CPSo is as defined in the **Table 3** above.

2.3.5.2 The target cancer risk (TCR); ensuing from the ingestion of carcinogenic heavy metals (As, Pb, Cd, Cr, Ni) were estimated using equation 6

$$TCR = \sum_{i=1}^{k} CR_i \, ; i = 1, 2, 3, ... k \qquad (6)$$

3. Results and discussion

Table 4 below shows the results obtained for each of the heavy metal in each sample. The values of Zn for all the locations are in the range 0.302 mg/kg to 56.406 mg/kg, the mean 21.842 mg/kg, while the highest value was obtained in location SGF. As concentration level range between ND and 0.818 mg/kg, with mean value considering all the sampling location 0.169 mg/kg and highest value of 0.818 mg/kg from sampling collection point EPG.

Table 4. The concentration levels of each of the metals per sample location (mg/kg)

Sampling Location	Mean Heavy metal Concentrations mg\kg							
	Zn	As	Cu	Hg	Pb	Ni	Cd	Cr
NOA	14.221	0.319	0.043	0.011	0.043	0.611	1.318	0.219
NOB	16.109	0.039	0.215	0.081	0.037	1.236	0.406	0.733
WPC	14.878	0.041	0.062	0.204	0.021	0.337	0.365	1.403
WPD	28.139	0.053	0.122	0.092	1.742	0.065	0.302	0.818
SGE	17.318	0.019	0.188	ND	1.422	0.319	1.427	0.065
SGF	59.406	0.063	0.048	0.007	9.109	0.399	0.188	1.196
EPG	24.365	ND	0.033	0.076	7.878	0.041	1.048	0.807
EPH	0.302	0.818	0.079	0.446	0.139	0.253	0.033	0.376
Mean	21.842	0.169	0.099	0.115	2.549	0.408	0.636	0.702
Median	16.714	0.047	0.071	0.079	0.781	0.328	0.386	0.770
StdDev	17.242	0.281	0.069	0.149	3.744	0.381	0.543	0.464
Max	59.406	0.818	0.215	0.446	9.109	1.236	1.427	1.403
Min	0.302	ND	0.033	ND	0.021	0.041	0.033	0.065

ND indicates Not Detectable

Cu concentration in all the samples is in the range of 0.033 mg/kg and 0.215 mg/kg and the highest value occurs from the sampling location NOB. In Hg, the mean concentration is 0.115 mg/kg while its highest value is 0.446 mg/kg in location SGE Hg was not detected in the sample. Pb concentration levels are in the range 0.021 mg/kg and 9.109 mg/kg with the mean of 2.549 mg/kg, the lowest value and the highest value occurs at sampling location WPC and SGF points. The mean concentration value of Ni, Cd and Cr are 0.408 mg/kg, 0.636 mg/kg and 0.702 mg/kg respectively, while their values are in the range of 0.041 mg/kg – 1.236 mg/kg, 0.033 mg/kg – 1.427 mg/kg and 0.065 mg/kg – 1.403 mg/kg respectively. The highest value occurs in sampling location NOB, SGE and WPC respectively. All the concentration levels of each metal per sampling location are used both for the environmental impacts and health risk assessment.

3.1 Metal Pollution index (MPI)

Since there was accumulation of heavy metals in most of our environments, this leads to the contamination of the food chain. The accumulation of potentially toxic metals in biota may cause potential health threat to the consumers. Therefore, MPI has been evaluated so that the comparisons of the total content of metals from the individual sampling locations may be analysed in each location as in **Fig. 1**.

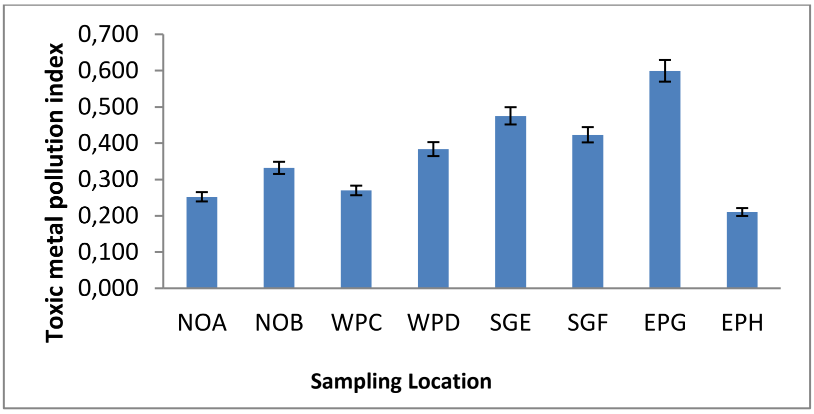

Figure 1. Toxic metal pollution in each of the sampling locations

In each of the sampling locations the percentage of the MPI varies, sampling location NOA has 25.20%, NOB has 33.20%, and WPC has 27.00%, WPD has 38.40% while SGE, SGF, EPG and EPH has 47.50%, 42.30%, 60.00% and 21.00% respectively. This is an indication of pollution level in each sampling location. Thus, from the sampling locations the MPI value can be described as follows in terms of the location EPG > SGE > SGF > WPD > NOB > NOA > EPH. Higher value of MPI indicates high concentration of the toxic metal thus, the sampling location with higher MPI shows that Phaseolus Vulgaris has higher toxic metal accumulation in long time.

