ECOTOXICOLOGICAL RISK ASSESSMENT OF BIOAVAILABLE HEAVY METALS IN SOILS AROUND BORI MECHANIC VILLAGE IN BORI, RIVERS STATE, NIGERIA

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ABSTRACT
The study assessed the ecotoxicological risk of bioavailable heavy metals cadmium, chromium, copper, nickel, lead and zinc (Cd, Cr, Cu, Ni, Pb and Zn) in soils around Bori mechanic village. The composite soil samples collected from different sites were prepared and atomic absorption spectrophotometer (AAS) was used for the analysis of the heavy metals. From results, the mean concentrations of bioavailable heavy metals in the agricultural soils decreased in the order Pb (39.78) > Zn (33.18) > Cr (33.09) > Cu (22.12) > Ni (12.77) > Cd 91.29) all in mg/kg. The mean concentrations of Cd (1.29), Cr (33.09), Cu (22.17) and Pb (39.78) exceeded the USEPA soil guidelines, Cd (0.60), Cr (25.00), Cu (16.00) and Pb (35.00) respectively. The calculated values of MERMQ (0.14) and M-PERQ (0.27), all indicating 21% probability of being toxic, reiterated the fact that the bioavailable heavy metals have the potential of making the agricultural soils toxic. These heavy metals posed potential ecological risk with the RI value of 1240.99 which indicated highly strong potential ecological risk to the study area due to anthropogenic activities. Based on the results and findings of this study, the soils around mechanic village are polluted with heavy metals introduced into this area due to mechanic related activities. Therefore, education and legislation on mechanic village should be intensified. Modern waste disposal facilities be introduced to ensure proper waste management.

Keywords: *Ecotoxicological risk, Bioavailable heavy metals, Hazard quotient, Toxic risk index*

1.0 INTRODUCTION

Heavy metals are natural components of ecosystems and their optimal concentration in the plants and animals is a sine qua non characteristic for healthy biotic activities (Gao *et al.,* 2014). However, when found in high concentrations in the soil, or water, the heavy metals might become a threat to the ecosystem due to its inherent ecotoxicity features, persistence and tendency to biomagnificate. Therefore, the concentrations of heavy metals in the soil sediment or water may result to human intoxication through food web (Zahra *et al.,* 2014; Jin *et al.,* 2015; Wang *et al.,* 2015).

Ecotoxicotogical studies which connect ecology and toxicology aim at understanding and predicting effects of chemicals such as heavy metals, PAHs, PCBs, etc on natural communities (ecosystems) under realistic exposure conditions Jiang *et al.,* (2014). Their methods have been applied with more importance to estimate the quality of soils, water, sediments and the atmosphere. Jiang *et al.,* (2014), Camargo, *et al.,* (2015) explained that soils are an important indicator of the health of ecosystems because they naturally operate as a heavy metal reservoir, due to the capacity of holding more than 90% of metals in the environment (Zahra *et al.,* 2014). Therefore soils are a potential secondary source of heavy metals which might be released back into aquatic ecosystems along with changed environmental conditions (Wang *et al.,* 2015).

One method largely used to evaluate the level of heavy metal concentrations of a specific study area and the potential risks associated with the increase in heavy metal concentrations is to study the bioavailability of the heavy metals in soils of the study area (Nwineewii and Nyodee, 2021). This study considered heavy metals to be bioavailable, whenever they are deposited in and incorporated to the soils through weak chemical bonds or in metal complexes, created by colloidal materials such as dissolved organic matter, hydroxyl, carbonates and sulphates. The bioavailability and ecotoxicity of heavy metals in soil depend on the interactions between many variables such as pH, salanity, redox potential, mineral and organic content and resident biota (Jiang *et al.,* 2015).

