IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 10, October 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Assessment Of Potential Health Risks Associated With Remediated And Non-Remediated Soils at Illegal Mining compound in Dareta, Zamfara, Nigeria.

Sulaiman, M.B.[1*], Salahu, K.[2], Isa Zubairu[3]

[1]Department of Pure and Industrial Chemistry, University of Nigeria, Nsukka, Enugu State, Nigeria
[2]Department of Biochemistry and Forensic Science, Nigeria Police Academy Wudil, Kano State, Nigeria.
[3]Department of Civil engineering, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria
[*]Corresponding author. E-mail: sulaimanmuhammadbashir@gmail.com

Abstract

The study assessed the levels of some heavy metals in remediated and non remediated soil at illegal gold mining activities at Dareta, Nigeria was carried out. Pollution indices and human health risk parameters were determined in order to assess the potential health risk to the local environment. Soil samples were collected and analysed for metals (Pb, Cd, Fe, Cu, Mn, Ni and Cr) using atomic absorption spectrometry. Pollution indices studies revealed that soil samples were not polluted from both the remediated and non-remediated soil, except Cd in non-remediated soil which fell in class 1 from unpolluted to moderately polluted. The evaluated the health risks of heavy metals in the soil through three exposure pathways: oral ingestion, inhalation, and dermal absorption, shows that both carcinogenic risk and non-carcinogenic hazards posed by heavy metals to adults and children are acceptable not exceed the safety threshold, which negatively do not affect the target community.

Keywords: Potential health risk, Pollution indices, Heavy Metals, Remediated soil

I. Introduction

Environmental problems caused by mining have attracted a great deal of research attention [1-2]. Mining, especially illegal mining damages the surface vegetation and soil and changes the hierarchical structure of natural soils. Environmental pollution from heavy metals has been studied to cause severe illness and sudden death in human beings for many centuries. It can be from air, water or land and can result from mining, automobile exhaust, agricultural and industrial activities among others [3]. Therefore, environmental problem of soil pollution by heavy metals has received increasing attention in the last few decades in both developing and developed countries throughout the world [4]. Heavy metals are of considerable environmental concern due to their toxicity, wide sources, non-biodegradable properties and accumulative behaviors [5]. Heavy metals are natural components of the environment, being present in rocks, soil, plants and animals. They occur in different forms: as minerals in rock, sand and soil; bound in organic or inorganic molecules or attached to particles in the air. In today’s industrial society, there is no escaping exposure to toxic chemicals and metals [6].
The presence of gold deposits discovered in some parts of Nigeria has attracted a lot of unemployed youth and small-scale miners to venture into these areas. The rapid and unorganized mining in various rural areas have contributed to the elevated levels of heavy metals in rural environment in developing countries [6]. According to Hossn *et al*., (2001) although adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues and is even increasing in some areas [7]. In 2010, lead poisoning was reported in some part of the state where illegal mining were taking place. Galadima and Garba (2010) reported that Zamfara lead poisoning is the worst and most recent heavy metals incidence in the Nigeria records that claimed the lives of over 500 children within seven months in 2010 [3].
The illegal miners from seven villages in Zamfara State brought rocks containing gold ore into the villages from small scale mining operation; the villagers never knew that the ore also contained extremely high levels of lead. The primary exposure routes for children and adults identified in these villages are incidental ingestion of contaminated soils and dusts, consumption of food contaminated by soil and dust sources, ingestion of contaminated water, and inhalation of contaminated dusts [8]. Dareta village is one of such mining fields. There is tendency for the crude process to contaminate the environment with other types of heavy metals apart from the lead which is a cumulative metal; it still remains a major hazard for human health.

2.0 Materials and methods

2.1 Study Area

The study area is Dareta village, Anka Local Government Area of Zamfara State in northern Nigeria. Dareta is village of Anka L.G.A located on latitude 12°06′30″N and longitude 5°56′00″E, and has an area of 2,746 km² and a population of 142,280 according to the 2006 population and housing census [9]. Dareta village is characterized with a Sudan savannah climate with temperatures rising up to 38 ^{o}C between March and May. Rainy season starts in late May to September while the dry season known as harmattan lasts from December to February having an annual average rainfall of about 579 mm.

2.2 Soil sample collection and processing

Soil Samples was collected from remediated soil in some of the compounds in Dareta village, the samples were collected from 0-15 cm. A sample was also collected from non-remediated soil in the compound, at each sampling locations, five subsamples were randomly collected to make a composite sample. A total of ten different composite samples were collected for the study. Each soil sample (500 g) were placed inside polyethylene bag and covered with aluminum foil. The samples were taken to the laboratory and stored under room temperature until analysis.

2.3 Sample preparation and digestion of soil

The air dried soil samples were sieved through 1mm mesh standard sieve. 1g of each prepared soil sample was put into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml of concentrated $HClO_4$, HNO_3 and H_2SO_4 respectively. The mixture was placed on a hot plate in a fume cupboard for three hours at 80 ^{o}C. The digest was filtered into 100 ml standard flask and made to mark with distilled water. Pb, Cd, Fe, Cu, Mn, Ni and Cr were all determined with atomic absorption spectrophotometer (AAS). All the samples analysis was done in three replicates [10].

