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EVALUATION OF HEAVY METALS' HEALTH RISK INDEX IN VEGETABLE AMARANTH AND SUNFLOWER: A CASE STUDY OF SOME SELECTED AREAS IN KANO STATE NIGERIA

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ABSTRACT
The lack of regular Control of pollution produce from industries affects both air and soil in the environment. Vegetable Amaranth and Sunflower flower were used to study the presence of heavy metals (Mn, Zn, Cr, Fe, Cd, Pb, Ni and Cu) produced as pollutants, within five (5) selected areas in Kano state, Nigeria. Atomic Absorption Spectroscopy (AAS), was used to analyze the samples obtained. Six (6) parameters; Daily Intake of metals (DIM), Daily Intake Rate (DIR), Average daily Dose (ADD), Cancer Risk (CR), Hazard Quotient (HQ), and Hazard Index (HI), were computed. 60, 05, 30, 50, 02 and 09 mg/kg were the highest values of HQ found to be for Cd, Pb, Mn, Zn, and Cu respectively, and are not within the safe range as reported by international standards. However 2.0 X 10^{-06} and 2.0 X 10^{-06} were the average daily dose obtained for Cd and Ni respectively. However when the average daily dose (ADD) was computed, 5.0X 10^{01} was the highest value obtained and 2.0 X 10^{-01} and 2.0 X 10^{-6} were found to be the highest values for the Cancer Risk (CR) for Cd and Ni respectively. ADD and CR were computed and compared with referral oral dose, but no possible deleterious health impact observed with respect to international standard.
Keywords: Heavy Metals, Health risk, Sunflower, and Vegetable Amaranth.

INTRODUCTION

Introduction of foreign material into a medium, which is unwanted, is referred to as pollution. In general pollution can be either point source or non point source. Therefore, there are various ways by which environment can be polluted. Technological development as well as lack of control and regulation of pollutant emission from industries continues to impact on air, water and soil quality in urban, semi urban and rural communities. Mining, smelting, irrigating with sewage and some other human activities are possible sources of pollutants **(**Zheng *et al.,2010*). Mbong *et al.,* (2014) define heavy metals as elements known to have atomic weight between 63.545g and 200.5 g and relative gravity greater than 4.00, and Chromium (Cr)}. These metals have different effect (both positive and negative), which may include Cancer, renal diseases, short life span, anosmia, poisoning, e.t.c. (Thomson, 2009; Bergeson, 2008 and Audi *et al.,* 2003).

Ismail, *et al.* (2014) analyzed the uptake of heavy metals near metal – scrap dumpsite Zaria, Nigeria. Zheng (2010) lead his team and reported how people are exposed to heavy metal and their possible health risk assessment in Northeast of China. Calculation of oral intake of metals from soil through consumable plants/vegetable was reported to be dependent on the consumption rate of Heavy metals and Body weight (Cui *et a*l. 2004). Arora *et al.*, (2008) and Sajjad *et al.,* (2009) reported that daily intake rate is the product of the average metal content in each vegetable (plants) with the respectable consumable rate. Hazard evaluation for people living in the study sites was assessed by calculating the average daily intake of heavy metals from soil to the plants through different exposure path (Ahmed *et al.*, 2016). Khan *et al.*,(2008,) reported that National Research Council (NRC) has outlined four steps in estimating health risk agent, which are hazard identification, exposure assessment, dose/response assessment, and risk characterization. While Ahmed *et al.,* (2016) and Seyoud *et al.,* (2016) reported possible exposure of Nigerian to health risk index in Bread consume in Gombe state, Nigeria.

The objectives of this research, is to analyze the heavy metals (as pollutant) uptake rate and its health effect in human via the consumption of vegetable Amaranth (*Amaranthus cruennsus L*) and Sunflower (*Helianthus annus*) in some selected areas in Kano state, Nigeria. Cd, Cr, Mn, Zn, Pb, Cu, Fe and Ni, were the heavy metals determined in five (5) areas selected.

The analysis of the samples was done using Atomic Absorption Spectrophotometry (AAS).