It is necessary to point out that ecotoxicological studies are paramount to help managing the ecosystem. The management of the ecosystem is achieved by studying the bioavailable heavy metal concentrations, quantify the extent of heavy metal pollution using the pollution indices such as contamination factor (CF) and assess ecotoxicological risk of agricultural soils using mean effects range median quotient (MERMQ) mean probable effects level quotient (M-PEL-Q). Hazard Quotient (HQ) Toxic Risk Index (TRI) and potential ecological risk index (RI).

Therefore, the work tends to investigate ecotoxicological risk of bioavailble heavy metals in agricultural soil around Bori mechanic village. The data generated in this work provides baseline information for effective management strategy to enhance food quality and safety.

2.0 MATERIALS AND METHODS

2.1 Study Area

Bori mechanic village is located at the East-South part of Bori urban. It was established since 1980 with many different workshops. Various forms of mechanic activities go on in this auto-mechanic village which is up to 2 kilometers square. This village is expanding as well as generating wastes on the soil. This village is located in the agricultural settlement of Bori urban. It is an area mapped out by the government of the State for artisans in automobile business which involves constant changing of used motor engine oils and motor parts. Bori mechanic village is one of the busiest areas in Bori metropolis considering the volume of other business activities due to its central location following that Bori metropolis is the traditional headquarter of Ogoni land.

Bori mechanic village was divided into four cardinal points, East, West, North and South. The soil samples were collected from the four cardinal points with their coordinates showing in Table 1 including the control point.

Table 1. Sample points and its coordinates

Sample Points		Coordinates
1.	East	4^{0} 39^{1} 58^{11}N | 7^{0} 22^{1} 49^{11}E
2.	West	4^{0} 36^{1} 59^{11}N | 7^{0} 21^{1} 51^{11}E
3.	North	4^{0} 38^{1} 57^{11}N | 7^{0} 23^{1} 53^{11}E
4.	South	4^{0} 37^{1} 58^{11}N | 7^{0} 22^{1} 50^{11}E
	Control site	4^{0} 40^{1} 22^{11}N | 7^{0} 21^{1} 56^{11}E

2.2 Soil Samples Collection and Analysis

Soil samples at surface level of the depth 0 – 15cm, were collected from the four cardinal points (North, South, East and West of the mechanic village and equally controlled sample was collected at sampling point outside the study area, with the aid of a stainless-steel hand auger. Three soil samples from each sampling point were randomly collected to make a composite sample. The collected composite samples were stored in properly labelled polythene bags for analysis.

The soil samples were air-dried for 2 days, homogenized and sieved through a 2mm mesh to obtain uniform size. The soil samples were subjected to wet digestion using nitric- perchloric acid method in line with the works of Ogunkunle *et al.,* (2013) and Oladeji *et al.,* (2016). 2 grams of each sample were weighed into a 50ml beaker, then added to the sample were 20mls and 10mls of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) respectively for 30 – 45 minutes at 60^0C. The solution was allowed to cool at room temperature, filtered into a 50ml mark with distilled water. The digested samples were used for determination of concentration of the heavy metals: Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb) and Zinc (Zn) using atomic absorption spectrophotometer (AAS).

2.3 Pollution or Contamination Indices for Heavy Metal Analysis

To determine the status of contamination in the study area the following pollution indices were used:

2.3.1 Contamination Factor (CF)

Contamination Factor (CF) can be used to indicate the environmental contamination of a specific metal in the study sample. This (CF) factor is calculated using the equation by Bassey *et al.,* (2019) expressed as

$$CF = \frac{Csample}{Cref} \quad (1)$$

Where Cf represents contamination factor (mg/kg)
Csample represents average metal concentration in the study sample (mg/kg).
Cref represents the same metal concentration in the reference sample (mg/kg).
The contamination factor (CF) is classified by Hamid *et al.,* (2016) indicated in Table 2.

Table 2: Classification of Contamination Factor

Contamination Factor (CF)	Description
CF < 1	Low contamination
1 < CF < 6	Moderate contamination
3 < CF < 6	High contamination

Source: Bassey *et al.,* (2019)

2.4 Ecotoxicological risk assessment of heavy metal concentrations

In the present study, comparisons of heavy metals (Zn, Pb, Cd, Ni, Cu and Cr) concentrations (mg/kg) in soil samples from the studied land uses with threshold, midrange and extreme effects guideline values were carried out.

