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Assessment of Heavy Metal Pollution in Farmland Soils and Potential Health Risk to Farmers in Mubi, Adamawa State (Nigeria)

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Abstract:

This study was conducted to establish a relationship between the heavy metals concentrations in farmlands soils and their potential health risks to farmers following either ingestion, dermal or inhalation exposure pathways. In the study, the average mean concentrations of Cadmium (Cd), Cupper (Cu), Nickel (Ni), Lead (Pb), and Zinc (Zn) determined in the farmland soils using atomic absorption spectrophotometer (AAS) were observed to follow the ranking Ni (10.52±0.26 mg/kg) > Pb (5.03±0.33 mg/kg) > Cu (1.44±0.41 mg/kg) > Zn (1.40±0.55 mg/kg) > Cd (0.31±0.50 mg/kg) respectively. From these concentrations, the estimated average daily intake (ADI_i) for the metals for each exposure pathway and for both age categories (adults and children), were observed to follow the decreasing order Cd<Zn<Cu<Pb<Ni. The non-carcinogenic risks determined by estimating the target hazard quotient (THQ) for all the metals and for each exposure pathway were observed to be less than (<) 1.This suggests no potential health risk to the farmers. Similarly, the cumulative non-carcinogenic risks for each exposure pathway were also observed to produce a potential human health index (HI) values <1, suggesting no significant health risks for both adults and children. The HI were observed to fall in this order $HI_{dermal}>HI_{Ing}>HI_{Inh}$ respectively. From the results, the HI values for children were observed to be much higher than the adults, suggesting that, at a relatively high levels of exposure, children will be more likely at risk than the adults. The lifetime carcinogenic risk (CRI) for both ingestion and inhalation exposure pathways were found to be below the level of concern ($<10^{-4}$). The CRI_{Ing} for both age categories were observed to be in the order of Cd>Pb and the CRI_{Inh} in the order Ni>Cd>Pb. The total carcinogenic risk (TCRI) for each exposure pathway show high probability of carcinogenic risk by ingestion route for children. From the results it will suffice to say that children exposed to the farmland soils laden with the heavy metals could be more susceptible to potential carcinogenic and non-carcinogenic risk than the adults. Indicating some concerns toward toxic heavy metals accumulation and the potential health risk implication to the farmers cultivating the farmland soils.

Keywords: Soil; Metals; Risk assessment; Average daily intake; Target hazard quotient; Cancer risk index

Introduction:

In some parts of Nigeria, the fertility of lands for agricultural purposes has been eroded over the years to a level where achieving food security and sustainability is becoming a mirage. The health and viability of soil for agricultural enterprises has been overshadowed by economic considerations, bordering from overexploitation of farmlands resources to meet population demands to the indiscriminate use of agrochemicals to boost crop production. The dynamics of such lands use not only influences the overall soil health status, and the key aspects of the ecosystem (Paz-Kagan *et al*, 2014) but also has a direct salient effect to the farmers tilling the soil (Wang *et al*, 2018).

Soil is a finite resources of the ecosystem, a repository of nutrients, and a reservoir of inbounds/offload environmental wastes (Bwatanglang *et al*, 2019). As a repository of contaminants can readily accumulate heavy metals and transfer same into the plants, the animal grazing on the polluted plants and the farmers exploiting the land resources. The transfer chain from the polluted soil can induce biological toxicity, given rise to long-term health hazards to human through several exposure pathways such as ingestion, dermal contact or by inhalation (Adamcova *et al*, 2016; Gworek *et al*, 2016; Zhao *et al*, 2015; Abrahams, 2002; Sheramati and Varma, 2010; Toth *et al*, 2016; Papa *et* *al*, 2010, USEPA, 2011). The buildup of contaminants in farmland soils is multidimensional, emanating from human activities such as use of agrochemicals, and irrigation with wastewater. Influx of contaminants from waste incineration, sewage sludge, mining activities, oil combustion, use of leaded gasoline, paints contributes to heavy metal buildup in soils (Shahbazi *et al*, 2017). The use of agrochemicals has been identified to contribute to the buildup of contaminants in soil and serve as causative factors to the pathogenesis of several diseases. Nitrogen-based fertilizer were reported to increase the concentrations of Cd in soil and plants (Wangstrand *et al*, 2007). The accumulation of Cd, F, Hg, Pb, and As in soil are also linked to Phosphate fertilizers (Guo and Zhou, 2006; Channa *et al*, 2015). Metals such as Cu, Hg, Mn, Pb and Zn were once used as components of insecticides and fungicides in UK (Raymond and Felix, 2011). Pesticides application were also reported to mediate Cu, Mn, Zn, Br, Sr, Cr , As, Pb and Ti ions bioavailability in soils and plants (Garba *et al*, 2018; Shomar, 2006; McLaughlin *et al*, 2000;Tao *et al*, 2008; Jorgensen *et al*, 2005).