2.4 Quality assurance procedure

Recovery study method was used for the validation of the digestion method. This was done by determining metal concentrations in triplicate samples of un-spiked and spiked soil samples. Spiking was performed by adding 1 ml of various concentrations of the metal standard solution to 1 g of soil sample, which was later subjected to the digestion procedure. The formula for calculating the percent recoveries was:

$$\% \text{ Recovery} = \frac{s-y}{z} \times 100$$

s = concentration of metal in spiked sample, y = concentration of metal in un-spiked sample, z = spiking concentration

Mean recoveries of the metals were Pb:94±4.0%; Cd:90±6.60%; Fe:92±6.0%; Cu:89±5.5%; Mn:95±3.0%; Ni:97±4.0%; Cr:91±4.3%.

2.5 Pollution indices

Pollution index are useful tools for processing, analyzing and conveying raw environmental information to decision makers, managers, technicians and the public [11]. The following indices: geo-accumulation index, contamination factor and pollution load index were used to measure the extent of pollution.

2.5.1 Geo-accumulation Index

Geo-accumulation Index defined as enrichment of metal concentration above baseline concentrations was calculated using the method proposed by Muller (1969) [12]. This method assesses the metal pollution in terms of seven (0 to 6) enrichment classes ranging from background concentration to very heavily polluted, as follows:

$$I_{geo} = \text{Log}_2 \left[\frac{C_n}{1.5\ B_n}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where C_n metal is the measured concentration of the examined heavy metal in the soil sample and B_n is the geochemical background concentration or reference value of the metal n. The factor 1.5 is introduced to minimize the effect of possible variations in the background or control values which may be attributed to lithogenic variation in the soil. The world average elemental concentration in mg/kg (Cu = 45, Cd = 0.30, Cr = 90, Fe = 47200, Mn = 850, Ni = 68, Pb = 20 and Zn = 95) reported by Turekian and Wedepohl (1961), in the earth's were used as reference in this study [13]. According to Huu *et. al.,* (2010) seven contamination classes

are used to define the degree of metal pollutants in soils based on the increasing value of the index of geo-accumulation as follows: [14].
Igeo < 0 means unpolluted
0 ≤ Igeo <1 means unpolluted to moderately polluted
1 ≤ Igeo <2 means moderately polluted
2 ≤ Igeo <3 means moderately to strongly polluted
3 ≤ Igeo <4 means strongly polluted
4 ≤ Igeo <5 means strongly to very strongly polluted
Igeo > 5 means very strongly polluted

2.5.2 Contamination factor

The contamination factor was derived by employing the model by Lacatusu (2000) [15].

$$CF = \frac{\text{Contamination of the metal in soil}}{Taget\ (Bakground)\ value} \quad \ldots\ldots (2)$$

The target (background) value is reference value of metals (DPR, 2002) for maximum allowable concentration of metals in Nigeria soil (Pb = 85, Cd = 0.8, Fe = 5000, Cu = 36, Mn = 476, Ni = 35, Cr = 100, Zn = 140) in mg/kg, Cf values greater than one defines the pollution range while values than one defines the contamination range [16]. The standard employed for interpreting soil heavy metals contamination/pollution index varies from country based on the chosen factors Lacatusu (2000) [15]. Significance of intervals of contamination /pollution factor (CF) as stated by Lacatusu (2000) is given as <0.1: Very slight contamination; 0.10-0.25: Slight contamination: 0.26-0.5: Moderate contamination; 0.5-0.75: Severe contamination; 0.76-1.00: Very severe contamination 1.1-2.0: Slight pollution; 2.1-4.0: Moderate pollution; 4.1-8.0: Severe pollution; 8.1-16: Very severe pollution; 16.0: Excessive pollution [15].

2.5.3 Pollution load index (PLI)

Pollution load index (PLI) developed by Thomilson *et al*.(1980) [17]., as follows:

$$PLI = (Cf_1 \times Cf_2 \times Cf_3 \times Cf_4 \ldots Cf_n)^{1/n} \quad \ldots\ldots (3)$$

Where n is the number of metals studied and *Cf* is the contamination factor calculated as described in Equation 1. The PLI gives an estimate of the metal concentration status. The rank of values of PLI <1 donate perfection: PLI = 1 present that only baseline levels of pollutant are present and PLI > 1 would indicate deterioration of site quality.