Table 5. The EDI (mg/kg) levels of each of the metals intake per the specified meal for an adult

Sampling Location	Estimated Daily Intake for Adult (mg\day\kg bodyweight)							
	Zn	As	Cu	Hg	Pb	Ni	Cd	Cr
NOA	1.5187E-05	3.41E-07	4.59E-08	1.17E-08	4.59E-08	6.53E-07	1.41E-06	2.34E-07
NOB	1.7204E-05	4.17E-08	2.30E-07	8.65E-08	3.95E-08	1.32E-06	4.34E-07	7.83E-07
WPC	1.5889E-05	4.38E-08	6.62E-08	2.18E-07	2.24E-08	3.60E-07	3.90E-07	1.50E-06
WPD	3.0051E-05	5.66E-08	1.30E-07	9.83E-08	1.86E-06	6.94E-08	3.23E-07	8.74E-07
SGE	1.8495E-05	2.03E-08	2.01E-07	0.00E+00	1.52E-06	3.41E-07	1.52E-06	6.94E-08
SGF	6.3443E-05	6.73E-08	5.13E-08	7.48E-09	9.73E-06	4.26E-07	2.01E-07	1.28E-06
EPG	2.6021E-05	0.00E+00	3.52E-08	8.12E-08	8.41E-06	4.38E-08	1.12E-06	8.62E-07
EPH	3.2252E-07	8.74E-07	8.44E-08	4.76E-07	1.48E-07	2.70E-07	3.52E-08	4.02E-07

The EDI (mg\day\kg bodyweight) of these metals is based on the quantity of Phaseolus Vulgaris consumed in daily bases, **Table 5** show the EDI in adult and **Table 6** show EDI for the children per samples. However, the highest EDI was obtained in Zn for children and adult, while As and Pb has the lowest rate of EDI as indicated in **Tables 5 and Table 6**. The values of EDI are indicators for the health assessment; this is because the EDI is a quantity that has impacts on the other parameters in assessing the health implications in both the carcinogenic and non-carcinogenic metals identified in Phaseolus Vulgaris consumption.

Table 6. The EDI (mg/kg) levels of each of the metals intake per the specified meal for children

Sampling Location	Estimated Daily Intake for Children (mg\day\kg bodyweight)							
	Zn	As	Cu	Hg	Pb	Ni	Cd	Cr
NOA	2.01E-05	4.52E-07	6.09E-08	1.56E-08	6.09E-08	8.66E-07	1.87E-06	3.10E-07
NOB	2.28E-05	5.53E-08	3.05E-07	1.15E-07	5.24E-08	1.75E-06	5.75E-07	1.04E-06
WPC	2.11E-05	5.81E-08	8.78E-08	2.89E-07	2.98E-08	4.77E-07	5.17E-07	1.99E-06
WPD	3.99E-05	7.51E-08	1.73E-07	1.30E-07	2.47E-06	9.21E-08	4.28E-07	1.16E-06
SGE	2.45E-05	2.69E-08	2.66E-07	0.00E+00	2.01E-06	4.52E-07	2.02E-06	9.21E-08
SGF	8.42E-05	8.93E-08	6.80E-08	9.92E-09	1.29E-05	5.65E-07	2.66E-07	1.69E-06
EPG	3.45E-05	0.00E+00	4.68E-08	1.08E-07	1.12E-05	5.81E-08	1.48E-06	1.14E-06
EPH	4.28E-07	1.16E-06	1.12E-07	6.32E-07	1.97E-07	3.58E-07	4.68E-08	5.33E-07

The cancer risk probability may be more visible in carcinogenic metals, while other health issues may arise generally from the carcinogenic and non- carcinogenic. Therefore, in assessing the probabilistic health risk in Phaseolus Vulgaris Dietary intake, the multi-carcinogenic metals identified in the samples were used to estimate daily intake in both the children and the adult. The results are as shown in **Fig. 2** and **Fig. 3** below. EDI obtained from the multi carcinogenic metals in any consumable items are the most likely agent of cancer induced in the consumers. Thus, **Fig. 2** below show the EDI for children using the multi carcinogenic metals factor. Samples from location SGF and EPG have prominently high values in

