

Original Research Article

ESTABLISHING RISK ASSESSMENT FROM RECLAIMED NEKEDE MECHANIC VILLAGE OWERRI, NIGERIA.

ABSTRACT

The current resettlement of Nekede Auto-Mechanic village by Imo State government of Nigeria created a sparse piece of land awaiting government utilization. Risk assessment was carried out on the land using existing boreholes and soil to determine possible land utilization potential. The physicochemical water analysis showed no contamination of boreholes present. The high value of COD correlated with the high levels of Fe in soil and water samples. The concentration of heavy metals showed that Fe was very much present in the soil while Pb, Cd and Cu had reduced concentrations. The risk assessment for the soil samples showed that Fe had the highest mean and median value. The highest mean value for water was Cu. Highest variance value was Cu for soil, while Pb had the lowest value in water. The Hazard quotient of water samples showed that hazards exist for Cd, Cu and Pb but was at moderate level for only Fe. Estimated daily/weekly water intakes were all below WHO/FAO standards. The soil enrichment factor showed no enrichment for Pb, minimal enrichment for Cd, moderate enrichment for Cu and significant contamination for Fe. The ecological risk assessments for the heavy metals were at low ecological risk. Furthermore, potential ecological index depicts Fe and Cd at considerable level of ecological risk. Consequently, although contaminants exist, however, the reclamation of Nekede mechanic village may not be suitable for agricultural or recreational purposes.

Keywords: Auto mechanic, risk assessment, contamination, Pollution, soil and Water.

27 **1.0 INTRODUCTION**

28 The levels of heavy metal (HM) pollution in soils and water vary with seasonal changes
29 irrespective of pollution source. Accordingly, studies around electronic waste dumpsite site in
30 Nigeria, showed that the concentrations of Pb, Cr, Ni, Cd and Zn varied with the season,
31 albeit concentrations of the metals exceeded maximum permissible limit [1]. These high
32 concentrations of HMs were more pronounced in areas of dumpsites and automobile
33 activities, and eventually increases greater likelihood of contamination of groundwater on the
34 surrounding community [2]. Also the human exposures to the heavy metals are dependent on
35 toxicity levels and exposure duration.

36 In this regard, high levels and duration of Pb, Cd, Cu and Fe have been determined to cause
37 liver and kidney damage, DNA damage, neuro-symptomatic disorders, and human
38 carcinogens [3, 4]. On the other hand, the HMs in the soil are often absorbed by arable plants
39 and when consumed by humans poses health challenges. Furthermore, the surrounding soil
40 often presents acidic environment that solubilizes the metal to ions, hence, increasing the
41 likelihood of bio-accumulation [5]. Subsequently, the presence of certain toxic metals in the
42 soil hinders biodegradation of organic contaminants and may pose health risks and hazards to
43 humans. Also, when the ecosystem gets contaminated, there is transmission of contamination
44 through soil, food chain sources, surface water and bore holes. Howbeit, anthropogenic
45 activities are notorious for pollution occurrences [6, 7]. These anthropogenic pollution
46 sources are mainly reported to be caused by population growth, unsafe agricultural practices,
47 industrial activities and urbanization [8]. Furthermore, wastewater discharged from industrial
48 and related activities constitute the main component of water pollution due to higher oxygen
49 demand and nutrient availability in the water bodies. Hence, promoting blooming of toxic
50 algal, which disrupts aquatic ecosystem [8, 9]. Research has also shown that high
51 concentrations of some heavy metals are found in urban rivers, alongside higher levels of

52 physiochemical contaminants: TDS, COD, BOD and TSS [10]. Thus regular water quality
53 assessments are significant indicators of pollution levels [7] at active anthropogenic areas like
54 the auto-mechanic villages.