It is well established as discussed above that agricultural practices contributes immensely to heavy metals upload in soil and plants with unintended health risks to humans. Heavy metals contracted from polluted farmlands were detected in many parts of the human body such as the bone, nails, blood and hair (Hobarth *et al*, 1993). About 90.50, 69.31, and 6.90 $mg \cdot kg^{-1}$ of As, Cr, Cu, and Pb were detected in the fingernail, hair, and blood samples of people living in agricultural soil near arsenic coal mining areas in Xingren County , southwest China (Li *et al*, 2018). In the study the concentrations of the metals were observed to be higher in the Fingernail samples from females than males and increased proportionally with age in all the three biological samples. Several research were conducted in Nigeria to ascertain the level of heavy metal contaminations in agricultural soils (Musa *et al*, 2017; Iyaka and Kakulu, 2009; Adepetu *et al*, 1979; Adagunodo *et al*, 2018; Bwatanglang *et al*, 2018). These studies though discussed the chemistry of farmland soils across Nigeria, place little emphasis toward establishing the susceptibility of exposure to the local farmers through comprehensive human health risk assessment. For these reasons, this present study underscore the importance of carrying out a risk assessment of polluted farmlands on local farmers following several exposure pathways. The study was conducted to establish the heavy metal pollution level in farmlands soils located in Mubi province, Adamawa state, Nigeria and evaluated the potential health risks to farmers following either ingestion, dermal or inhalation exposure pathways.

Material and Methods

Sample Collection and Treatment

The farmland soil samples were collected in Mubi North and Mubi-south ranged from 10-20 cm and 20-30 cm depth. The collection site is 100 m away from the river side and each point of collection was on different portion of farmland in the six communities of Mubi North and Mubi South of Adamawa State. The six community Farmlands are Digil, Vimtim, Yawa, Gella, Madanya and Dirbishi all located in Mubi North and Mubi-South Local

Government, Adamawa State, Nigeria as shown in figure 1. Geographically, Mubi falls within the Sudan savannah vegetation zone of Nigeria, is located on latitude 10° 30’15”N and 100 1500” N and Longitude 13^0 1500” E and 130 4506” W. The area has a tropical climate with an average temperature of 32^0 to 37^0 C, with an average relative humidity ranging from 28% to 45% and an average rainfall, of about 105 mm (Adebayo, 2004). The Soil samples from each site were collected and homogenized and the digested samples subjected to Heavy Metal analysis using Atomic Absorption Spectrophotometer (AAS) (Oluyemi *et al*, 2008).

Health Risk Characterization

The risk assessment were evaluated by integrating the concentration level of the metals in the farmland soils to quantitatively estimate the likelihood of health hazard to the farmers through multiple exposure pathways. The average daily intake (ADI) of the toxic metals (mg/kg/day) following either oral ingestion, dermal contact, or inhalation exposure pathways respectively were determined using the expressions described in equation 1-3 (Sun and Chen, 2018).

$$ADI_{Ing} = 10^{-6} \text{ x } C_{soil} \times ({}_{Ing}R \times EF \times ED) / (BW \times AT) \quad (1)$$

$ADI_{Inh} = C_{soil} \times ({}_{Inh}R \times EF \times ED)/ (PEF \times BW \times AT)$ (2)

$ADI_{dermal} = 10^{-6} \times C_{soil} \times (SA \times AF \times ABS \times EF \times ED)/ (BW \times AT)$ (3)

Where ADI_{Ing}, ADI_{Inh} and ADI_{dermal} represents the average daily intake by ingestion, inhalation and dermal contact respectively. The C_{soil} is the concentration of metals in the soil. Table 1 shows the other risk exposure factors described in equation 1-3 and their functions relevant to the risk assessment processes (Sun and Chen, 2018; USEPA, 2004; DEA, 2010).