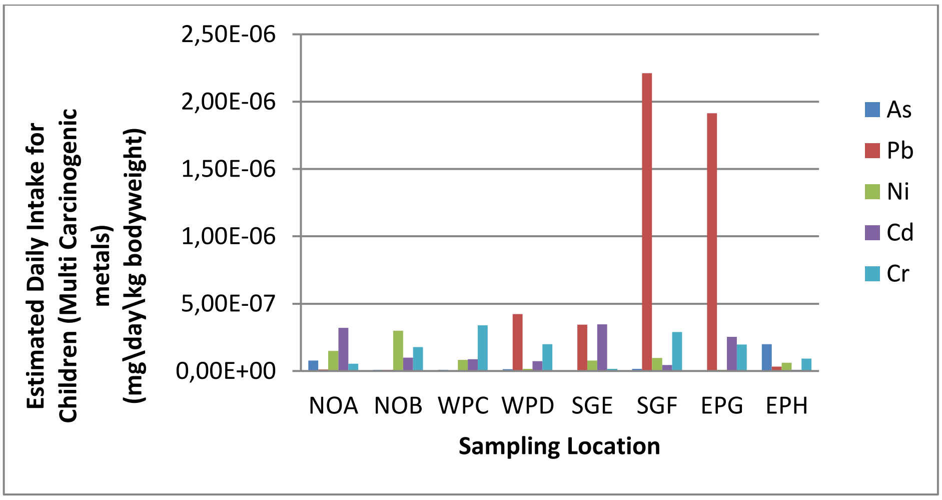

Figure2. Estimated daily intake from multi carcinogenic metals Phaseolus Vulgaris Dietary intake in children.

Pb compared to other metals whereas in some samples Pb is not really in the samples as compared to others. However in children, samples from locations WPD, SGE, SGF, and EPG have higher probabilistic cancer manifestation effects in a life time for the children. In all the samples Ni, Cr and Cd are seen to have values below 5.00 E-07, even with that the cumulative effects may be something that needed to be concern in terms of health and environment. Figure 3 show the EDI in adult considering the multi carcinogenic metals.

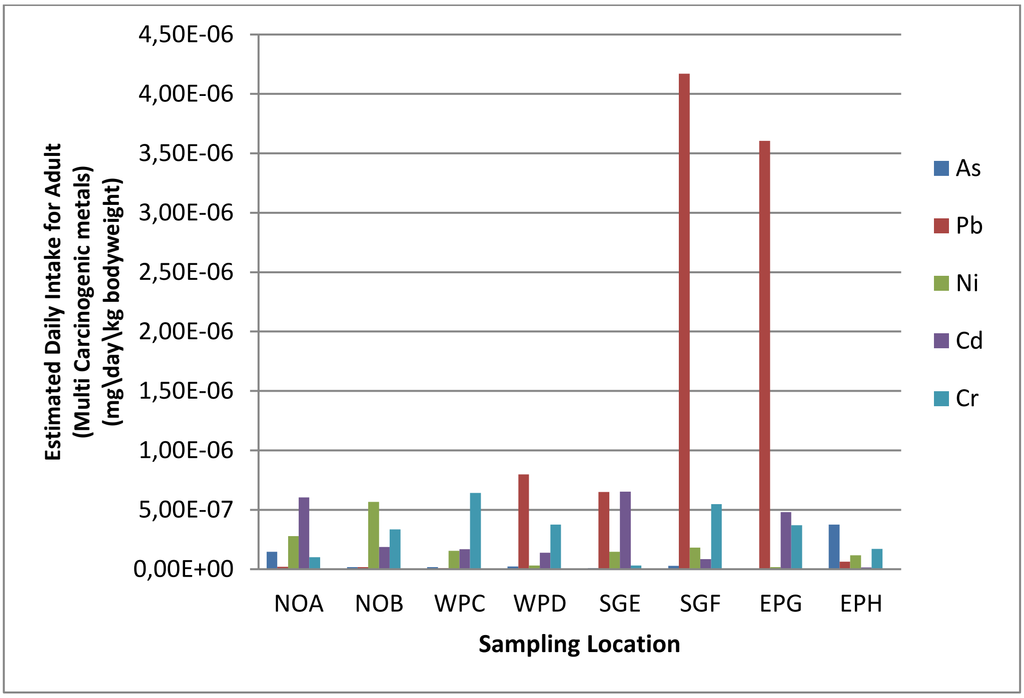

Figure 3. Estimated daily intake from multi carcinogenic metals Phaseolus Vulgaris Dietary intake in Adult

The EDI in adult is relatively higher than the children, from samples locations SGF and EPG the values of Pb is above 3.50E-06 for adults but for the children they are below 2.60E-06. The identified heavy metals are as the results pollutions the environment; therefore **Table 7** shows the possible sources of such heavy metals and their health effects if the metal gets higher than the recommended values on daily bases. Most of the metals get to the crops through the soil fertility aids that is using fertilizers to help improve yielding and also through preservation method, which is addition of chemical to food stuff in other to prevent insects from feeding on the crops.