Governing Equations

Calculation of oral intake of metals from soil through consumable plants/vegetable was computed using equation (1) (Cui *et al.*, 2004):

$$DIM = M_{sample} \times C_{metal} \quad (1)$$

where DIM is daily Intake of Metals, M_{sample} Is mass of the samples and C_{metals} Is concentration of metals in the sample.

Arora *et al.*, (2008) and Sajjad *et al.*, (2009) reported that daily intake rate (DIR) is the product of the average metal content in each vegetable (plants) with the respectable consumable rate. The mathematical representation is given as

$$DIR = C_{metal} \times C_{factor} \times DIM \quad (2)$$

Where C_{metal} is concentration of sample(s), C_{factor} is the conversion factor DIM is daily intake of metals (DIM) and Daily intake Rate (DIR)

U.S. Environmental Protection Agency (USEPA-1989) characterized human health risk using hazard Quotient (HQ). It is mathematically represented in equation (3) as:

$$HQ = \frac{DIM \times C_m}{R_f D \times BW} \quad (3)$$

where DIM is Daily Intake of Metals (kg/day), C_m Concentration of Metals (mg/kg) and R_fD is the Oral referral dose for metals (mg/kg of body weight).

Guerra *et al.* (2010) computed the hazard index (HI) by taking the cumulative sum of all the heavy metals (HM) present in the samples. The expression is given by equation (4) as:

$$HI = \sum HQ_{metal} HQ_{Cr} + HQ_{Cu} + HQ_{Fe} + HQ_{Zn} + HQ_{Pb} + HQ_{Cd} + HQ_{Mn} \quad (4)$$

It is assumed that the magnitude of the adverse effect will be proportional to the sum of multiple metal exposures. It also assumes similar working mechanisms that linearly affect the target.

The Cancer Risk (CR) can be calculated using equations (5) and (6) as:

$$Cancer\ Risk\ (CR) = ADD \times SF \quad (5)$$

$$ADD_{sample} = \frac{C_m \times Ing\ R \times EF \times ED}{BW \times AT} \quad (6)$$

where **SF** slope factor, ADD is Average Daily Dose (mg/kg), Cm is concentration of samples, Ing R is consume rate, EF is exposure factor, ED is Exposure frequency , BW is body weight, and AT is Average time (Guerra *et al.* 2010).

MATERIALS AND METHODS

The scope of this research was restricted to five locations within Kano State, Nigeria. Kano is a state in Nigeria, located between latitude 12°15'S and 12°35'N of equator and longitude 8°20'W and 8°27'E of meridian. The five (5) experimental plots were set up within Kano State, Nigeria including; Bayero University, Kano Screen House (BUK-C) – 8°28'0" E and 11°59'0" N , and Bayero University, Kano Environment (BUK-E) – 8°28'0" E and 11°59'0" N are in Gwale Local Government Area (LGA), Kofar Ruwa (K) is located in Dala LGA – 8°29' 5" E and 12°1' 5" N, Naibawa (N) is located in Kumbotso LGA – 8°35'0" E and 11°58'0"N and Sharada (S) Kano Municipal LGA - 8°29'5"E & 11°58'0"N as shown in Figure 1.

Samples Preparation, Digestion and Analysis

The samples were collected at two growth stages of the five experimental plots at 4th and 5th months before and after sowing. The plants samples were washed in salt water to eliminate dust, dirt, possible parasite or their eggs. The samples were then shade dried (i.e air dried under shade) for seven days. The dried samples were homogenized by grinding using ceramic coated grinder. All the soil samples were spread on plastic trays and allowed to dry at ambient temperature for seven days. The final samples were kept in labeled polythene bags at ambient temperature (Labeled).

One gram (1g) of the plant samples were weighed into a beaker, and 30ml of Aqua regia (HNO_3 + HCL, 3:1) was added into the beaker. The mixture was then placed on hot plate until the plant tissues dissolved by the acid. The mixture was then removed and allowed to cool in a desiccator. The solution of the mixture (filtrate) was obtained by filtering it with Whatman No.42 filter paper. The solution (Suspension) was filled to mark level (50ml) with distil water in a volumetric flask and kept for analysis. The heavy metal (Pb, Cd, Ni, Cu, Cr, Zn, Mn and Fe) concentration were determined by Atomic Absorption Spectrometry (AAS) - model 210 VGP BUCK SCIENTIFIC-. Analysis of each sample was carried out in triplicate (Yeasmin, et al., 2013. with Modification).