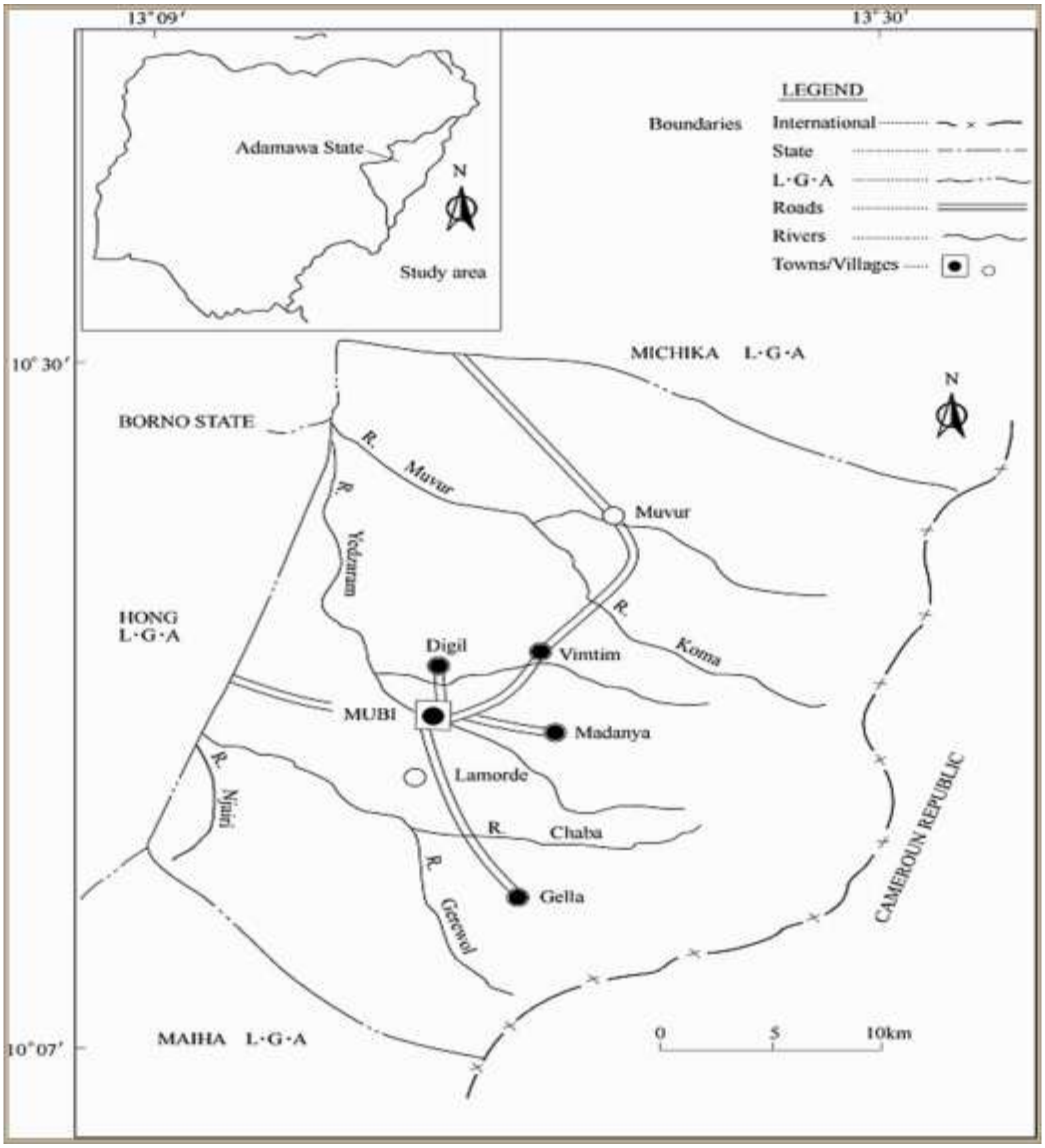

Figure 1: The study area showing the sampling points (Adebayo, 2004)