The health effect varies and depends on the type, amount, and exposures to the metal. However, the health risk index has been evaluated for both the children and the adult as shown in **Fig. 4** and **Fig. 5** below.

Table7. Shows the likely sources of metals in this study and their health effects (Prabhat *et al*., 2019; Jezierska-Tys *et al*., 2013)

Heavy metal	Sources	Health Effects
Chromium	Pesticide and Fungicide	Cancer Nephritis Ulceration
Lead	Plastic, Auto-Exhaust	Cardiovascular disease, Neurotoxic diseases
Cadmium	Fertilisers	Carcinogenic, lung diseases, fragile bone
Zinc	Fertilizer	Fatigue, Dizziness, renal damage
Nickel		Lung Cancer, Neurotoxic and infertility
Arsenic	Pesticides and herbicides	Carcinogenic, Immunological
Mercury		Immune disorders, nervous system and lungs problems, lungs and kidneys

Fig. 4 shows the health risk index in adult for each of the sampling locations of Phaseolus Vulgaris that are widely consumed. The HI is an indicator of how serious the pollution can be in human when they consume Phaseolus Vulgaris, here in figure 4 the HI from each of location are: EPH > EPG > SGF > NOA > SGE > WPD > WPC > NOB. The highest value of HI in adult within 5% error is 4.59E-03 while the lowest is 1.00E-03. Therefore the value of HI obtained for the adults is less than unity.

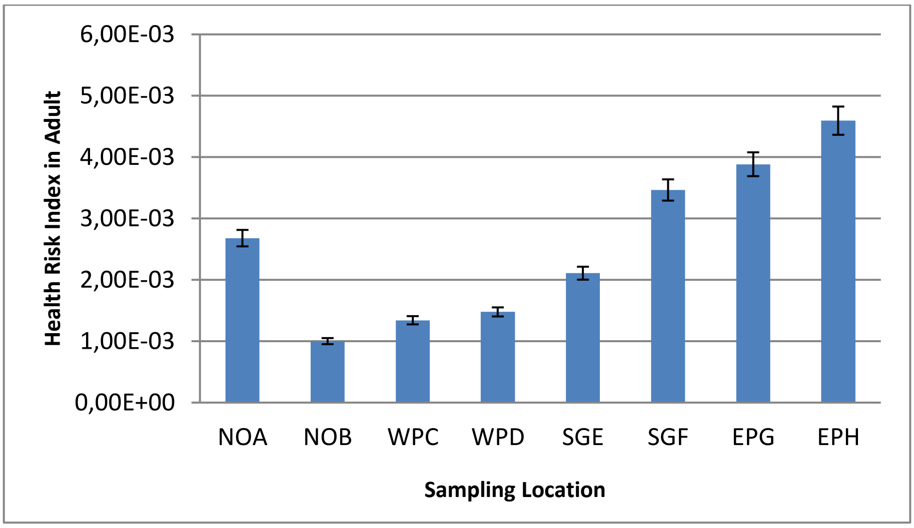

Figure 4. Health risk index in each sampling location for the Adults

The children HI was also evaluated determine the severity of the exposure, **Table 5** shows the results. The HI for children is in the range 6.09E-03 and 1.33E-03 from the sampling areas. In sampling location EPH we have the highest HI, while in sampling location NOB we have the lowest value of HI, so therefore the order is EPH > EPG > SGF > NOA > SGE > WPD > WPC > NOB.