55 The increasing presence of automobiles in Nigeria, have also been accompanied by
56 corresponding increase in auto mechanic workshops in cities and towns. Hence, there is the
57 resultant increase in engine oil usage and its unsafe disposal practices [8]. The released
58 pollutants including heavy metals, oil and grease build up, seep into the soil, polluting soil
59 and groundwater aquifers [9, 10]. Studies on auto-mechanic villages in Nigerian cities
60 revealed that in Abakaliki town, most auto-mechanic workshops disposed their used motor
61 oil, lubricants, gear oil and other solvents indiscriminately [11]. In Makurdi, the levels of Zn
62 and Cd in two selected auto mechanic villages exceeded WHO standards [12]. Also in
63 Ibadan, groundwater was contaminated by higher Cu concentrations [13, 14]. Furthermore,
64 research also showed that within Nsukka and Udenue, phyto-assessment of maize survival
65 showed bio-accumulation of heavy metals [15]. In addition, auto-mechanics in Nekede auto
66 mechanic village disposed spent engine oil within the surrounding vicinity and no measures
67 were in place for collection, disposal and cleanup of oil spills. Moreover, the atmospheric
68 emissions of gasoline and diesel combustion engines compounds the problem [16, 17, 18].
69 Consequently, Pb, Cr, Cd, Mn, Ni and Cu, have all been identified as the abundant metals
70 found in auto-mechanic villages in Nigeria [19, 20, 21] with pollution concerns. Thus,
71 following the urbanization of Owerri town embarked upon by Imo state government of
72 Nigeria, the Nekede auto-mechanic workshop in Owerri was relocated in February 2018.
73 Hence this created the need for risk assessment of the land and to provide data for decisions
74 making.

76 **2.0 MATERIALS AND METHODS:**

77 **2.1 Soil Collection**

78 The surface soils were scooped out and soil samples collected randomly from four sites at the
79 depth of 10 cm using a soil auger and spatula. The sites were four different road byways
80 connecting different auto-mechanic service workshops. The samples were placed in four
81 different sterile black polythene bags to minimize degradation and then transferred to a proof
82 insulated box to avoid irradiation. The soils were air dried for three days, grounded and
83 sieved through a 2 mm sieve. They were stored in tagged polythene bags and taken
84 immediately to the laboratory for analysis [22]. Loamy soil samples were obtained from a
85 horticulture garden along Port-Harcourt Road, Owerri Imo state, Nigeria.

86 **2.2 Water Sample Collection**

87 Water samples were collected from four different boreholes using new labeled plastic bottles
88 that had been washed and air dried for 24 hours. The water collection sites were boreholes
89 located at the byways connecting the four selected sites of the auto-mechanic service
90 workshops. Afterwards, they were then placed in a black light proof insulated box for
91 preservation and protection from UV radiation. They were then taking to the laboratory for
92 analysis. The Coca Cola bottled Eva water was used as Control sample to compare our
93 samples and water standards.

94 **2.3 Study Area**

95 The study area is Nekede Auto-Mechanic Village, located within the Owerri Municipal
96 council in Imo State of Nigeria as shown in figure 1. Owerri is in the South eastern region
97 with longitudinal locations $6^{\circ} 32^1$ to $7^{\circ} 15^1$ East and Latitudinal locations $6^{\circ} 20^1$ to $6^{\circ} 35^1$
98 North respectively. It has fairly low topography and undulating land surface. The Nekede

Mechanic village is in the sandy Benin Formation and well drained by Otamiri River and Nworie River. The workshop had existed for over 35 years with up to a 1000 automobile auto technicians working at the site on a land area of more than 20 hectares with 12 major roads. The majority of the auto technicians serviced between 5 and 10 vehicles per week, ranging from minor faults to major breakdown. An estimated 1.5 million liters of used oil or 7400 drums of spent engine oil are discharged at the site annually and other waste products like scrap metals, paints and tires. [17, 18, 23, 24]. Also in figure 2 Below is a picture of Nekede Auto-mechanic workshop showing an empty land that is currently bare and unutilized after relocation of technician