Table 1: Exposure factors used for the health risk assessment through different exposure pathways for soil

Factor	Unit	Children	Adult
Body weight (BW)	kg	15	60
Exposure frequency (EF)	days/year	350	350
Exposure duration (ED)	years	6	30
Ingestion rate ($_{Ing}R$)	mg/day	200	100
Inhalation rate ($_{Inh}Rair$)	m^3/day	10	20
Skin surface area (SA)	m^2	2100	5800
Soil adherence factor (AF)	mg/cm^2	0.2	0.7
Dermal Absorption factor (ABS)	-	0.1	0.1
Particulate emission factor (PEF)	m^3/k	1.3×10^9	1.3×10^9
Conversion factor (CF)	kg/mg	10^{-6}	10^{-6}
Average time (AT)	days		
For carcinogen		365 x 70	365 x 70
For non-carcinogens		365 x ED	365 x ED

The potential non-carcinogenic risk posed by the metals in the soil to the farmers were estimated based on the Target Hazard Quotient (THQ) and the Health Index (HI). The THQ as described in equation 4 is a function derived by relating the estimated ADI of each element with their respective reference dose (RfD) for each exposure pathway (Sun and Chen, 2018; Bwatanglang *et al*, 2019). The RfD for each metal and for each exposure pathway are presented in table 2. The HI as described in equation 5, is used to predict the cumulative non-carcinogenic effect posed by the individual metal presents in the soil samples (USEPA, 1997; Kohzadi *et al*, 2018). The cancer risk index (CRI) on the other hand represents the probability of developing any type of cancer over a lifetime. Estimated using the calculated ADI for each exposure pathway and their respective cancer slope factors (CSF) for each metal. The description is presented in equations 6 (Sun and Chen, 2018).

$$THQ = \frac{ADI_i}{RfD_i} \quad (4)$$

$$HI = \sum THQ_i \quad (5)$$

$$CRI = ADI_i \ x \ CSF_i \quad (6)$$

For the non-carcinogenic risk, a THQ or HI values < 1 signify that farmers exposed to the metals from the soil through either of the exposure pathways are unlikely to experience any adverse health hazard (Bwatanglang *et al*, 2019). A level of concerns however exist, if the THQ or HI >1, suggesting the likelihood of contracting non-carcinogenic risk (Sun and Chen, 2018; Bwatanglang *et al*, 2019). For the carcinogenic risk, if the estimated cancer risk index value is 10^{-6}<CRI <10^{-4} suggest that the exposed farmers are not in immediate danger for potential carcinogenic risk. However, a CRI > 10^{-4} suggest that the farmers are more likely exposed to carcinogenic risk (Sun and Chen, 2018; Bwatanglang *et al*, 2019). The probability of potential carcinogenic risk over a lifetime through multiple exposure pathways are described in equation 7.

TCRI= CRI *(ing)* + CRI *(inh)* + CRI *(dermal)* (7)

Where, CRI *(ing)*, CRI *(inh)*, and CRI *(dermal)* are risks contributions through ingestion, inhalation and dermal pathways respectively (Kamunda *et al*, 2016).

Table 2: Reference doses (*RfD*) in (mg/kg-day) and Cancer Slope Factors (*CSF*) for the individual heavy metals per exposure pathways

Elements	RfD_{Ing}	RfD_{Dermal}	RfD_{Inh}	CSF_{Ing}	CSF_{Dermal}	CSF_{Inh}	Ref.
Cd	5.60E-04	5.00E-04	5.7E-05	3.80E-01	-	6.30E+00	23,27
Pb	3.60E-03	5.25E-04	3.52E-03	8.50E-03	-	4.20E-02	23,27,28
Cu	3.70E-02	2.40E-02	4.02E-02	-	-	-	23,27
Zn	3.00E-01	7.50E-02	3.00E-01	-	-	-	23,27
Ni	2.00E-02	5.60E-03	-	-	-	8.40E-01	23,30