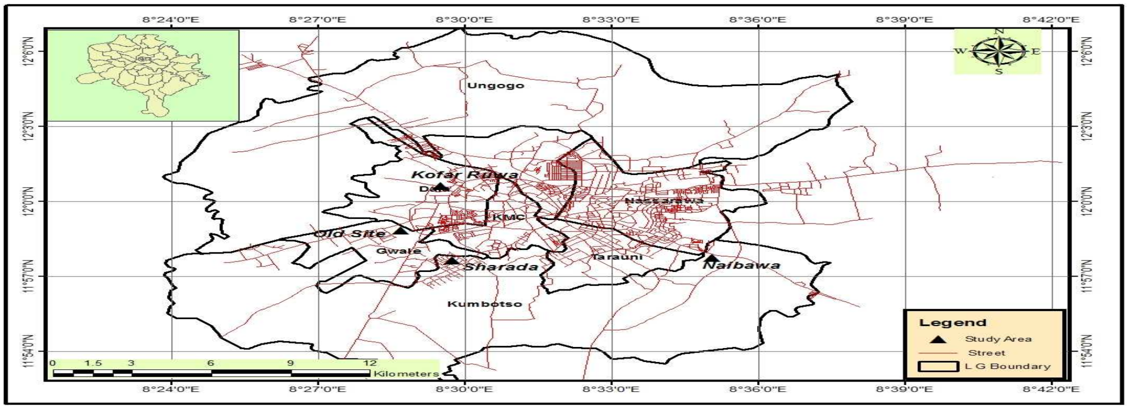


Figure 1: The five (5) selected sample site: Sharada, Kofa Ruwa, Naibawa and Bayero University (two locations) Kano.

RESULTS AND DISCUSSION

Daily Intake of Metals (DIM) and Daily Intake Rate (DIR)

Daily consumption of the samples (Vegetable and Sunflower) was obtained from the selected samples sites (Kofar Ruwa, Naibawa, BUK and Sharada environments) for both children and adults. The intake values were computed by taking the average value of metals in all the five (5) sites and considering that each person (Adults) to be 75kg (average) while 35kg for the children with consumption of 150g/day and 75g/day respectively. The daily intake of metal (DIM) and Daily Intake Rate (DIR) were calculated using equations (1) and (2), [the conversion factor used was 0. 0.085 (Arora *et al.*, 2008 and Sajjad 2009)]. From the computed values figures 2 to 18 were generated. These gave the comparison between adult and children intake rate with the upper tolerable daily intakes (US EPA, 2011).

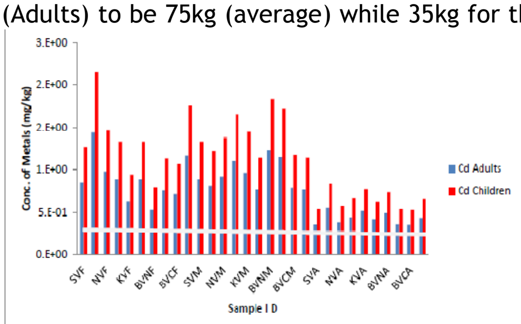


Fig. 2: DIM for Cd (6.4 X 10^{-02})

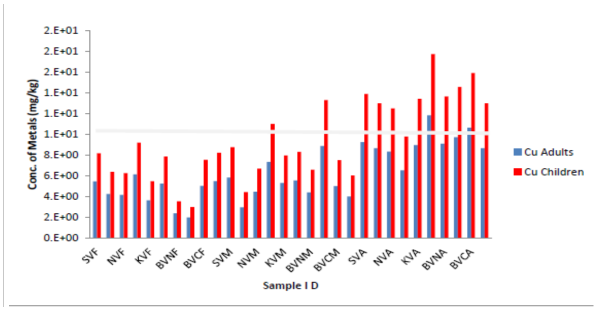


Fig. 3:DIM for Cu (10)