2.6 Health Risk Assessment

Health risk assessment models were developed basically in Europe and in the United States. The risk assessment is a multi-step procedure that comprises of data collection (gathering and analyzing the site data relevant to human health), exposure assessment (estimation of the magnitude of actual and/or potential human exposures), toxicity assessment (determination of adverse effects associated with exposure to different metals) and risk characterization (summarizes and combines outputs of the calculations of exposure and toxicity assessments) [18]. Three transmission media have been put forward for calculating the risk assessment of heavy metals, namely soil, groundwater and air (Lai *et al.*, 2010) but risk assessment study will be based on the exposure pathway of soil medium. Direct exposure of human to heavy metals in contaminated soil can occur through three exposure pathways: (a) direct ingestion of substrate particles, (b) inhalation of suspended particles through the mouth and nose, and (c) dermal absorption of elements in particles adhered to exposed skin [19]. The average daily intake dose or intake (ADD_{nc}, mg/kg/day) by for non-carcinogenic through each of three exposure pathways to soil was calculated using three following equations proposed by (USEPA 1989) [20].

$$ADD_{inh\text{-}nc} = \frac{C \times R_{inh} \times EF \times ED}{PEF \times BW \times AT} \quad \ldots\ldots (4)$$

$$ADD_{ing\text{-}nc} = \frac{C \times R_{ing} \times EF \times ED \times 10^{-6}}{BW \times AT} \quad \ldots\ldots (5)$$

$$ADD_{derm\text{-}nc} = \frac{C \times SL \times SA \times ABS \times EF \times ED \times 10^{-6}}{BW \times AT} \quad \ldots\ldots (6)$$

Where $ADD_{ing\text{-}nc}$, $ADD_{inh\text{-}nc}$, $ADD_{derm\text{-}nc}$ are average daily dose for ingestion, inhalation, dermal contact respectively, C is Concentration of the contaminant in the medium (mg/kg), EF is exposure frequency (day/year), ED is exposure period (year), AT_{nc} is average time for non-carcinogens, BW is body weight (kg), PEF is soil to air particulate emission factor (m^3kg^{-1}), SA is skin surface area available for exposure (cm^2), SL is soil-to-skin adherence factor ($mg.cm^{-2}.h^{-1}$) and ABS is dermal absorption factor (dimensionless).

The potential health risk of the soil heavy metal was estimated using a hazard quotient (HQ). The non cancer hazard quotient (HQ) assumes that there is a level of exposure known as the reference dose (RFD). The reference dose is an estimate of daily exposure to human pollution. Hazard quotient (HQ) is defined as the ratio of the average daily intake or dose (ADD) (mg/kg/day) to the reference dose (RfD, mg /kg/day) (USEPA 2010) [21].

$$HQ = \frac{DI}{Rfd} \quad \ldots\ldots (7)$$

ADD = Average daily dose (mg/kg/day) for the different exposure routes,

RfD = Reference dose (mg/kg-day Table 2).

The overall potential risk posed by a mixture of heavy metals, expressed as a total hazard index (THI) is determined from the sum of the HQs for each heavy metal.

Total Hazard Index (THI) = $\sum^{n}_{i-1}$ HQ ………………..……… (8)

The greater is the value of HQ and HI above 1, the greater is the level of concern since the accepted standard is 1.0 at which there will be no significant health hazard [19]. The probability of experiencing long-term health hazard effects increases with the increasing THI value [22].

The carcinogenic risk is calculated for life time exposure and is estimated as the incremental probability of an individual to develop cancer over a life time as a result of total exposure to potential carcinogens 23

As carcinogenic substances Pb, Cd, Ni and Cr were selected to assess the carcinogenic hazard risk (Total Risk) using the following Equations:

$$ADD_{inh\text{-}ca} = \frac{C \times IR \times EF \times 10^{-6}}{BW \times AT_{ca}} \quad \ldots\ldots (9)$$

$$IR = \frac{ED_{chld} \times R_{ing.chld}}{BW_{chld}} + \frac{(ED_{adult} - ED_{chld}) \times R_{ing}}{BW_{adult}} \quad \ldots\ldots (10)$$

$$ADD_{ing\text{-}ca} = \frac{C \times EF \times ET \times ED \times 10^{3}}{PEF \times BW \times AT_{ca}} \quad \ldots\ldots (11)$$

$$ADD_{derm\text{-}ca} = \frac{C \times ABS \times EF \times DFS \times 10^{-6}}{AT_{ca}} \quad \ldots\ldots (12)$$

$$DFS = \frac{ED_{chld} \times SA_{chld} \times SL_{chld}}{BW_{chld}} + \frac{(ED_{adult} - ED_{chld}) \times SA_{adult} \times SL_{adult}}{BW_{adult}} \quad \ldots\ldots (13)$$

Where $ADD_{inh\text{-}ca}$, $ADD_{ing\text{-}ca}$, $ADD_{derm\text{-}ca}$ are average daily dose for inhalation, ingestion, dermal contact respectively, C is Concentration of the contaminant in the medium (mg/kg), IR is ingestion rate (mg/kg), EF is exposure frequency (day/year), ED is exposure period (year), ET is exposure time, AT_{ca} is average time for carcinogens, DFS is soil dermal contact factor, LT is lifetime exposure and PEF is soil to air particulate emission factor (m^3kg^{-1}).