Results and Discussion:

The average mean concentration of Cd, Cu, Mn, Ni, Pb, and Zn in the farmland soils collected from Madanya, Vimtim, Yawa, Blue house, Dirbishi, and Digil in Mubi North and Mubi South Local Government Area of Adamawa state are presented in figure 2. From the results, the concentrations of the metals in the farmlands soils follow the order Ni>Pb>Cu>Zn>Cd and further observed to fall respectively below the permissible limits (PL) of 100 mg/kg, 200 mg/kg, 50 mg/kg, 250 mg/kg, and 10 mg/kg set for agricultural soils (Toth *et al*, 2016; UNEPA, 2013). However, for the purpose of this study, the concentration of the heavy metals in the farmland soil in relation to its impact to human health will be weighed based on the PL allowable in edibles rather than the values set for agricultural soil as indicated above. This was based on the assumption that, the heavy metals concentrations that are considered safe and within the PL set for agricultural soils will be of great health concerns if the same level of heavy metals are intentionally or unintentionally ingested, inhaled or come in contact with the skin (Raymond and Felix, 2011). Therefore, to get the health risk picture following direct exposure to the farmland soils through either of the exposure pathways, the concentration of metal in the soil will be assessed based on PL allowable in edibles (FAO/WHO, 2011)

The average mean concentration of Cd collected from the farmlands is about 0.31± 0.50 mg/kg. This values were found to be above the 0.05 mg/kg set by the FAO/WHO (FAO/WHO, 2011). Cadmium as low as ∼1 mg/kg can induce both carcinogenic and non-carcinogenic related effects. In addition to its carcinogenic tendency are also implicated in hepatic, renal, and pulmonary health-related complications (Ahmed *et al*, 2015; Friberg *et al*, 1971). When compared to the 0.20 mg/kg limits set by the FAO/WHO (FAO/WHO, 2011), the average mean concentration of Cu (1.44±0.41 mg/kg) in the farmland soils were found to be very significant to be of concerns. Though Cu is classified as essential trace elements (Paul *et al*, 2012; Xuedong *et al*, 2012), above the PL are health risk promoting factors, implicated in health-related complications such as gastrointestinal tract disorders, diarrhea, stomatitis, tremor, hemoglobinuria, ataxia, vomiting and convulsion (Duruibe *et al*, 2007; Babula and Adam, 2008).

As presented in the figure, the average mean concentration (10.52± 0.26 mg/kg) of Ni in the farmland soils samples were observed to be higher than the FAO/WHO standards of 0.2 mg/kg (FAO/WHO, 2011). Nickel occurs naturally in the soils as a result of the weathering of the parent rock (McGrath, 1995). Agricultural fertilizers, especially phosphates, are also a significant source of nickel in the soil. Nickel, is a tumor promoting factor, an agent that can also induce systemic reactions (Babula and Adam, 2008; Patrick-Iwuanyanwu and Chioma, 2017). Lead is another classic example of toxic metals, the level in the soils (5.03± 0.33 mg/kg) were also found to be higher compared to the 0.35 mg/kg set by the FAO/WHO (FAO/WHO, 2011). The presence of Pb occurs largely from anthropogenic sources. A classic example of carcinogens, a highly toxic metal even at a very low dose (Jabeen *et al*, 2010), known to impair cognitive development in children, facilitate the development of high blood pressure and cardiovascular diseases (Ullah *et al*, 2014). Zinc on the other hand are released to the environment from both natural and anthropogenic sources. In the farmland system, in addition to other anthropogenic sources, application of fertilizers are possible route for Zn mobilization in farmland soils (Fischer *et al*, 1984). However, the concentration of Zn in the samples (1.40± 0.55 mg/kg) were generally found to be lower than FAO/WHO standards (FAO/WHO, 2011). Zinc is also considered an essential trace elements, less toxic among its pairs. However, above the PL promotes health complications such as nausea, vomiting, diarrhea, fever and lethargy (Fischer *et al*, 1984).