Soil quality guideline (SQG) values in Table 3 established by Deng *et al.,* (2012) were employed for the calculation of

- Means effects range median quotient (MERMQ).
- Mean Probable effects level quotient (M-PEL-Q).
- Hazard Quotient (HQ)
- Toxic Risk Index (TRI)

Table 3: Threshold, midrange and extreme effects soil guidelines for selected heavy metals (mg/kg).

Quality Guidelines	Cr	Cd	Ni	Pb	Cu	Zn
Effects of low Range (ERL)	8.1	1.2	20.9	46.7	34.0	150.0
Effects of Median Range (ERM)	370.0	9.6	51.6	218.0	270.0	40.0
Threshold Effect Level (TEL)	52.3	0.68	15.9	30.2	18.7	124.0
Probable Effect Level (PEL)	160.0	4.21	42.8	112.0	108.0	271.0

Source: Deng *et al.,* (2012)

Mean Effects Range Median Quotient (MERMQ)

MERMQ is suitable tool for assessing the harmful impact on soils. This index was applied to identification and prioritization of areas with potential hazards with respect of quality of soils in the studies areas. The value of ERM in Table 3 was used for the calculation of MERMQ.

The MERMQ was calculated by dividing each metal concentration by its respective ERM value and averaging the individual quotients (Kowalska *et al.,* 2018). MERMQ was calculated based on the following formula

$$MERMO = \frac{\Sigma\left(\frac{Cn}{ERM}\right)}{n} \qquad (2)$$

Where,

Cn = Concentration of each analysed heavy metal
ERM = Values given in Table 3 by Deng *et al.,* (2012).
n = The number of analysed heavy metals.

In this index all the heavy metals under investigation were combined in a single value for four risk levels of the MERMQ index by Wang *et al.,* (2015) as:

MERMQ ≤ 0.1 (low priority risk level and 9% probability of being toxic)
0.1 < MERMQ ≤ 0.5 (Medium-low priority risk level and 21% probability of being toxic)
0.5 < MERMQ ≤ 1.5 (high-medium priority risk level and 49% probability of being toxic)
MERMQ > 1.5 (high priority risk level and 76% probability of being toxic).

Mean probable effects level quotient (M-PEL-Q).

M-PEL-Q index combined metal content and PEL-SQG values for the measured heavy metals for the study.

The M-PEL-Q index was calculated with the formula adopted by Luo *et al.,* (2012) as

$$\text{M-PEL-Q} = \frac{\Sigma(Ci/_{PEL})}{n} \qquad (3)$$

Where;

Ci = Concentration of heavy metal analysed in soil samples.
PEL = SQG values for the measured heavy metals in Table 3
n = The number of heavy metals under investigation.

Several toxicity probability classes were defined by Sarnla *et al.,* (2013) as

M-PEL-Q ≤ 0.1 (low degree of contamination with 8% probability of being toxic)
0.11 < M-PEL-Q < 2.3 (medium-low degree of contamination with 21% probability of being toxic)
1.5 < M-PEL-Q < 2.3 (high-medium degree of contamination with 49% probability of being toxic)
M-PEL-Q ≤ 2.3 (high degree of contamination with 73% probability of being toxic).

Hazard Quotient (HQ)

The relative toxicities posed by heavy metals to the environment were evaluated by computing the hazard quotient (HQ) using the equation by Luo *et al.,* (2012) as:

$$HQ = \frac{C\ metal}{SQG} \quad (4)$$

Where;
C_{metal} = Observed concentration of metal in soil.
SQG = Soil quality guideline.