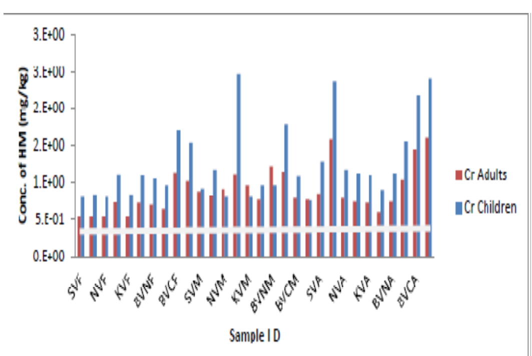


Fig. 4: DIM for Cr (1.05X 10^{-02})

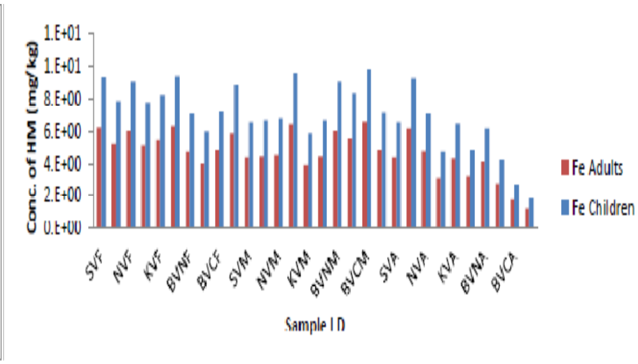


Fig. 5: DIM for Cr (45)

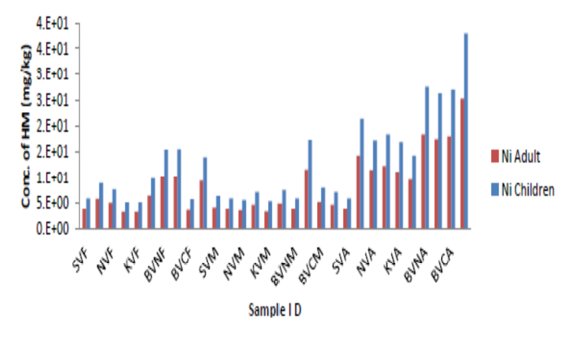


Fig. 6: DIM for Ni (8 X 10^{00})

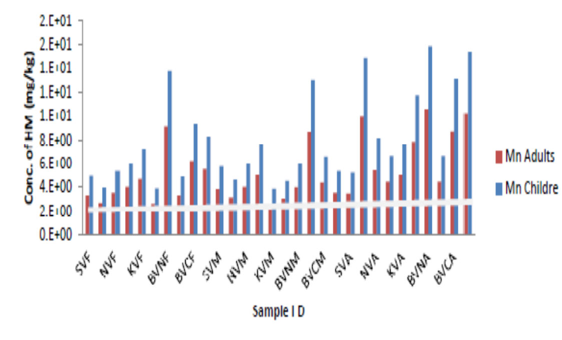


Fig. 7: DIM for Mn (11)

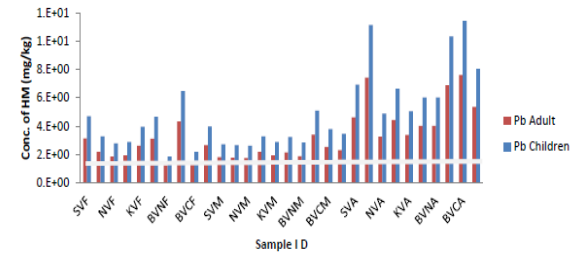


Fig. 8: DIM for Pb (2.4 X 10^{-01})

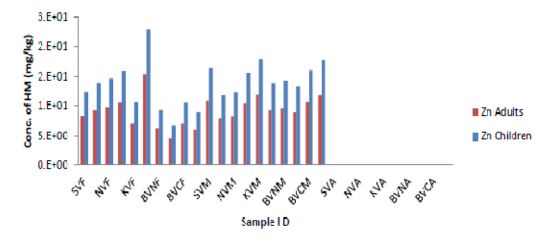


Fig. 9: DIM for Zn (40)

From Figure 1 to 9; which presented the values of DIM in comparison to upper tolerable limit, it was found that Copper (Cu), Iron (Fe), Zinc (Zn) and Manganese (Mn) were below the upper tolerable daily intake for all the sites. While Cd and Pb recorded variations, in some values that are high, as for Cr, all the samples are above the limit. It can equally be deduced that children are more exposed compare to Adults in all the sites.