Total cancer risk (R_{Total}) for carcinogens, the dose was multiplied by the corresponding slope factor (SF) to produce a level of excess life time cancer risk (Table 1). The cumulative carcinogenic risk was expressed as the total cancer risk (R_{Total}).

$$R_{Total} = \sum_{i}^{n}. Risk \quad \ldots\ldots (14)$$

$$Risk = ADD_{ca} \times CSF \quad \ldots\ldots (15)$$

R_{Total} surpassing 1*E*-04 are viewed as unacceptable, R_{Total} below 1*E*-06 are not considered to pose significant health risks, and lying between 1*E*-04 and 1*E*-06 generally considered acceptable, depending on the situation and circumstances of exposure [24].

Table 1: Values of variables for human health risk assessment

Parameters	Unit	Definition	Child	Adult	References
C	mg/kg	heavy metal concentration			
ABS	----	dermal absorption factor	0.001	0.001	[25]
SL	mg/cm^2	soil to skin adherence factor	0.2	0.07	[26]
BW	kg	average body weight	15	70	[20]
ED	year	exposure duration	6	25	[26]
EF	day/year	exposure frequency	350	350	[22]
ET	h/day	exposure time	24	24	[28]
R_{ing}	mg/day	soil ingestion rate for receptor	200	100	[26]
R_{inh}	m^3/day	soil inhalation rate for receptor	10	20	[29]
SA	cm^2/event	exposure skin surface area	2800	3300	[26]
AT_{nc}	day	averaging time non-carcinogenic	ED × 365	ED × 365	[27]
AT_{ca}	day	averaging time for carcinogenic	LT × 365	LT × 365	[27]
LT	year	life time	70	70	[29]
PEF	m^3/kg	particulate emission factor	1.316×10^9	1.316×10^9	[26]

Table 2: Toxicological parameters for different heavy metals of health risk assessment

		RfD/mg/kg/d			SF/mg.d/kg	
Metal	**RfD_{ing}**	**RfD_{inh}**	**RfD_{derm}**	**SF_{ing}**	**SF_{inh}**	**SF_{derm}**
Ni	2.00*E* - 02	2.06*E* - 02	5.40*E* - 03		2.60*E* - 04	
Pb	1.40*E* - 03	3.52*E* - 03	5.25*E* - 05	8.50*E* - 03	1.20*E* - 05	
Cu	4.00*E* - 02	4.02*E* - 02	1.20*E* - 02			
Cd	1.00*E* - 03	1.00*E* - 05	2.50*E* - 05		1.80*E* - 03	
Cr	3.00*E* - 03	2.86*E* - 05	6.00*E* - 05		1.20*E* - 02	
Mn	1.00*E* - 01	4.00*E* -04				

3.0 Results and Discussion

3.1 Heavy metals content in the soil

The concentrations of heavy metals in soil samples were detected along the depth of the soil layer at the site; the results are shown in Table 3. The heavy metal concentration in the soil sample was found in the following order: Cr > Pb > Cu > Cd > Fe > Ni. The high levels of Cr (12.30) and Pb (1.1989) concentrations in soil at the site, and 0.0001, 0.0002, 0.0003, 0.0003, and 0.0006 for Ni, Fe, Cd, Mn and Cu respectively, are found to be low as in remediated soil, while in non remediated soil was found to be in the following order: Cr > Cu > Cd > Pb > Fe > Ni > Mn. However, Pb, Cu and Cd concentration in this study is higher than those reported by (Omono and Samuel, 2012) in mining environment farm at Itakpe, Nigeria, but lower in Ni [30]. The concentration of heavy metal in the study is lower than those reported by (Jinman *et al.*, 2013) in reclaimed soils at an opencast coal mine at Heidaigou, China [31].

Table 3: Concentration heavy metals (mg/kg) of soil samples in remediated and non-remediated soil

Metals	Pb	Cd	Fe	Cu	Mn	Ni	Cr
Remediated	1.1989	0.0003	0.0002	0.0006	0.0003	0.0001	12.300
Non-Remediated	0.1800	0.2700	0.1000	0.8800	0.0035	0.050	13.300

3.2 Pollution indices

The results of the geo-accumulation index of the soil samples from the remediated and non-remediated soil are presented in (Figure 1). The geo-accumulation index of the metals from all soil samples I_{geo} revealed that all the studied in respect to all metals fell into class 0 - unpolluted except Cd in non-remediated soil which fell in class 1 from unpolluted to moderately polluted.