Anthropogenic sources in addition to the use of phosphoric fertilizers could introduce trace amount of heavy metals in the farmland ecosystems (Alves *et al*, 2016). Continual application of nitrogen and phosphate fertilizers were linked to Cd and Pb build up in farmland soils (Wangstrand *et al*, 2007; Guo and Zhou, 2006; Sabiha *et al*, 2009). The concentrations of Cd in fertilizer depends on the source of the rock used in the production of the fertilizer. Phosphate rock used for the manufacturing of phosphate fertilizer in addition to phosphorus also contain trace amounts of Cd, Cu, Cr, Ni, Pb and Zn (Sabiha *et al*, 2009). The elemental composition of sedimentary phosphate rock shows it to contain about 69 times the level of Cd compared to non-phosphate containing rock (Roberts, 2014). Even though the concentrations reported in this study are lower than the values reported by some researchers in Nigeria (Musa *et al*, 2017; Iyaka and Kakulu, 2009; Adepetu *et al*, 1979; Adagunodo *et al*, 2018). The continual exposure to these heavy metals in the farmland soils could expose the farmers to potential non-carcinogenic or carcinogenic risk either by ingestion, inhalation or dermal exposure as the case maybe.

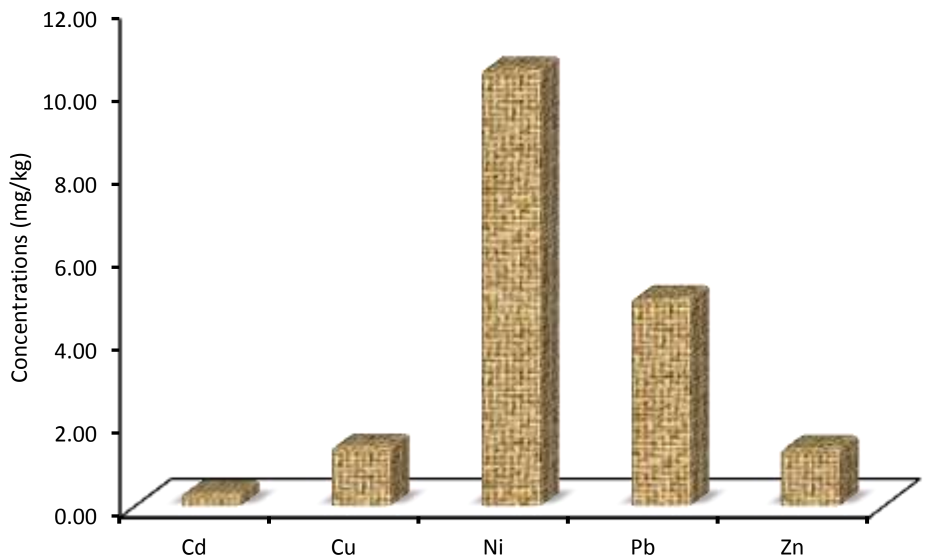

Figure 2: The average mean concentrations of Cd, Cu, Ni, Pb, and Zn collected from farmland soil in Madanya, Vimtim, Yawa, Blue house, Dirbishi, and Digil of Mubi North and Mubi South Local Government Area of Adamawa state. The results are presented as Mean± SD of three replicate analysis.

The estimated average daily intake (ADI) for the metals (Cd, Cu, Ni, Pb, and Zn), for each exposure pathway (ingestion, dermal contact and inhalation) are presented in table 3. For both age categories (adults and children), the ADI_i were observed to follow the decreasing order Cd<Zn<Cu<Pb<Ni respectively. The highest ADI of 1.35E-04 mg/kg were observed in children exposed to Ni following the ingestion route. These values as presented in the table were observed to be lower than their RfD values