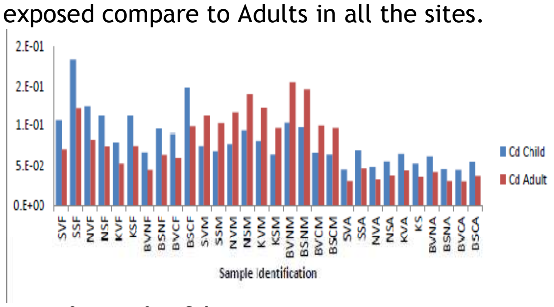


Fig. 10: DIR for Cd

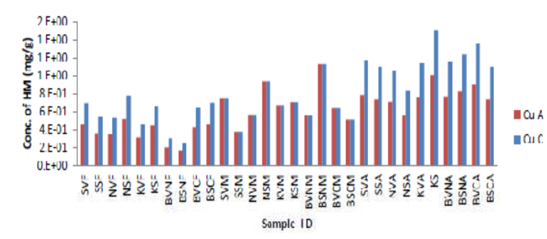


Fig. 11: DIR for Cu

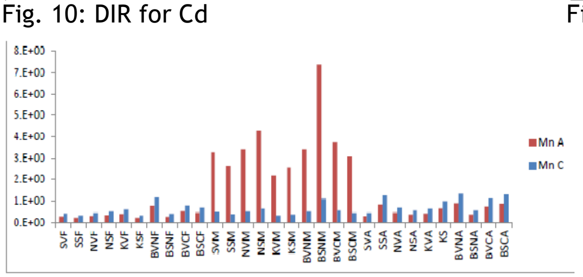


Fig. 12: DIR for Mn

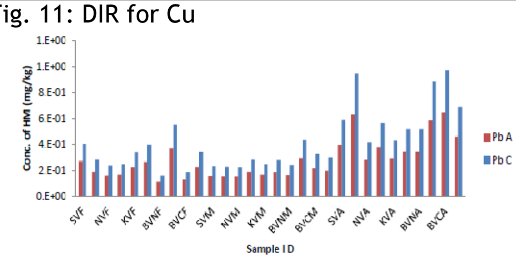


Fig. 13: DIR for Cr

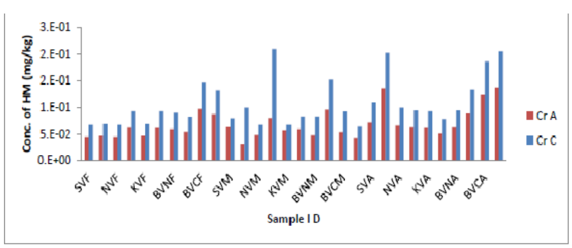


Fig. 14: DIR for Pb

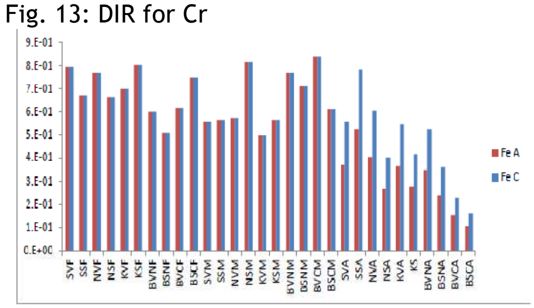
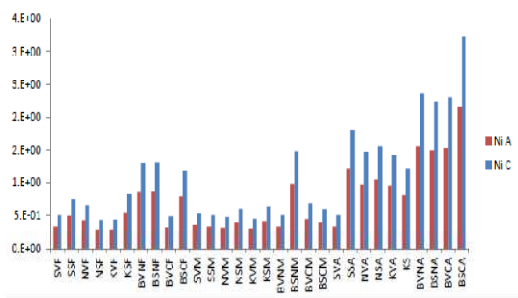