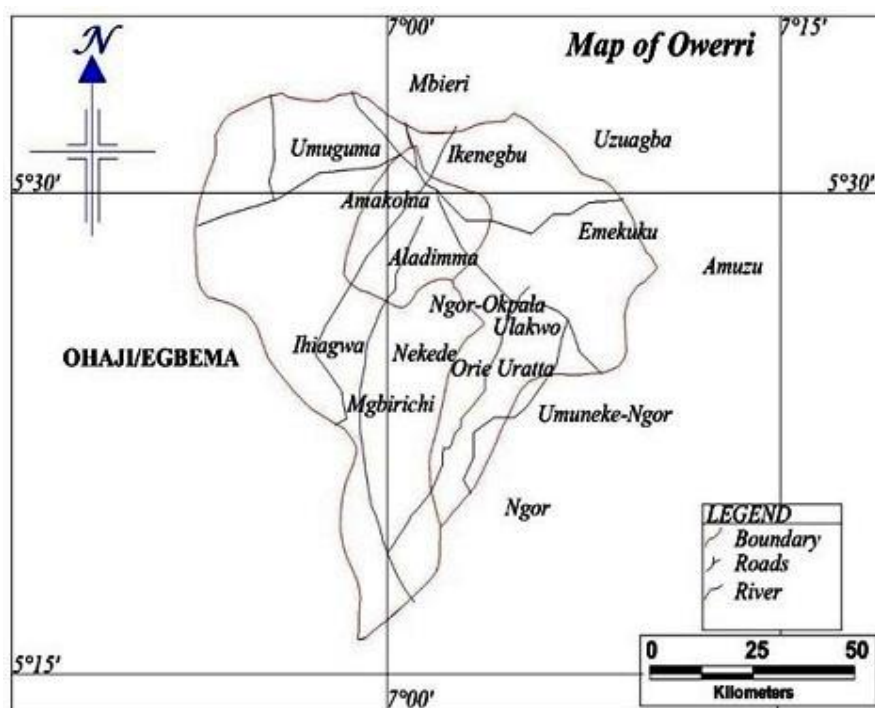


Figure 1: Geographical location of Nekede Mechanic village in Owerri, Imo-state Nigeria.
Source: Department of Surveying and Geo-informatics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria 2016.



Figure 2: Area view of Nekede Auto mechanic village. (a) abandoned entrance leading to the mechanic village, (b) abandoned vehicles at the site, (c) abandoned sparse of land overgrown with weeds, (d) ongoing excavation and removal of waste dumps near a dredging site

2.4 SOIL-WATER ANALYSES

Using a thermometer, the water temperatures were measured in-situ to obtain a stable reading. The pH was determined using JENWAY pH meter and conductivity was measured using Hanna instrument (DDS).22C. The physico-chemical parameters measured were dissolved oxygen (DO) and biological oxygen demand (BOD) using JPB-607A portable DO₂ meter. The DO₂ meter was calibrated using 5% sodium Sulphate solution and incubated in a 250 mL wrinkle's bottle for a period of 5 days at 20 °C. The chemical oxygen demand (COD), total hardness (TH), total alkalinity (TA), was determined by titrimetric method. Gravimetric method was used for total solutes (TS), Total Dissolved Solids (TDS) and Total Suspended Solids (TSS). Turbidity was determined by photometric method using HACH DR/2010 spectrometer [8, 9]. The soil PH was determined by gravimetric analysis, and the solvent hexane used for the extraction of oil and grease in the soil.

2.5 SOIL DIGESTION

The soil samples were sieved through a 2 mm mesh size and 1 g was weighed into 100 mL beaker and 10 mL of concentrated HNO₃ diluted to 5% was measured and added to each sample. The suspensions were heated in an oven for 7 hours to obtain supernatant liquid with several additions 10 mL nitric acid. After 7 hours, the samples were further washed with small portions of 5% nitric acid solution. Each sample was filtered into 100 mL standard flask and de-ionized water was used to wash it down and make up sample solutions up to 100 mL. They filtrate were analyzed for Fe, Cu, Cd and Pb using AAS [22, 25]. This sampling was done run in triplicates and average value were reported for this work.