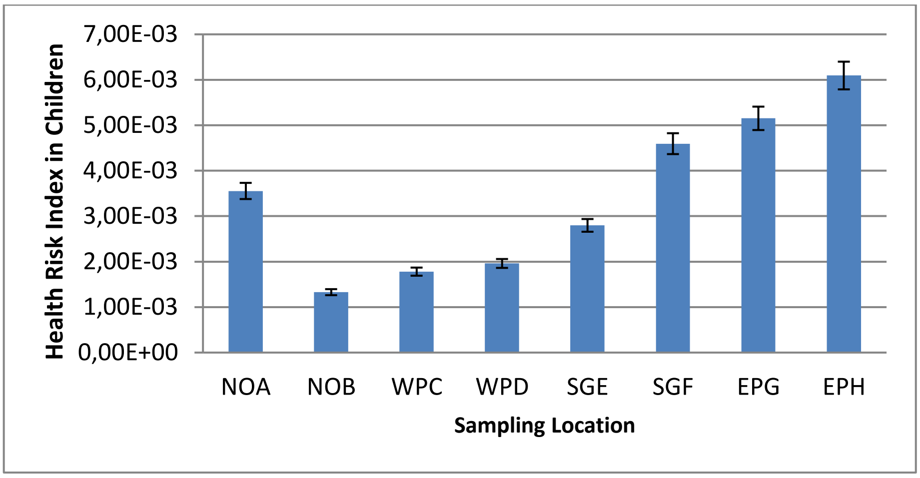

Figure 5. Health risk index in each sampling location for the Children

For the HI value obtained is less than 1, which implies that there may no serious health effect through the exposure to the heavy metals. However, on the long term bases, bio-accumulation may be great concern to an individual that are within the sampling locations EPH, EPG, SGF and NOA in both the children and the adult. Since the HI is less than unity in both the adult and children, then carcinogenic metals are considered for the targeted cancer risk (TCR) in both the adult and children.

Therefore, **Fig. 6** below shows the TCR in adult for each of the sampling location. In adult the TCR are in the order of increment NOB > NOA > EPH > SGF > WPC > SGE > EPG > WPD.

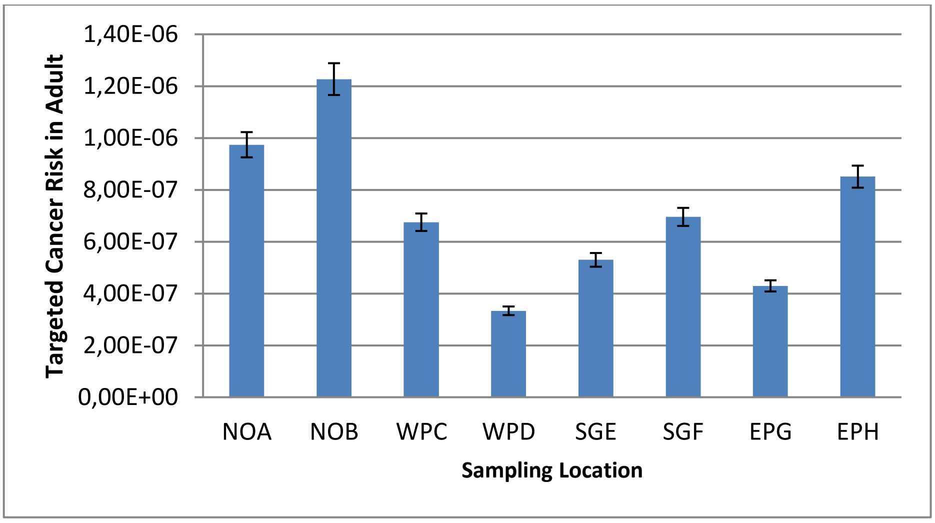

Figure 6 shows targeted cancer risk in adults

This implies that for adult that consumes Phaseolus Vulgaris from sampling location NOB the TCR is higher than those in location NOA, and EPH, the trend is not different in the children as indicated in **Fig. 7**; but children have lower TCR when compared to the TCR in adult; however, the TCR is generally low as seen in this work, nevertheless; they may deserve attention because they are serious health issues in a long term even though the obtained values are not so high.

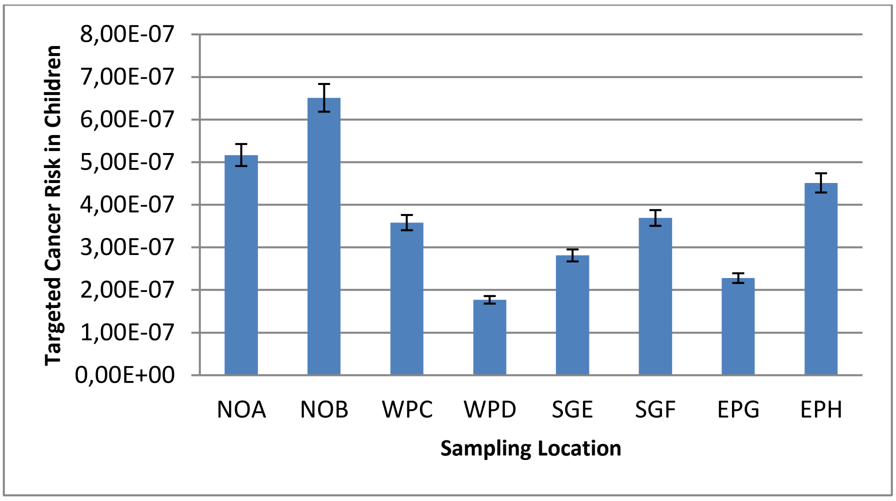

Figure 7 shows targeted cancer risk in children

This is because of their effects on the different organs of the body as indicated in **Table 7** above, these effects varies from one part of the human body to the other. From this cumulative effects of the targeted metals, the TCR in the children shows that NOB > NOA > EPH > SGF > WPC > SGE > EPG > WPD same trends like in the adults but of lower values than an individual sampling location in each case.