The soil quality guideline (SQG) adopted for calculating the HQ in this study was the threshold effects level TEL) by Deng *et al.,* (2012) indicated in Table 4 According to Deng *et al.,* (2012), the classification of HQ was indicated as

HQ < 0.1 = No adverse effects
0.1 < HQ < 1 = Potential hazards
1 < HQ < 10 = Moderate hazards
HQ > 10 = High hazards

Toxic Risk Index (TRI)

The toxic risk developed by Jiang *et al.,* (2014) was applied to estimate risk to the environment. The two threshold values for SQGs (TEL and PEL standard) were used to calculate TRI following equation 5.

$$TRI = \sqrt{\frac{\left({Ci}/{PEL}\right)^2 + \left({Ci}/{PEL}\right)^2}{2}} \quad (5)$$

Where;
Ci = Concentration of heavy metal
TEL = Threshold effect level for the heavy metal.
PEL = Probable effect level for heavy metal

TEL and PEL SQG values as indicated in Table 3 Jiang *et al.,* (2014) interpreted the TRI values as;

$TRI \leq 5$ = No toxic risk
$5 < TRI \leq 10$ = Low toxic risk
$10 < TRI \leq 15$ = Moderate toxic risk
$15 < TRI \leq 20$ = Considerable toxic risk
$TRI > 20$ = Very high toxic risk

2.5 Potential ecological risk assessment for heavy metals

The potential environmental risk factor was calculated to assess the concentration of heavy metals in soil and the ecological and environmental effects of heavy metals (Riyad, *et al.,* 2015). The ecological risk index (RI) was calculated according to equations (6) and (7) by Wang *et al.,* (2015).
The pollution indices have their various formulae for calculation as well as their standards for classification.

$$Er = T_1 \times C_f \tag{6}$$

Where

Er = Ecological factor
T_1 = Toxic response factor for the selected heavy metal indicated in Table 4.
Cr = Contamination factor

Table 4: Toxic response factor

Element	Cr	Cd	Cu	Mn	Ni	Pb	Zn
Toxic response factor	2	30	5	3	5	5	1

Source: Wang *et al.,* (2015)

$$R_1 = \Sigma Er \tag{7}$$

Where;

R_1 = Potential ecological risk index
Er = Ecological risk factor

The potential ecological risk index is defined, according to Wang *et al.,* (2015), as the sum of the risk factors (equation 7). The classification of potential ecological factors are classified as shown in Table 5.

Table 5: The Potential Ecological Risk Factor

Risk level	**Ecological risk factor (ER) value**	**Risk degree**	**Potential ecological risk (RI) value**
Low	$Er < 40$	Low	$150 < RI$
Moderate	$40 \leq Er < 80$	Moderate	$150 < RI < 300$
Considerable	$40 \leq Er < 160$	Considerable	$300 < RI < 600$

High	160 ≤ Er < 320	Very high	RI > 600

Source: Wang *et al.*, (2015)

2.6 Statistical Analysis

The data were statistically analyzed using analysis of variance (ANOVA) to detect any significant difference between the soil sample means of different sampling points of the study area. Omega squared (W^2) by Huck (2012) was used to determine whether the various heavy metals interact significantly with each other, with the equation 8 as

$$W^2 = \frac{SS_{between}}{SS_{between} + SS_{within}} \quad (8)$$

Where

W^2 = Omega squared

$SS_{between}$ = Between sample means

SS_{within} = Within sample means

Huck (2012) described the levels of interaction based on the calculated value of W^2 as shown in Table 6.

Table 6. Different levels of interactive relationship

Value of Omega squared (W^2)	Level of interactive relationship
0.01 – 0.05	Small interactive relationship
0.06 – 13	Medium interactive relationship
≥ 14	Large interactive relationship

Source: Huck (2012)

3.0 RESULTS AND DISCUSSION

3.1 Mean Concentrations of bioavailable Heavy Metals

The results of the analysis for the descriptive statistics of bioavailable heavy metals (mg/kg) in agricultural soils are presented in Table 7.

Table 7: Descriptive Statistic of heavy metal concentrations (mg/kg) in agricultural soils.