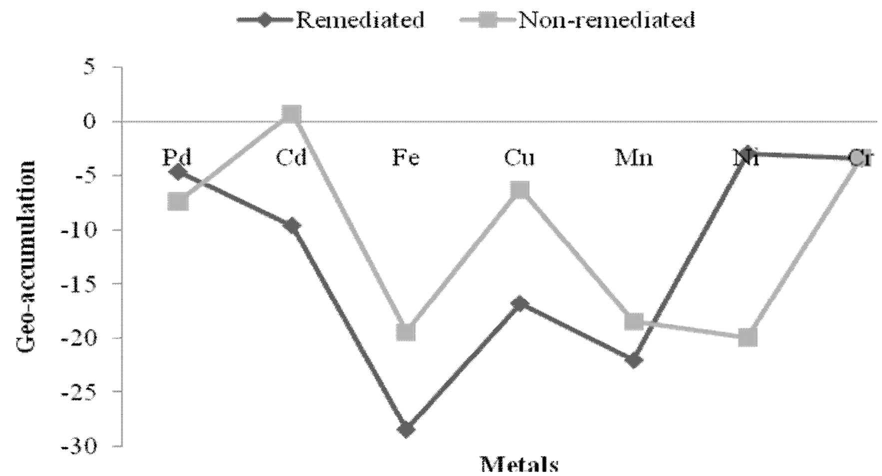

Figure 1: Geo-accumulation index of the metals in remediated and non- remediated soil

The assessment of the overall contamination of the studies was based on contamination Factor (Figure 2). It was observed that Cd recorded very slight contamination in remediated soil and slight contamination factor in non-remediated soil. Other element such as Pb, Cu, Ni, fe, Mn Cr also recorded very slight contamination factor in a soil samples. These indicated contaminations of soil from both remediated and non-remediated soil were all ranged from very slight to slight contamination in respect to all metals. CF for all metals from both remediated and non-remediated is un-polluted, this indicates very low anthropogenic pollution at the sites. The pollution load index values (Figure 2) were less than 1 for each metal in all samples, thus indicating perfection.

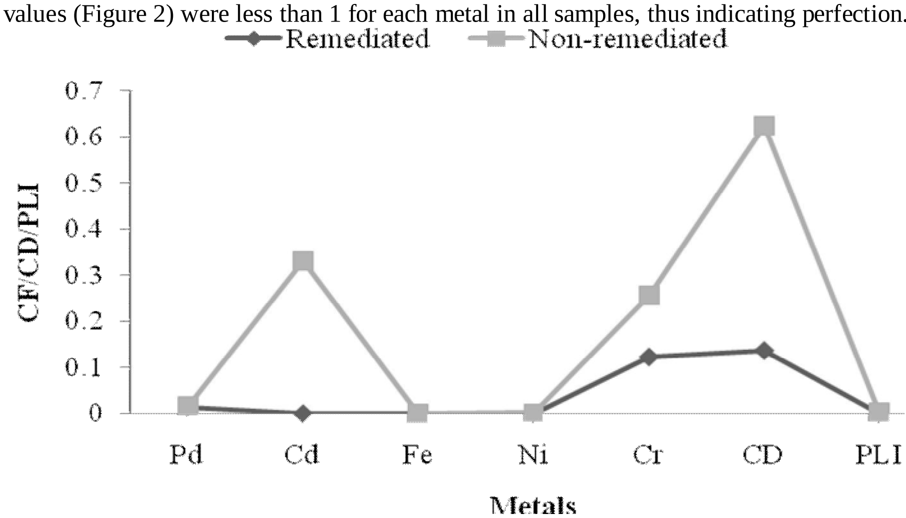

Figure 2: Contamination factor/Degree of contamination/Pollution load index of the metals in remediated and non- remediated soil

3.3 Health risk assessment

Table 4 present the results of $ADDs_{nc}$, HQs and THIs of heavy metals for both adult and child from three exposure pathways. The exposure pathway which on the average resulted in the highest levels of risk for adults and children expose to soil dust is ingestion followed by dermal contact with inhalation being the least (Van den berg 1995). For non-carcinogenic hazard the values are; for the oral (HQ_{ing}), inhalation (HQ_{inh}), and dermal (HQ_{derm}) routes of exposure to the detected heavy metals. The combined HI values for adults are 0.045 and 7.51*E* - 03 for the soils from the remediated and non-remediated soil respectively; both values are below the safety threshold (HI < 1.0). Moreover, the current heavy metal concentrations in soil in the site do not pose any additional non carcinogenic hazard for adults living in or near the site. The combined HI values for children are 0.487 and 0.085 for the soils from the remediated and non- remediated soil respectively, indicating that the heavy metals detected was also are below safety threshold. Therefore, the current heavy metal concentrations in both remediated and non-remediated soil do not pose any additional non carcinogenic hazard for children living in or near the site. The individual hazard indexes (HI) of all the metals were less than one indicating that there was little or no probable adverse health risk.