as listed in table 2. From the result, the average exposure dose of the three exposure pathways are observed to decreased in the order of ADI_{Inh}<ADI_{Ing}<ADI_{Dermal} for the adults and ADI_{Inh}< ADI_{Dermal}<ADI_{Ing} for children respectively. The results shows that children are more likely to accumulate more of the metals than adults principally through ingestion exposure pathway. This could be linked to the higher intake rates per unit body weight observed in children (Sun and Chen, 2018, Xiao *et al*, 2017). The unintentional oral contact with the contaminated soil, and the slow detoxification processes common among children are additional factors contributing to the likelihood of health risk among children (Sun and Chen, 2018, Xiao *et al*, 2017, Bwatanglang *et al*, 2019). In study by Chabukdhara, and Nema, (2013), Chen *et al* (2012) and Olawoyin *et al* (2012), the potential health risk in children are observed to be caused by the direct oral ingestion of contaminated soils rather than dermal contact and inhalation. Similar observation were reported by Sun and Chen, (2018) and Yiran *et al*, (2013). The ingestion of dust or soil laden with heavy metals were reported to adversely increase the level of Pb in blood among children (Healy *et al*, 1982) and further reported to increase the blood-Pb level in two-thirds of children in Shenzhen city in China (Yiran *et al*, 2013; Isham, 2005). The ADI assessments bring into fore, the level of daily exposure or intake of these heavy metals by the local farmers through ingestion, inhalation or dermal contact that could leads to health concerns. However, from the results of this study, on the overall, it will suffice to say that children tilling the soil on a daily basis could be more susceptible to a higher level of exposure dose compared to the adults

Table 3: Average daily intake (ADI) values in mg/kg/day for adults and children in the farmland soils

	ADI_{Ing}		ADI_{Inh}		ADI_{Dermal}	
Metals	Adults	Children	Adults	Children	Adults	Children
Cd	4.95E-07	3.96E-06	7.62E-11	1.52E-10	2.01E-06	8.32E-07
Cu	2.29E-06	1.83E-05	3.53E-10	7.06E-10	9.31E-06	3.85E-06
Ni	1.68E-05	1.35E-04	2.59E-09	5.17E-09	6.83E-05	2.82E-05
Pb	8.03E-06	6.42E-05	1.24E-09	2.47E-09	3.26E-05	1.35E-05
Zn	2.22E-06	1.78E-05	3.42E-10	6.84E-10	9.03E-06	3.74E-06

The potential non-carcinogenic effects posed by the individual metal presents in the soil samples are presented in table 4. The target hazard quotient (THQ) as described in the table for all the metals and for each exposure pathway were observed to be <1, suggesting no potential health risk following either ingestion, inhalation or dermal exposure for both the adults and children respectively. Target hazard quotient for the ingestion exposure pathways for both the adults and children were observed to follow the ranking Pb>Cd>Ni>Cu>Zn. For the inhalation exposure pathway, the THQ follow the order Cd>Pb>Cu>Zn. For this exposure pathways, no RfD set for Ni. Furthermore, the exposure through the dermal route were observed to follow the order Pb>Ni>Cd>Cu>Zn for both adults and children. Similarly, the cumulative non-carcinogenic health risks (HI) for each exposure pathway were also observed to be <1. Suggesting no significant level of concerns for non-carcinogenic related health risks for both adults and children. The HI for the adults and children were observed to fall in this order HI_{dermal}>HI_{Ing}>HI_{Inh} respectively. From the results, the HI values for children were observed to be much higher than the adults suggesting that, at a relatively high levels of exposure, children will be more likely at risk than the adults, considering the higher intake rates per unit body weight observed in children (Sun and Chen, 2018, Xiao *et al*, 2017. Wang *et al*, (2018) reported similar finding in farmland soil from Lingyuan, in the west of Liaoning Province, China. In the study, the human health hazard assessment for the Non-carcinogenic risk HI < 1, indicating that potential toxic elements in soil have no significant effect on people's health through exposure. The result further shows higher exposure risk index for children related largely to the unintentional ingestion of dust by children and handling of edible item with unclean hands (Sun and Chen, 2018; Kamunda *et al*, 2016; Yiran *et al*, 2013, Xiao *et al*, 2017, Bwatanglang *et al*, 2019)

Table 4: Hazard quotient (*HQ*) values for heavy metals for adults and children in the farmland soils.