2.6 RISK ASSESSMENT

The risk assessment for water was evaluated by calculating the hazard quotient, estimated daily intake, and estimated weekly intake. The enrichment factor, ecological risk and potential ecological risk index was employed to calculate the risk assessment for the soil. Their formulae and expressions are as seen in table 1.

Table 1: Risk assessment parameters for soil and water risk assessment

PARAMETER	FORMULAE	DESCRIPTION
Hazard Quotient [26]	$HQ = \frac{EC}{EC_{benchmark}}$ $EC = EEC / \text{Screening benchmark}$	Estimates how much contaminant in sediment of water
Estimated daily Intake [27]	$EDI = \frac{MC \times FD}{BW}$	Estimates concentration of Metal with respect to consumption
Estimated weekly intake [26]	$EDI = \frac{MC \times FDC}{BW}$ $EWI = (Cm \times ConsR) / BWBW$	Estimates Amount of contaminants ingested over a lifetime with no significant risks
Enrichment Factor [7]	$EF = \frac{(Ci/CA)_{sample}}{(Ci/CA)_{background}}$	Shows the disturbance degree of Human activities on the natural environment
Ecological Risk [7]	$EF = \frac{(Ci/CA)_{sample}}{(Ci/CA)_{background}}$ $ER = Tr \times CF = Tr \times (Cs/CCn)$	Estimates potential; ecological risk

Potential ecological risk index [28]	$PERI = \sum_{i=1}^m E_i$	Estimates sum of potential risk of individual metals
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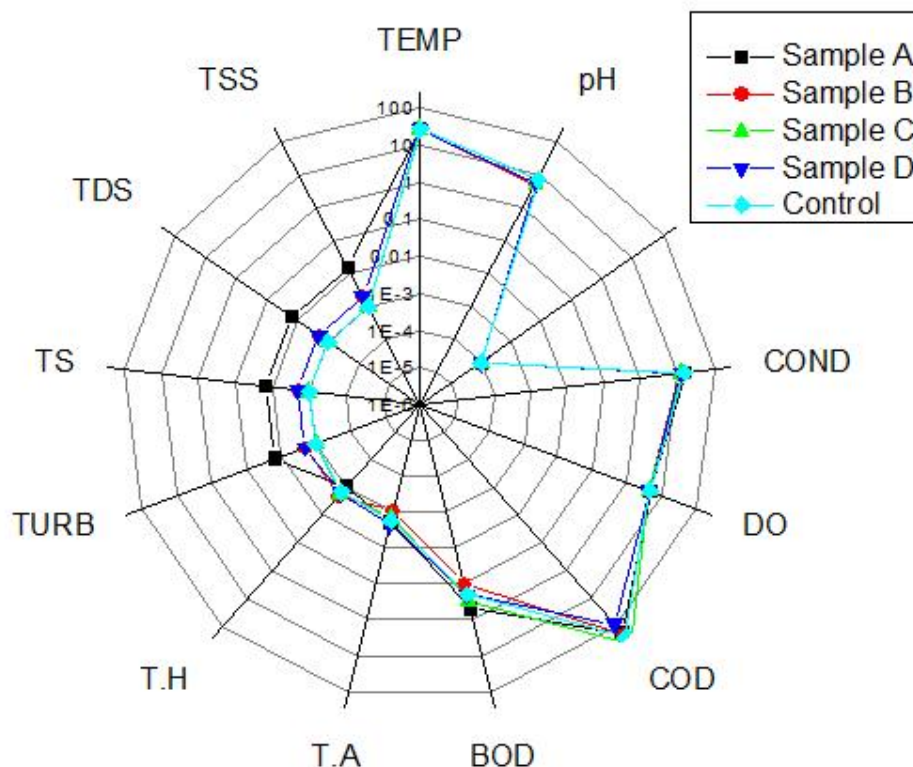
147 *BW: average human body weight at 65kg adult; Cm: concentration of the metal in water; ConsR:*
148 *weekly consumption of water at 20 L per week; Ci: concentration of element being determined; CAi:*
149 *concentration in the topsoil sample; ; Cf: contamination factor; Cn: evaluation of reference value for*
150 *the metal i, Cs: measure concentration for the heavy metal, EEC: estimated environmental*
151 *contaminant concentration at the site; Er: potential risk of individual element, FDC: average water*
152 *daily intake (3 L/day/person); Screening bench mark: generally a no-adverse effects level*
153 *concentration level; MC: average concentration of metal in water (mg/l); level m; metal; Tr: toxic*
154 *response factor for the given element ie toxicity.*