Table 4: Non carcinogenic hazards of heavy metals corresponding to different exposure pathways for remediated and non- remediated soil

Remediated soil					
Groups Age	**Metals**	**HQ_{ing}**	**HQ_{inh}**	**HQ_{derm}**	**HI**
Children	Pb	1.10*E* - 02	1.65*E* - 07	4.09*E* - 03	1.51*E* - 02
	Cd	3.84*E* - 08	1.46*E* - 08	4.19*E* - 01	4.19*E* - 01
	Cu	1.92*E* - 07	7.25*E* - 12	1.79*E* - 03	1.79*E* - 03
	Mn	3.84*E* - 10	3.64*E* - 10	NC	3.64*E* - 10
	Ni	6.40*E* - 08	2.36*E* - 12	6.63*E* - 04	6.63*E* - 04
	Cr	5.24*E* - 02	2.09*E* - 04	1.82*E* - 03	5.45*E* - 02
Adults	Pb	1.17*E* - 03	7.08*E* - 08	7.22*E* - 05	1.24*E* - 03
	Cd	4.11*E* - 07	6.24*E* - 09	3.80*E* - 02	3.80*E* - 02
	Cu	2.05*E* - 08	3.11*E* - 12	1.58*E* - 04	1.58*E* - 04
	Mn	4.11*E* - 09	1.56*E* - 10	NC	4.27*E* - 09
	Ni	6.85*E* - 09	1.01*E* - 12	5.86*E* - 03	5.86*E* - 03
	Cr	6.62*E* - 13	8.95*E* - 05	6.67*E* - 05	1.56*E* - 04
Non remediated soil					
Children	Pb	1.64*E* - 02	2.48*E* - 08	1.23*E* - 04	1.65*E* - 02
	Cd	3.45*E* - 03	1.31*E* - 05	3.87*E* - 05	3.50*E* - 03
	Cu	2.81*E* - 04	1.06*E* - 08	2.63*E* - 06	2.84*E* - 04
	Mn	4.48*E* - 07	4.25*E* - 10	NC	4.25*E* - 10
	Ni	3.20*E* - 05	1.18*E* - 09	3.31*E* - 07	3.23*E* - 05
	Cr	5.67*E* - 02	2.41*E* - 05	7.94*E* - 03	6.47*E* - 02
Adults	Pb	1.76*E* - 04	1.04*E* - 08	1.08*E* - 05	1.87*E* - 04
	Cd	3.70*E* - 04	5.62*E* - 06	3.42*E* - 05	4.10*E* - 04
	Cu	3.01*E* - 05	4.55*E* - 09	2.32*E* - 07	3.03*E* - 05
	Mn	4.80*E* - 08	1.81*E* - 10	NC	4.82*E* - 08
	Ni	3.42*E* - 06	5.05*E* - 10	2.93*E* - 08	3.45*E* - 06
	Cr	6.07*E* - 03	1.03*E* - 04	7.02*E* - 04	6.88*E* - 03

NC: not calculated.

For carcinogenic risks hazard values of (As, Cr, Pb, and Ni) are shown in Table 6 R_{Total} of the soil samples from the remediated and non remediated soil. The combined HI values are 1.48*E* - 08 and 5.28*E* - 14 for adults from the remediated and non- remediated soil respectively and 1.59*E* - 08 and 1.42*E* - 08 for children, which were all below the range of 1*E* - 04 and 1*E* - 06. Comparison of the values of using multiple pathways shows that carcinogenic risks do not attribute any risk exposure.

Table 5: Individual carcinogenic risk of carcinogens in remediated and non- remediated soil

Remediated soil					
Groups Age	**Metals**	**R_{ing}**	**$R_{inh-child}$**	**R_{derm}**	**R_{Total}**
Children	Pb	1.50*E* - 08	1.43*E* - 12	NC	1.5*E* - 08
	Cd	NC	5.38*E* - 14	NC	5.38*E* - 14
	Ni	NC	2.59*E* - 15	NC	2.59*E* - 15
	Cr	NC	1.48*E* - 08	NC	1.48*E* - 08
Adults	Pb	1.50*E* - 08	2.15*E* - 13	NC	1.5*E* - 08
	Cd	NC	4.84*E* - 11	NC	4.84*E* - 11
	Ni	NC	1.29*E* - 12	NC	1.29*E* - 12
	Cr	NC	1.59*E* - 08	NC	1.59*E* - 08
Non remediated soil					
Children	Pb	2.24*E* - 09	1.28*E* - 12	NC	2.24*E* - 09
	Cd	NC	4.82*E* - 14	NC	4.82*E* - 14

	Ni	NC	2.32*E* - 15	NC	2.32*E* - 15
	Cr	NC	2.32*E* - 15	NC	2.32*E* - 15
Adults	Pb	2.24*E* - 09	1.26*E* - 12	NC	2.24*E* - 09
	Cd	NC	4.34*E* - 14	NC	4.34*E* - 14
	Ni	NC	1.16*E* - 12	NC	1.16*E* - 12
	Cr	NC	1.42*E* - 08	NC	1.42*E* - 08

NC: not calculated.

The results of the health risk assessment shows that, both carcinogenic risk and non-carcinogenic hazards posed by heavy metals to adults and children are acceptable not exceed the safety threshold, which negatively do not affect the target community. Integrated health risk assessments should include the assessment of pollutants carried by four media (atmosphere, soil, water, and food chain) using the three main pathways (ingestion, inhalation, and dermal absorption) to the body. In view of the lack of information on the eating habits of the local population and the limitation on testing programmers', this study only evaluated the health risks of heavy metals in soil through three exposure pathways: oral ingestion, inhalation, and dermal absorption.