	THQ_{Ing}		THQ_{Inh}		THQ_{Dermal}	
Metals	Adults	Children	Adults	Children	Adults	Children
Cd	8.85E-04	7.08E-03	1.34E-06	2.67E-06	4.02E-03	1.66E-03
Cu	6.20E-05	4.96E-04	8.78E-09	1.76E-08	3.88E-04	1.61E-04
Ni	8.41E-04	6.73E-03	-	-	1.22E-02	5.04E-03
Pb	2.23E-03	1.78E-02	3.51E-07	7.02E-07	6.21E-02	2.57E-02
Zn	7.41E-06	5.93E-05	1.14E-09	2.28E-09	1.20E-04	4.98E-05
HI	**4.03E-03**	**3.22E-02**	**1.70E-06**	**3.40E-06**	**7.88E-02**	**3.26E-02**

The lifetime carcinogenic risk (CRI) for all the metals and for each exposure pathway for the adults and children are presented in table 5. The carcinogenic risk were analyzed for Pb, Cd, and Ni for the ingestion and inhalation exposure pathways only. No cancer slope factor set for dermal exposure pathways as well for Cu and Zn. Thus these parameters are not included in the carcinogenic risk analysis. A cancer risk index in the range of 10^{-6} to 10^{-4} are considered acceptable. However, a significant level of concern arises for CRI values > 10^{-4} (Sun and Chen, 2018; Bwatanglang *et al*, 2019). From the results presented in the table, the CRI for both ingestion and inhalation exposure pathways were found to be below the level of concern (<10^{-4}). The CRI_{Ing} for both age categories were observed to be in the order of Cd>Pb and the CRI_{Inh} in the order Ni>Cd>Pb. In all, the CRI for both exposure pathways were observed to be higher in children than the adults. The combined effect for each exposure pathway (TCRI) show high possibility of carcinogenic risk by ingestion route for children. From the results it will suffice to say that children are more susceptible to potential carcinogenic risk than the adults. Furthermore, the ingestion exposure pathway were observed to be the major route compared to the lifetime CRI by inhalation exposure pathways. According to the results, the potential carcinogenic risk following the ingestion route could come from Cd exposure. Similarly, exposure to Ni could be the likely source of carcinogenic risk by inhalation exposure pathway. Though, the results didn't predict a potential carcinogenic risk from Cd or Pb exposure, at a relatively high levels of exposure, children will be more likely at risk than the adults. Suggesting that continual exposure to these toxic metals in the farmland soils could promote toxic induce effects to the farmers. The susceptibility of children to the non-carcinogenic and carcinogenic risks compared to the adults could be linked to the higher intake rates per unit body weight observed in children (Sun and Chen, 2018; Xiao *et al*, 2017; Bwatanglang *et al*, 2019). The unintentional oral ingestion as well as the slow detoxification processes are additional contributing factors to the increase susceptibility by children (Sun and Chen, 2018; Xiao *et al*, 2017; Bwatanglang *et al*, 2019). The high CRI by ingestion route were observed to follow the same outcome by Sun *et al*, (2018) reporting exposure by ingestion route to be the major contributor to the lifetime cancer risk.

Table 5: Cancer risk (CRI) values for heavy metals for adults and children in the farmland soils.

	CRI_{Ing}		CRI_{Inh}	
Metals	Adults	Children	Adults	Children
Cd	1.88E-07	1.51E-06	4.80E-10	9.60E-10
Ni	-	-	2.17E-07	4.35E-07
Pb	6.83E-08	5.46E-07	5.19E-11	1.04E-10
TCRI	2.57E-07	2.05E-06	2.18E-07	4.36E-07

Conclusions:

The study establishes that toxic heavy metals in farmland soils could be transmitted to the farmers through ingestion, inhalation or dermal contact. Continual exposure to these toxic metals could promote toxic induce effects to the farmers. In the study, the average mean concentrations of the metals in the farmland soils follow the order Ni>Pb>Cu>Zn>Cd respectively. The THQ and the HI for the non-carcinogenic risk in the adults and children were all <1 for all the metals, and for all the exposure pathways. Suggesting that farmers cultivating the farmland are in no immediate danger to potential non-carcinogenic risk. The CRI for both ingestion and inhalation exposure pathway were found to be below the level of concern ($<10^{-4}$). The TCRI index for each exposure pathway show high probability of carcinogenic risk by ingestion exposure pathway and the order for exposure was observed to be in decreasing order, adults<children. Indicating some concerns toward toxic heavy metals accumulation and the potential health risk implication to the farmers cultivating the farmland soils.

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