Heavy Metals	Min	Max	Mean ± STD	Control Mean value	USEPA soil guidelines (Salah *et al.*, 2015)	World Average value of unpolluted soil (Al Obaidy Moshhadi 2013)	WHO permissible level
Cadmium (Cd)	0.01	3.15	(0.97) 1.29± 1.42	0.32	0-60	0.53	1.00
Chromium (Cr)	0.63	41.22	(264.68)33.09± 6.71	15.61	25	83	5.00

Copper (Cu)	12.51	31.35	(176.95) 22.12± 5.36	15.59	16	24	100
Lend (Pb)	17.70	43.65	(318.23) 39.78 ± 3.23	19.12	35	44	8.00
Nickel (Ni)	7.12	15.62	(102.18) 13.77 ± 2.19	8.37	16	34	5.00
Zinc (Zn)	25.73	38.16	(265.40)33.18± 4.35	26.76	110	100	10.00

From the descriptive statistics of the concentrations in Table 7, the mean concentrations bioavailable heavy metals in the agricultural soils decrease in the order Pb (39.78) > Zn (33.18) > Cr (33.09) >Cu (22.12) > Ni (12.77) > Cd (1.29). The mean concentrations of Cd (1.29) Cr (33.09) Cu (22.17) and Pb (39.78) exceed the USEPA soil guidelines, Cd (0.60), Cr (25.00), Cu (16.00) and Pb (35.00 respectively. The means concentrations of Ni(12.77) and Zn (33.18) were below the USEPA guideline of I (16) AND Z n (110) respectively. The mean values of Cr (33.09 mg/kg), Cu (22.12 mg/kg), Pb (39.78 mg/kg), Ni (12.77 mg/kg), and Zn (33.18 mg/kg) were all below world average values of unpolluted soil, Cr (83.00 mg/kg), Cu (24.00 mg/kg), Pb (44.00 mg/kg), Ni (34.00 mg/kg), and Zn (100.00 mg/kg). The mean value of Cd (1.29mg/kg) exceeded the and average value Cd (0.53 mg/kg) of unpolluted soil. The low concentrations of Cd and Cu during wet season may be ascribed to its removal by crops or plants grown in this study area of course plants or crops are grown during wet season in the study area. These findings support the results of the studies by Ololade (2014), Sarala and Uma (2013), which highlighted the low concentrations of some heavy metals during wet season.

Result of comparison with the soil guidelines indicate that the agricultural soils of the study area are polluted by Cd, Cr, Cu, Pb and Zn. These findings are in agreement with the results reported on different agricultural soils conducted by Hongxue *et al.,* (2020) on heavy metal contamination and ecological risk assessment of the agricultural soil in Shanxi province, China, Yerima *et al.,* (2020) on ecological risk assessment of mineral and heavy metals levels of soil around auto mechanic village, Wukari, Nigeria. The mean concentrations of the bioavailable heavy metals in this study are higher than the observations of the studies by Elias and Gbadegesin (2011) on source identification, ecological risk and spatial analysis of heavy metals contamination in agricultural soils of Janjaro area, Kurdistan region, Iraq but lower than the concentrations of heavy metals in study on ecological risk assessment of potentially toxic metals in soils around used automobile park and mechanic workshops by Menkiti *et al.,* (2017) I Lagos State, Nigeria.

3.2 Contamination Factor (CF)

The contamination factor (CF) values for each bioavailable heavy metals are presented in Table 8.

Table 8. Contamination Factor (CF) values for Heavy Metals

Sampling Sites	Heavy Metals					
	Cd	**Cr**	**Cu**	**Pb**	**Ni**	**Zn**
1.	10.00	0.72	0.95	4.06	0.39	0.71
2.	10.60	0.69	0.94	3.88	0.37	0.78
3.	7.27	0.76	0.88	4.01	0.34	0.56
4.	6.67	0.77	1.16	3.96	0.40	0.75
Control site	2.13	0.35	0.69	1.91	0.25	0.56