155 **3.0 RESULTS AND DISCUSSIONS**

156 **3.1 Physicochemical Analyses**

157 The physicochemical results are shown in figure 3 below. The plot showed the four samples
158 (A, B, C and D) and the control sample. The majority of the analyzed parameters: oil and
159 grease, turbidity, TS, TDS, TSS, TH and TA were all below maximum contamination levels.
160 Hence, they indicated minimal contamination of water were from the bore holes. The water
161 temperature values were within ambient levels, hence suggests no significant active microbial
162 or chemical activity. The pH values ranged from 5.1-5.4 which implies that all sampled water
163 were slightly acidic compared to control samples at 7.0 neutrality. The acidity of the water
164 samples may have resulted from the enormous acid discharged from motor batteries in the
165 mechanic workshops before relocation. Additionally, the emission of carbon dioxide from
166 motor exhaust fumes, when absorbed as acid rain will eventually lower the pH levels of the
167 soil. The conductivity of all the samples were low compared with WHO 500 (µs/cm)
168 threshold. The COD values observed were very high, an indication of solubility of some
169 metal involved in oxygen transport. However, it may also be induced by low DO level in the
170 samples, an indication of possible metallic activity like oxidation of iron to ferrous and ferric
171 ion which increases the COD.

172 The BOD value was found in the range of 0.1 to 0.5mg/l, which is low compared to WHO
 173 standard. The TH value observed for all samples varied from 0.001 mg/L to 0.002 mg/L
 174 while the control sample had 0.0015 mg/l hence below WHO 150 mg/L standard. The heavy
 175 metals of Cd, Cu, Pb and Fe were all below detectable limits in the water samples [24, 25, 26,
 176 27].

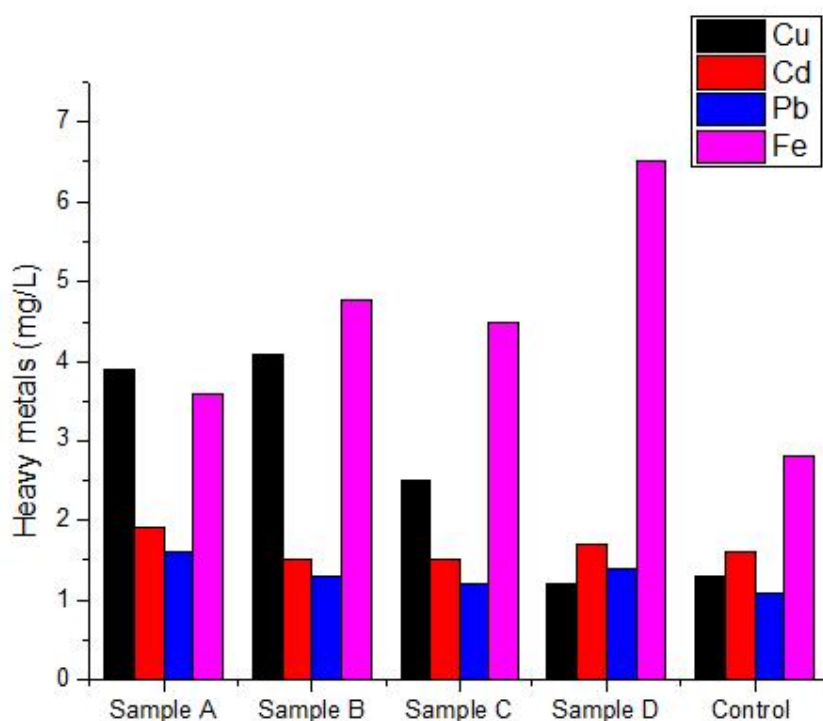


177
 178 Figure 3: Radial plot showing the physico-chemical values of water samples in Nekede
 179 Mechanic village.