Fig. 8 shows the incremental lifetime cancer risk (TC) in adults for individual targeted carcinogenic metals from this we observed that Ni is the most prominent in all this metals considered in this work, while As follows in each of the sampling location. The highest TC in Ni was found in sampling location NOB with the value of 9.62E-07, NOA have the TC Ni value of 4.75E-07.

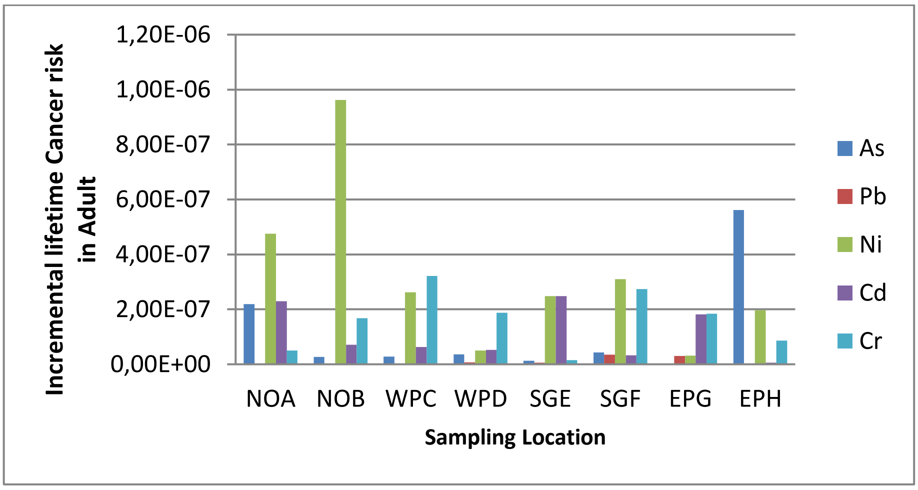

Figure 8 Incremental life time cancer risks in adult

The highest value of TC obtained in As was from sampling location EPH and the value was 5.62E-07, followed by 2.19E-07 from the location NOA. In figure 9, sampling location NOB have the highest TC in Ni which is 5.10E-07, while sampling location NOA has 2.52E-07 in Ni all other sampling locations falls below that in Ni. For the rest of the carcinogenic metal found in the samples the TC falls below 2.00E-07 expect for As in sample location EPH. Since this work is multi carcinogenic metals, the obtained TC values were less than the permissible limits of 10^{-4}.

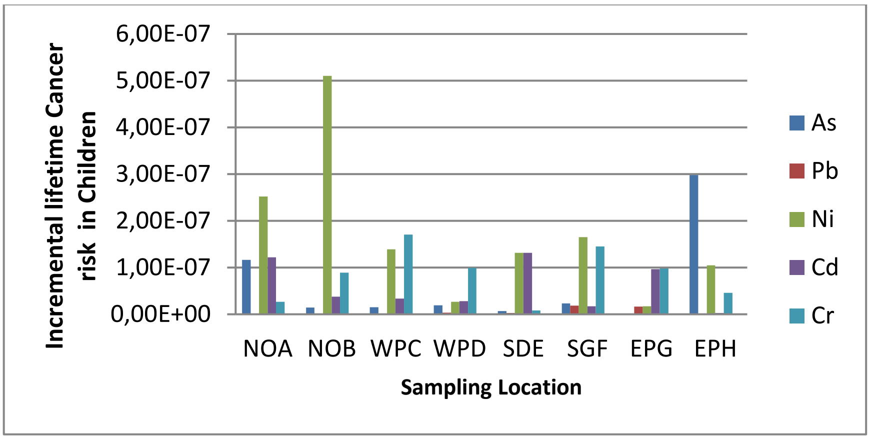

Figure 9 Incremental life time cancer risk in children

The implications of these are that the incremental lifetime cancer risk as seen from both **Fig. 8** and **Fig. 9** above is one in ten millions in sampling locations WPC, WPD , SGE, SGF, EPG and EPH in both the adults and the children. Whereas from samples locations NOA and NOB the TC values show one in a million for adults and remained as one in ten millions for the children. It is an indication that in a life time the adults may have cancer faster than the children in this case.