Fig. 15: DIR for Fe



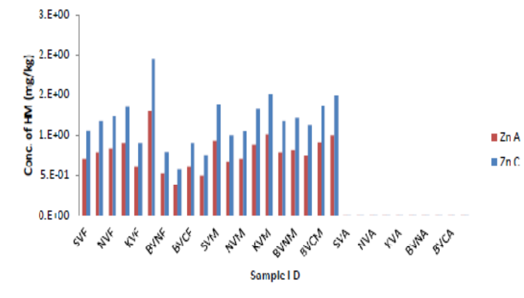
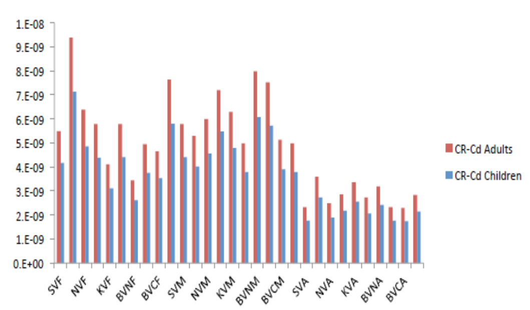


Fig. 16: DIR for Ni

Fig. 17: DIR for Ni

The rate of consumption equally reveals that Children consume more Heavy Metals than Adults in all the sites and for all the Heavy metals.



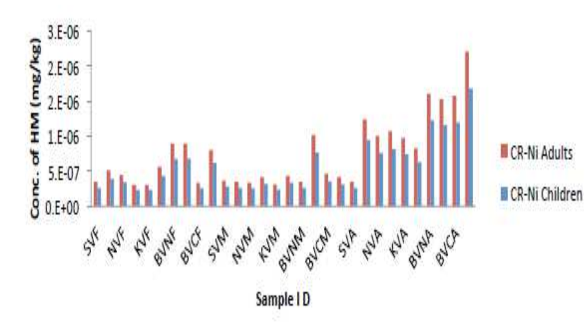


Fig. 18: CR for Cd

Fig. 19: CR for Ni

Estimation of Hazard Implications

The estimation of the hazard exposure can be deduced using hazard quotient and hazard index (since more than one heavy metal was involved). The hazard quotient and index were calculated using equation (3) and (4). Pb, Mn, Ni, and Cu are all greater than 1 with the highest hazard quotient values of 04 and 05, 09 and 09, 09 and 060, and 06 and 08, for adults and children respectively. Cr, Fe and Zn were found to be less than 1 with corresponding highest values of 2.0 X 10^{-02} and 5.0 X 10^{-02}, 2. X 10^{-01} and 4.0 X 10^{-01} and 10 and 50 for adults and children respectively. While Cd has more than 50% of the sites are greater than 1 with the highest HQ value of 20 and 50 for adults and children respectively. USEPA (2013) reported that if HQ values are greater or equal to 1 then the consumers are at risk. By extension considering the values obtained in this research work, it can be concluded that the sample is not safe for human consumption.

More than one Heavy Metal was involved in this research; hence the need to compute the hazard index (HI) was required. The computed values of HI, was used to obtain the percentage of HI for individual through consumption and presented in pie chart given in figures 20 and 21. The highest HI values for adult and children are 100 (Sharada Sunflower , Kofar Ruwa Sunflower, BUK Sunflower Screen House, BUK Sunflower Environ, BUK Vegetable Screen House & BUK Vegetables Environs) and 200 (Naibawa Sunflower & BUK Sunflower Environs).