4.0 Conclusion

Soil is an important constituent of the biosphere and any contamination to it affects the quality of human life. The study assessed of pollution by heavy metals in remediated and non remediated soil at illegalgold mining activities at Dareta, Zamfara was evaluated using pollution indices like geo-accumulation index and potential health risk. Pollution indices studies showed that soil samples were not polluted both from the remediated and non-remediated soil, except Cd in non-remediated soil which fell in class 1 from unpolluted to moderately polluted. Human health risks were assessed based on environmental exposure to heavy metals. Both carcinogenic risk and non carcinogenic hazards of heavy metals for adults and children in soil samples were acceptable.

References

[1] D. Cao, G. Wang, Y. Wang, J. Xiang, and Y. Si, "Accumulation of heavy metals in dominant plants growing on mineral areas in Anhui Tongling". *Journal of Agro. Environmental Science*, Vol. 24 No. 6, 2005, pp 1079-1082.

[2] F.G.M. Rodrcguez, E. Shumilin, and R.I. Sclnchez, "Heavy metal pollution monitoring using the brown seaweed Padina durvillaei in the coastal zone of the Santa Rosalca mining region, Baja California Peninsula, Mexico". *Journal of Applied Phycol*, Vol. 21, No. 1, 2009, pp. 19-26.

[3] A. Galadima, and Z.N Garba, "Heavy Metals Pollution in Nigeria: Causes and Consequences". *Elixir Pollution*, Vol. 45, 2012, pp. 7917-7922.

[4] L.P. Zhang, X. Ye, and H. Feng, "Heavy Metal Contamination in Western Xiamen Bay Sediments and Its Vicinity, China". *Marine Pollution Bull,* Vol. 54, 2007, pp. 974–982.

[5] R. Yu, X. Yuan, Y. Zhao, G. Hu, and X. Tu, "Heavy metal pollution in intertidal sediments from Quanzhou Bay, China. Journal of Environmental Science, Vol. 20 No. 6, 2008, pp. 664−669.

[6] T.I.N. Ezejiofor, A.N. Ezejiofor, A.C. Udebuani, E.U. Ezeji, E.A. Ayalogbu, C.O. Adjero, L.A. Ihejirika, C.E. Ujowundu, C.O. Nwaogu, A. Li, and K.O. Ngwaogu, "Environmental Metals pollutants Leads of a Densely Populated and Heavily Industrialized Commercial City of of Aba, Nigeria". *Journal of Toxicology and Environmental Health Science,* Vol. 5, No. 1, 2008, pp. 1-11.

[7] E. Hossn, G. Mokhtar, M. ElAwady, I. Ali, M. Morsy, and A. Dawood, "Environmental Exposure of the Pediatric Age Groups in Cairo City and its Suburbs to Cadmium Pollution". *Science of the Total Environment,* Vol. 273, 2001, pp.135-146.

[8] UNICEF., 2011. UNICEF Programme Cooperation Agreemen: Environmental Remediation Lead Poisoning in Zamfara Final Report. Blacksmith Institute, 1126. www. black smith institute.org.

[9] UNICEF., 2011. UNICEF Programme Cooperation Agreemen: Environmental Remediation Lead Poisoning in Zamfara Final Report. Blacksmith Institute, 1126. www. black smith institute.org.

[10] T.M. Chiroma, R.O. Ebewele, and F.K. Hymore, "Comparative Assessment of Heavy Metal Levels in Soil, Vegetables and Urban Grey Waste Water used for Irrigation in Yola and Kano". *International Rearch J ES. Vol.* 3, No. 2, 2014, pp. 01-09.

[11] S. Caeiro, M.H. Costa, and T.B. Ramos, "Assessing heavy metal contamination in Sado Estuary sediment: an index analysis approach". *Ecol Indicators,* Vol. 5, 2005, pp. 151–169.

[12] G. Muller "Index of geoaccumulation in sediments of the Rhine river". Geology Journal, Vol. 2 No. 3, 1969, pp. 108–118.

[13] K.K. Turekian, and K.H. Wedepohl, "Distribution of the elements in some major units of the earth's crust". *Bulletin of Geological Society of America* Vol. 72, 1961, p. 175–92.

[14] H.H. Huu, S. Rudy, and A.V. Damme, "Distribution and contamination status of heavy metals in estuarine sediments near Cau Ong harbor, Ha Long Bay, Vietnam". *Geology Belgica* Vol. 13, No. 12, 2010, pp. 37-47.

[15] R. Lacatusu, "Appraising levels of soil contamination and pollution with heavy metals. In: Heinike H. J., Eckrelman W., Thomasson A. J, Jones R. J. A, Montanarella L., Buckley B. (eds) Land information system for planning the sustainable use of land resources. European soil bureau. Research report no 4. Office for Official Publication of the European Communities, Luxembourg".2000, p. 393–402.