The CF values of Cd for the sampling sites are in the order 2 (10.60) > 1 (10.00) > 3 (7.27) > 4 (6.67). These CF values for Cd are of high contamination. For Cr the CF 4 (0.77) > 3 (0.76) > 1 (0.72) > 2 (0.69), which are of low contamination for Cu the CF values are 4 (1.16) > (0.95) > 2 (0.94) > (3 (0.88). For Cu, the CF value of 1.16 for sampling site 4 is moderate contamination while the CF values of sampling sites 1 (0.95), 2 (0.90) and 3 (0.88) are of low contamination. For Pb the CF values are 1 (4.06) > 3 (4.01) > 4 (3.96 > 2 (3.88). The CF values for Pb for all the sampling sides are of moderate contamination. For Ni, the CF values are 4(0.40) > 1 (0.39) > 2 (0.37) > 3 (0.34), which are all of low contamination. For Zn, the CF values are 2 (0.78) > 1 (0.71) > 3 (0.56), all these values indicate low contamination. The CF values of the investigated bioavailable heavy metals are higher than their CF values in the control sample. These results agree with the findings of the study by Menkiti *et al.,* (2017) carried out on the ecological risk assessment of potentially toxic metals in soils around used automobile parts and mechanic workshops in Lagos State, Nigeria. Menkiti *et al.,* (2017) identified high CF values of Cd, Cr, Cu, Pb, Zn and Ni in their studied locations. The CF values of these bioavailable heavy metals whether low or high indicate the contamination of the soils around mechanic village as a result of anthropogenic activities.

3.3 Quantification of MERMQ and M-PELQ for Agricultural Soils.

The calculated vales of MERMQ and M-PELQ are presented in Table 9.

Table 9. Calculated values of MERMQ and M-PEL-Q for Agricultural Soils.

Parameter	Calculated value	Indication
MERMQ	0.14	Medium bionty risk. 21% probability of being toxic.
M-PELQ	0.27	Medium-low degree of contamination. 21% probability of being toxic.

The calculated value of MERMQ is 0.14 (MERMQ = 0.14) which is of medium priority risk of the bioavailable heavy metals in the agricultural soil. This indicates 21% probability of being toxic of the heavy metals to the ecosystem.

The calculated value of M-PELQ is 0.27 (M-PELQ = 0.27), which is medium-low degree of contamination. This portrays 21% probability of being toxic.

These findings are in agreement with the study of (Bassey *et al.,* 2019). Bassey *et al.,* (2019) carried out the study on current risk impacts on Ologe and Badagry Lageons in Lagos, Nigeria. In their study, they observed that the M-ERM-Q calculated value of the metals ranged from 0.05 to 0.06 (mean value of 0.05) indicating that the combination of Cr, Cd, Cu, Zn and Pb may have a 12% probability of being toxic. The mean value of M-PELQ was equally observed to be 0.20, indicating that the contribution of Cd, Cr, Cu, Ni, Pb and Zn may have a 25% probability of being toxic. The calculated value of MERMQ = 0.14, and M-PERQ = 0.27, all indicating 21% probability of being toxic, reiterated the fact that the bioavailable heavy metals have the potential of making the agricultural soils to be contaminated.

3.4 Hazard Quotient (HQ)

The calculated values of HQ for each bioavailable heavy metals are presented in Table 10.

Table 10. Hazard Quotient (HQ) value

Heavy Metal	Threshold effect level (TEL)	Total concentration of metal (mg/kg)	Hazard Quotient (HQ)	Remarks
Cd	0.68	10.98	16.15	High hazards
Cr	52.30	264.68	5.06	Moderate hazard
Cu	18.70	176.95	9.46	Moderate hazards
Pb	30.20	318.23	10.54	High hazards
Ni	15.90	102.18	6.43	Moderate hazards
Zn	124.00	265.40	2.14	Potential hazards
Mean value			40.78(8.30)	

From the results in Table 10, the hazard quotient (HQ) values of Cd (16.15) and Pb (10.54) are of high hazards. The hazard quotient (HQ) values of Cr (5.06), Cu