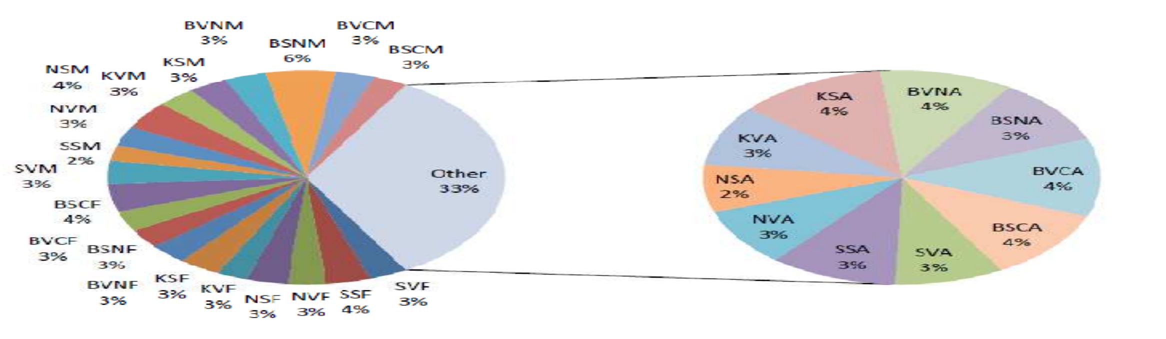


Figure 19: Hazard Index of all the HM for Adults

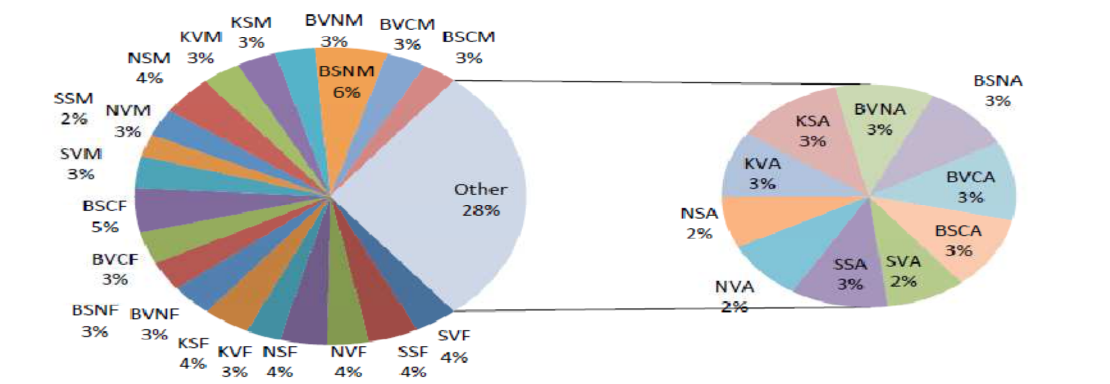


Figure20: Hazard Index of all the HM for Children

The Cancer risk values computed using equations 7 (However CR is dependent on ADD which was computed using equation 8). This results were compared with referral oral dose (US EPA, 1991), which revealed that the values have no possible deleterious health impact (as $ADD_{sam} < RfD$).

CONCLUSION

The Research determined the level of exposure the consumers of this resident area were exposed to (in term of DIM, DIR, ADD, HQ, and HI). The comparison between adult and children was deduced which reveal that children are more exposed than adult. Hence children are at more risk than adults. The Cancer risk values are below the tolerable limit and shows that the values have no possible deleterious health impact as $ADD_{sam} < RfD$. Pb, Mn, Ni, and Cu are all greater than 1 with the highest hazard quotient values of 04 and 05, 09 and 09, 09 and 06, & 06 and 08, for adults and children respectively. Cr, Fe and Zn were found to be less than 1 with corresponding highest values of $2.0X\ 10^{-02}$ and $5.0\ X10^{-02}$, $2.0X10^{-01}$ and $4.0\ X\ 10^{-01}$ & $1.0X10^{01}$ and $5.0X10^{01}$ for adults and children respectively. While Cd has more than 50% of the sites are greater than 1 with the highest HQ value of 20 & 50 for adults and children respectively. USEPA (2013) reported that if HQ values are greater or equal to 1 then the consumers are at risk (as the sample is not safe for human consumption). The highest HI values for adult and children are 1.0E02 (Sharada Sunflower , Kofar Ruwa Sunflower, BUK Sunflower Screen House, BUK Sunflower Environ, BUK Vegetable Screen House & BUK Vegetables Environs) and 200 (Naibawa Sunflower & BUK Sunflower Environs).

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