180
 181 The heavy metals concentration was plotted in figure 4. All the metals detected in the control
 182 samples were well below the concentration obtained at the four sites respectively. The result
 183 shows that Fe had the highest concentration among the metals in each of the four sampling
 184 sites. Cu metal showed an increase in site A, B and decreased again in site C and D.
 185 However, Pb and Cd remained low and of similar concentration at the four sampling sites.

186 These results were compared to Nigerian NESREA environmental standard (Cu = 1 mg/L, Cd
187 = 1 mg/L, Pb = 1 mg/L and Fe = 20 mg/L) and was below the Nigerian standard [24].
188 however, the high levels of Fe were also seen in similar work carried out at Nekede Mechanic
189 village by several researchers. [1, 18, 23 and 27]. Although previous research detected Fe at
190 very high concentrations but a decrease in heavy metal concentrations may be expected
191 following the relocation and ongoing environmental cleanup. Then again, the levels of Cd
192 were comparable to similar results obtained by researchers, however, at a lower level. Cu and
193 Pb showed no correlation with the present work. It can then be inferred that the absence of
194 anthropogenic pollution sources at the site has initiated gradual reduction of the land
195 contamination at Nekede mechanic village.

196



197

198 **Figure 4: concentration of heavy metals in the soil samples.**

199 The plot shows that the concentrations of the heavy metals were below the WHO standards
200 for all soil and water samples. Fe concentration had the highest while Pb had the lowest soil

concentration. The high levels of iron may be through the iron pipes and Iron scraps lying about the site. Thus their removal had induced equivalent reduction of their concentration. Also the absence of used and spent oil, tires and hydrocarbon sources had gradually affected the presence of Cd, Cu and Pb at the sampling sites.

The metal concentrations in the soil and water at the four different sites minimal variation. Hence, the averages of all the mean of the four sites for each metal were used for risk assessment calculation. The Background reference soil samples contained Fe = 15 mg/L, Cd = 7 mg/L, Cu = 3 mg/L and Pb = 7 mg/L. The toxic response factors used were Cd = 30, Cu = 5, Pb = 5 and 1.5 for Fe. Other reference calculations for experimental data were performed based on previously reported publications [7, 26, 27, 28, 29, 30, and 31]

Table 2: Statistics showing risk assessment of heavy metals from Nekede Mechanic Village

<i>SOIL</i>	Fe	Pb	Cd	Cu		<i>WATER</i>	Fe	Pb	Cd	Cu
<i>Mean</i>	80.225	3.975	9.275	6.925		<i>Mean</i>	0.035	0.003	0.0125	0.05
<i>Median</i>	80.350	2.4	8.95	4.1		<i>Median</i>	0.0025	0.0024	0.01	0.032
<i>Variance</i>	15.789	13.735	49.429	66.542		<i>Variance</i>	4.4×10^{-3}	3.5×10^{-6}	2.5×10^{-5}	2.0×10^{-4}
<i>STDEV</i>	3.973	3.706	7.031	8.157		<i>STDEV</i>	0.07	0.002	0.005	0.030
<i>EF</i>	5.348	0.567	1.325	2.308		<i>HQ</i>	6.800	0.600	0.666	0.200
<i>ER</i>	8.022	2.839	39.75	11.54		<i>EDI</i>	1.455	0.132	0.508	1.171
<i>PERI</i>	375	350	300	6.25		<i>EWI</i>	10.214	0.928	3.571	8.214