In each of the sampling locations the percentage of the MPI varies, sampling location NOA has 25.20%, NOB has 33.20%, and WPC has 27.00%, WPD has 38.40% while SGE, SGF, EPG and EPH has 47.50%, 42.30%, 60.00% and 21.00% respectively

Conclusion

This study have identified and quantified the following heavy metals Zn, Cu, Hg, As, Pb, Ni, Cd and Cr in Phaseolus Vulgaris samples. The maximum and minimum concentration levels of the heavy metals were in the range 59.406 – 0.302 mg/kg, for Zn, 0.818 – ND for As, For Cu we have 0.215 – 0.033 mg/kg, Hg is in the range of 0.446 – ND and that of Pb is 9.109 – 0.021 mg/kg, Ni, Cd and Cr are all in the range of 1.236 – 0.041 mg/kg, 1.427 – 0.033 mg/kg, 1.403 -0.065 mg/kg respectively. The average concentration of Zn, Cu, and Hg, As, Pb, Ni, Cd and Cr are 21.842 mg/kg, 0.169 mg/kg, 0.099 mg/kg, 0.115 mg/kg, 2.549 mg/kg, 0.408 mg/kg, 0.636 mg/kg, and 0.702 mg/kg respectively. The effects of heavy metals pollution may generally be noticeable in the liver, kidney and the brain and other part of the body, thus the MPI obtained here are less than 100%. The highest MPI value obtained is 60% that is a little significant because in a long term it may cause biodegradability, of organic pollutants thus making them less degradable causing double effect of polluting the environment. The estimated daily intake of the heavy metals was higher in Zn (2.33E-05) generally, when compared to other heavy metals; this may result into problems such renal damage in one life time. For the carcinogenic metals Pb have EDI of 2.72E-06 next higher value to that of Zn. This is an indication that there may not be immediate health problems in the populations because the health risk index in both the adults and the children are far less than unity in both cases. The THQ values obtained for both the adult and the children were far less than unity both in the carcinogenic and non-carcinogenic effects this implies that no immediate health issues in the consumption of Phaseolus Vulgaris and this result may form a baseline in make major policy on the standard acceptable metals. As a result of very low THQ, the health index shows that there cannot be immediate health problems but in a life time there may rear cases of metal pollutions problems. The TCR are all one in ten-millions in a population for both the adult and the children too which show that the probability is very low. The permitted CR for multi carcinogenic metals should be $< 10^{-4}$, the obtained results are within the range of the permissible limits.

Statements and Declarations

Ethics Approval and Consent to Participate

There is no need for any Ethical or consent approval for this research work.

Consent for Publication

We the above named authors, give our consent for the publication of this document including all the diagrams, tables and details within the text to be published in the Journal of physical Science.

Data Availability and Materials

The data that supports the findings of this study are available within the article.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. There is no known conflict of interest in this research work.

Funding

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This research work is not funded by any organization

Acknowledgement

We acknowledged Miss. Lawal in assisting during the collection of the samples, while Mr. Megida helped during the laboratory analysis of the samples.

References

Álvarez M. S., María A. Longo, Ana Rodríguez, Deive F. J. (2023), Heavy metals removal from soil/sediments washing effluents via biocompatible aqueous two-phase systems, *Journal of Water Process Engineering*, 53, 103851, https://doi.org/10.1016/j.jwpe.2023.103851

Antoine J.M.R., Fung L.A.H., Grant C.N. (2017). Assessment of the potential health risks associated with the aluminium, arsenic, cadmium and lead content in selected fruits and vegetables grown in Jamaica. *Toxicol Reports* 4, 181–187;

Bazzi, I. El Mouaden K., Chaouay A., Ait Addi A., Hamdani M., El Issami S., Hilali M., Hammouti B., Abbiche K., Salghi R. (2020), Monitoring heavy metal contamination levels and microbiological pollution in seawater of Agadir coastal zones, *Indonesian Journal of Science & Technology*, 5 (3), 463-469

Dickin, S.K., Schuster-Wallace, C.J., Qadir, M., Pizzacalla, K. (2016). A review of health risks and pathways for exposure to wastewater use in agriculture. *Environ. Health Perspect.* 124 (7), 900–909

El Hammari L., Latifi S., Saoiabi S., Saoiabi A., Azzaoui K., Hammouti B., Chetouani A., Sabbahi R. (2022), Toxic heavy metals removal from river water using a porous phospho-calcic hydroxyapatite, *Mor. J. Chem.* 10(1), 62-72, https://doi.org/10.48317/IMIST.PRSM/morjchem-v10i1.31752

El-Kady, A.A., Abdel-Wahhab, M.A. (2018). Occurrence of trace metals in foodstuffs and their health impact. *Trends Food Sci. Technol.* 75, 36–45.