(9.46) and Ni (6.43) are of moderate hazards. While the hazard quotient (HQ) value of Zn which is 2.14 is of potential hazard. The hazard quotient mean value of 8.30 for the study area is of moderate hazards. These hazard quotient values of these bioavailable heavy metals whether high, moderate or potential status indicate that these heavy metals are hazardous to the ecosystem. These findings are in agreement with the observations made by Pereira *et al.,*(2015) in their study on distribution and ecotoxicology of bioavailable metals and AS in surface sediments of Paraguacu estuary, Todos OS Santos Bay Brazil. They noted that the bioavailable metals studied in their work with hazard quotient value of 10.53, are potential hazardous threats to the ecosystem. This means that the bioavailable heavy metals for this study are hazardous to the agricultural soils.

3.5 Toxic Risk Index (TRI)

The calculated values of the toxic risk index (TRI) for bioavailable heavy metals are presented in Table 11.

Table 11. Toxic risk index (TRI)

Heavy Metal	(TEL) Value	PEL value	Conc. of metal	Toxic risk Index (TRI)	Remarks
Cd	0.68	4.21	10.98	11.57	Moderate toxic risk
Cr	52.30	160.00	264.68	3.76	No toxic risk
Cu	18.70	108.00	176.95	6.79	Low toxic risk
Pb	30.20	112.00	318.23	7.72	Low toxic risk
Ni	15.90	42.80	102.18	4.85	No toxic risk
Zn	124.00	271.00	265.40	1.66	No toxic risk
Toxic risk index mean value				(36.35) 6.06	Low toxic risk

The result in Table 11 indicated that Cd with the TRI value of 11.57 is of moderate toxic risk. The TRI values of Cu (6.79) and Pb (7.72) are of low toxic risk. The TRI values of Cr (3.76), Ni (4.85) and Zn (1.66) are of no toxic risk. The toxic risk index mean value of 6.06 for the study site indicated that the bioavailable heavy metals under study are capable of being toxic to the agricultural soils. This result is in consonant with the findings of Isleyan *et al.,*(2019) in their study on heavy metal profiles of agricultural soils in Sakarya, Turkey. Their findings revealed that heavy metals in concentrations above the threshold are;

3.6 Ecological Risk Index (ERI) and Potential Ecological Risk Index (RI)

The ecological risk index (ER) and the potential ecological risk index (RI) values of the bioavailable heavy metals are presented in Table 12.

Table 12: Ecological Risk Index (ER) and Potential Ecological Risk Index (RI) of soil samples

Sampling Sites	Ecological Risk Index (ER)						Potential Ecological Risk Index (RI)	Remarks
	Cd	Cr	Cu	Pb	Ni	Zn		
1.	300.00	1.44	4.75	20.30	1.95	0.71	329.19	Considerable risk
2.	315.00	1.38	4.70	19.40	1.85	0.78	346.11	Considerable risk
3.	218.10	1.52	4.40	20.05	1.70	0.56	246.33	Moderate risk
4.	200.10	1.54	9.80	19.80	2.00	0.75	233.99	Moderate risk
Control site	69.90	0.70	3.45	9.55	1.25	0.56	85.41	Low risk
Total value	1106.10	6.58	27.10	89.10	8.75	3.36	1240.99	Very high risk
Percentage contribution of each heavy metal to RI	89.13	0.53	2.18	7.18	0.71	0.27		

Table 12 reveals the ecological risk factors (ER) of the heavy metals and their contributions to the potential ecological risk index (RI) of the agricultural soils. From the Table 10 the sequence of the ecological risk index of the heavy metals is in the order Cd (1106.10) > Pb (89.10) > Cu (27.10) > Ni (8.75) > Cr (6.58) > Zn (3.36) Cd with the ER (1106.10) possess the highest level of ecological risk, contributing 89.13% to the potential ecological risk index (RI) while Zn with ER (3.36) possess lowest level of ecological risk, contributing 0.27% to the potential ecological risk index (RI). The release of Cd into agricultural soils causes great concern due to its high toxic response factor of 30.