[16] DPR (Department of Petroleum Resources)., 2002. Environmental guidelines and Standards for the petroleum industries in Nigeria Department of Petroleum Resources, Ministry of Petroleum and Mineral Resources, Abuja, Nigeria.

[17] D.C. Thomilson, D.J. Wilson, C.R. Harris, and D.W. Jeffrey, "Problem in heavy metals in estuaries and the formation of pollution index". *Helgol. Wiss. Meeresunlter*, Vol. 33, 1980, pp. 566–575.

[18] I. Grzetic, and R.A.H Ghariani, "Potential health risk assessment for soil heavy metal contamination in the central zone of Belgrade (Serbia)". *Journal of Serbian Chemical Society*, Vol. 73, No. 89, 2008, pp. 923-934.

[19] H.Y. Lai, Z.Y. Hseu, T.C. Chen, B.C. Chen, H.Y. Guo, and Z.S. Chen, "Health risk based assessment and management of heavy metalscontaminated soil sites in Taiwan". *International Journal of Environ Res Public Health*, Vol. 7, No. 10, 2010, pp 3595-3614.

[20] USEPA (US Environmental Protection Agency). 1989. Risk assessment guidance for superfund. human health evaluation manual. EPA/540/189/002, vol. I. Office of solid waste and emergency response. US Environmental Protection Agency. Washington, DC. Available from:<http://www.epa.gov/superfund/programs/risk/ragsa/index.htm>.

[21] USEPA (US Environmental Protection Agency)., 2010. Integrated Risk Information System (IRIS). United States Environmental Protection. Available online: http://www.epa.gov/iris/index.html (accessed on 4 October 2011).

[22] X. Wang, F. Wang, B. Chen, F. Sun, W. He, D. Wen, X. Liu, and Q. Wang, "Comparing the health risk of toxic metals through vegetable consumption between industrial polluted and nonpolluted fields in Shaoguan, South China". *Journal of Food Agric. Environment*, Vol. 10 No. 2, 2012, pp. 943-948.

[23] X.S. Luo, I. Ding, B. Xu, Y.J. Wang, H.B. Li, and S. Yu, "Incorporating bio accessibility into human health risk assessments of heavy metal sin urban park soils. Science of the Total Environment, Vol. 424, 2012, pp. 88–96.

[24] M. Fryer, C.D. Collins, H. Ferrier, R.N. Colvile, and H.M.J.Nieuwen, "Human exposure modelling for chemical risk assessment: are view of current approaches and research and policy implications". *Environmental Science and Policy*, Vol. 9, No. 3, 2006, pp. 261–274.

[25] USEPA (US Environmental Protection Agency), 2011. Regional Screening Level Table (RSL) for Chemical Contaminants at Superfund Sites; U.S. Environmental Protection Agency: Washington, DC, USA.

[26] USEPA (US Environmental Protection Agency)., 2001. Supplemental Guidance for Developing Soil Screening Levels for Superfunda. Sites. OSWER 9355.424. Office of Solid Waste and Emergency Response.

[27] USDOE (US Department of Energy)., 2011. The Risk Assessment Information System (RAIS). Oak Ridge, TN: U.S. Department of Energy's Oak Ridge Operations Office (ORO). USEPA (US Environmental Protection Agency), 1989. Risk assessment guidance for superfund. human health evaluation manual. EPA/540/189/002, vol. I. Office of solid waste and emergency response. US Environmental Protection Agency. Washington, DC. Available from:<http://www.epa.gov/superfund/programs/risk/ragsa/index.htm>.

[28] R. Van den Berg, 1995. Human exposure to soil contamination: a qualitative and quantitative analysis towards proposals for human toxicological intervention values. RIVM Report no. 725201011. Bilthoven, The Netherlands: National Institute of Public Health and Environmental Protection (RIVM).

[29] USEPA (US Environmental Protection Agency)., 2005. Region 6, Human Health Risk Assessment Protocol, Chapter 7: Characterizing Risk and Hazard, Multimedia Planning and Permitting Division. Office of Solid Waste, Center for Combustion Science and Engineering.

[30] W. Jinman, L. Weihong, Y. Ruixuan, Z. Ling, and M. Jianjun, "Assessment of the potential ecological risk of heavy metals in reclaimed soils at an opencast coal mine, China". *Disaster Advances*, Vol. 6 No. 3, 2013, pp. 366-377.

[31] C.M.A. Omono, and K. Samuel, "Determination of Heavy Metals in Forage Grasses (Carpet Grass (Axonopus ompresu), Guinea Brass (Panicum maximum) and Elephant Grass (Pennisetum perpereum) in the Vicinity of Itakpe Iron Ore Mine, Nigeria. International Journal Pure and Applied Science and Technology, Vol. 13, No. 2, 2012, pp. 16-25.