Gebeyehu, H. R., and Bayissa, L. D. (2020). Levels of heavy metals in soil and vegetables and associated health risks in Mojo area, Ethiopia. *PloS one* 15, e0227883. doi:10.1371/journal.pone.0227883,

Gress, J., de Oliveira, L.M., da Silva, E.B., Lessl, J.M., Wilson, P.C., Townsend, T., Ma,L.Q. (2015). Cleaning-induced arsenic mobilization and chromium oxidation from CCA-wood deck: potential risk to children. *Environ. Int.* 82, 35–40.

Jezierska-Tys S., Rutkowska A. (2013) Soil response to chemicals used in a field experiment. *Int. Agrophys.* 27, 151–158. Doi: 10.2478/v10247-012-0080-0.

Karim S., Aouniti A., El hajjaji F., Taleb M., Belbachir C., Hammouti B. and Zarrouk A. (2016), Bioaccumulation of heavy metals in commercially important marine fishes (Palaemon Serratus and Solea Vulgaris) caught in the Mediterranean coast from the North East of Morocco, *Der Pharma Chemica*, 8(19), 515-523

Khan,S., A. El-Latif Hesham, M. Qiao, S. Rehman, J.-Z. He. (2010) Effects of Cd and Pb on soil microbial community structure and activities, *Environ. Sci. Pollut. Res.*, 17 (2), 288-296, 10.1007/s11356-009-0134-4,

Kui Cai, Yanqiu Yu, Minjie Zhang, and Kangjoo Kim (2019). Concentration, Source, and Total Health Risks of Cadmium in Multiple Media in Densely Populated Areas, China. *Int. J. Environ. Res. Public Health*, 16, 2269; doi: 10.3390/ijerph16132269

Li Q, Cai S., Mo C., B. Chu, L. Peng, Yang, F. (2010). Toxic effects of heavy metals and their accumulation in vegetables grown in a saline soil *Ecotoxicol. Environ. Saf.*, 73 (1), 84-88, 10.1016/j.ecoenv.2009.09.002

Luo C, Liu C., Wang Y., Liu X., Li F., Zhang G., Li X. (2011) Heavy metal contamination in soils and vegetables near an e-waste processing site, south China, *J. Hazard. Mater.*, 186 (1), 481-490, 10.1016/j.jhazmat.2010.11.024,

Ogungbemi Kayode I., Margret B. Adedokun, Zaccheaus A. Ibitoye, Olusola. O. Oyebola, Joshua O. Ojo and Latifat R. Owoade (2022). Analysis and Estimated Daily Dose Intake of Toxic Metals in Commonly Used Building Materials and Its Health Impacts on the Society in Lagos, Southwest Nigeria. *Communication in Physical Sciences*, 8(3), 331-338

Prabhat Kumar Rai, Sang Soo Lee, Ming Zhang, Yiu Fai Tsang, Ki-Hyun Kim, *Heavy metals in food crops: Health risks, fate, mechanisms, and Management*. Jour. Environment International; 125 365–385, (2019).

Radojevic, M and V. Bashkin, *Practical environmental analysis*. The Royal Society of Chemistry London, pp. 287-361, (1999)

Štofejová, L.; Fazekaš, J.; Fazekašová, D. *Analysis of Heavy Metal Content in Soil and Plants in the Dumping Ground of Magnesite Mining Factory Jelšava-Lubeník (Slovakia)*. Sustainability, 13, 4508. https://doi.org/10.3390/su13084508 (2021).

Tepanosyan, G., Maghakyan, N., Sahakyan, L., and Saghatelyan, A. *Heavy Metals Pollution Levels and Children Health Risk Assessment of Yerevan Kindergartens Soils.* Ecotoxicology Environ. Saf. 142, 257–265. doi:10.1016/j.ecoenv.2017.04.013, (2017).

Toth, G., Hermann, T., Da Silva, M.R., Montanarella, L., Heavy metals in agricultural soils of the European Union with implications for food safety. *Jour. Environ. Int.* 88, 299–330. (2016)

United States Environmental Protection Agency, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*; US Environmental Protection Agency: Washington, DC, USA (2002).

United States Environmental Protection Agency (USEPA), *Reference Dose (RfD): Description and Use in Health Risk Assessment. Background Document 1A, Integrated Risk Information System (IRIS).* United States Environmental Protection Agency, Washington DC. ⟨http://wwwepa.gov/iris/rfd. htm.0.1016/j.foodchem.2006.03.001⟩; (2016).

Verma P, Agrawal M, Sagar R. (2015) Assessment of potential health risks due to heavy metals through vegetable consumption in a tropical area irrigated by treated wastewater. *Environ Syst Decis* 35, 375–388,