The release of Cd into the soils is accredited to the wear and tear of tyres and other auto parts. According to report by Nwineewii and Nyodee (2021), that Cd is used as cadmium covering to cover car furnitures, trucks, industrial tools and various kinds of fasteners including bolts, nuts and nails. The corrosion of batteries and metallic parts of radiators and cars also contributes to the input of Cd into the soils. These results agree with the findings of other researchers on ecological risk assessment of heavy metals in their various study areas. He *et al.,* (2014), Nwineewii and Nyodee (2021) and Riyad *et al.,* (2015) reported significant high potential ecological risks in their studies which were mainly due to high contribution of Cd load in the soils.

The values of potential ecological risk index (RI) presented in Table 10 for the sampling sites are in the order of 2 (346.11) > 1 (329.15) > 3 (246.33) > 4 (233.99) > control site (85.41). from the results the sampling sites 2 (346.11) and 1 (329.15) have considerable risk, sampling sites 3 (246.33) and 4 (233.99) are of moderate risk while the control site (85.41) is of low risk.

The value of potential ecological risk index (RI) of the study area is 1240.99, which is very high risk. This result tends to negative the finding of Edori and Kpee (2017) in their study on heavy metal pollutions in soils within Port Harcourt. Their study revealed that the heavy metals do not pose any ecological risk to the environment. Rather the result of this study agrees with findings of Bello *et al.,* (2016), Yerima *et al.,* (2020) and Riyad *et al.,* (2015), which reintegrated that heavy metals posed potential ecological risk to the environment. This ascertion affirms the case in this study with the RI value of 1240.99, indicating an overall highly strong potential ecological risk to the study area.

3.7 Statistical Analysis by ANOVA

The results of statistical analysis of the data using ANOVA are presented in Table 13.

Table 13: Summary of ANOVA of Bioavailable Heavy Metals from various sampling sites

Source of variation	SS	Df	M/S	F-ration	Critical value Flat 5% from the F-table
Between groups ($SS_{between}$)	445.42	1	445.42	0.30	F(1,14) = 4.54
Within groups (SS_{within})	20,826.68	14	1487.62		
Total	21,272.10	15			

SS = sum of square; Df = degree of freedom; Ms = mean square

The result indicates that the F-calculated value of 0.30 is lower than F-critical 0f 4.54 [$F(1,14) = 4.54$, $p < 0.05$]. This indicates that there is no significant difference between sample mean values of the soils around mechanic village. This suggested that pollution sources containing different loads of heavy metals as pollutants are mainly from mechanic related activities. The calculated value of Omega squared (W^2) was 0.02, which revealed interactive relationship among the heavy metals, though small interactive relationship, to bring about the ecotoxicological risk of the soils in the study area.

4.0 Conclusion

Ecotoxicology and distribution of bioavailable heavy metals in soils around Bori mechanic village were examined. Six heavy metals (Cd, Cr, Cu, Pb, Ni and Zn) in different sampling sites were analysed including the control site. From the results of the analysis the mean concentrations of Cd, Cr, Cu and Pb were above USEPA soil guidelines while those of Ni and Zn were below the soil guidelines.
These heavy metals under investigation posed potential ecological risk with the RI value of 1240.99 which indicated strong potential ecological risk to the study area due to mechanic related activities.
Based on the results and findings of this study, the soils of the study areas are polluted with heavy metals introduced into this area due to mechanic related activities. The high concentrations of these heavy metals in soils would mean danger to both plants and animals since these metals have the ability to bioaccumulate, biomagnify, and can be transferred from soil to plant, plants to animals, and humans. Suffice it to say, these metals could have direct or indirect effects on human health.
Therefore, education and legislation on mechanic village should be intensified. Modern waste disposal facilities be acquired by those concern to ensure proper waste management. These measures would bring about food quality and food safety.

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