3.2 Water Risk Assessment

The risk assessment of water showed that Pb had the least mean value at 0.003 while Cu was the highest at 0.05. Similarly, the median value of Pb was the lowest and Cu had the highest value at 0.032. The variance levels of the four metals were below 0.004 while standard deviation recorded highest as 0.07 of Fe. Thus statistically they were within acceptable range

and deviations. The hazard quotients of Pb, Cu and Cd were below 0.1 depicting that hazards exist. While the HQ of Fe was 6.80 showing that the hazard is at moderate level. The estimated daily intake and weekly intake were compared to WHO/FAO recommended guidelines standards estimated. At 1.17mg/2.85L/day, Cu was below WHO/FAO standard of 2mg/L/day, Cd was determined to be 3.57mg/20L/week and shows that it was smaller to WHO/FAO standard of 25µg/kg/day solid ingestion; since 1µg/L = 0.001 mg/L. The Pb Estimated Daily Intake at 0.132mg/2.85L/day was lower than 3ug/kg/day of WHO/FAO standard. Also Fe at 1.455mg/2.85L/week was lower than 17mg/day for males and 9-12mg/day for females. [32] All heavy metals were significantly lower than acute and toxicological reference points.

3.3 Soil Risk Assessment

The lowest mean and median levels of heavy metal concentrations in the soil were in Fe while Pb had the lowest mean and median value. The highest value for variance was shown by Cu and cadmium while Fe, and Pb had the lowest variance. However, Standard deviation for Fe and Pb were below 4.0 while that for Cu and Cd exceeded 7.0. These values were within acceptable error limits; hence results are statistically acceptable. The enrichment factor describes the anthropogenic contamination of heavy metals in the top soil. Interestingly, each metal had a different enrichment level; Pb at a value less than 1 belonged to class 0 showed no enrichment of the metal in the soil, Cd had a value of 1.325 and belonged to class 1, hence deficiency to minimal enrichment. The levels of Cu belonged to class 2, an indication of moderate enrichment while at 5.348 for Fe, it belonged to class 3 showing significant contamination. Thus Fe level is at a level of concern to the environment. The ecological risk assessment of the four metals, Fe, Pb, Cd and Cu were below *ER* 40, hence single pollutant degree of environmental risk for each metal was still at low ecological risk. The potential ecological index also known as the risk index (RI) showed that Fe and Cd were considerably

at ecological risk, Cu was at a moderate risk while Pb was at low ecological risk. The results of this risk assessment, lends credence to the high levels of iron whose risk index factor was assumed to be 1.5, while any significant increase in cadmium level can induce health challenges to surrounding community. [7, 29, 30, 31]

4.0 CONCLUSION

The results showed that pH was slightly acidic. The COD was high compared to WHO standard. The results for DO, BOD, TS, TH, TDS, TSS and TA were below toxic levels. The high levels of COD correlated with high values of Fe in the soil and water sample. The heavy metal concentrations of Fe, Cd, Cu and Pb in the water and soil samples were all below WHO standards. The risk assessment evaluation showed that Pb had the lowest mean and median value in the soil samples, and the lowest variance in water analysis. Fe had the highest mean and median value in soil analysis while Cu had the highest variance. The HQ shows that hazards exist for Pb, Cd, and Cu but only at moderate level for Fe. All estimated daily and weekly water intake were all below WHO/FAO recommended standards and poses no toxicological imminent threat. The risk assessment showed that for the soil samples, Fe had the highest mean and median value while Pb had the lowest mean and median value. Also the highest mean value for water was Cu and Pb had the lowest median value. Highest variance value was Cu in soil while Pb had the lowest in water. The water Hazard quotient of water samples shows that hazards exist was at moderate level for only Fe. All estimated daily/weekly water intake were all below WHO/FAO reference points. The soil enrichment factor showed no enrichment for Pb, minimal enrichment for Cd, moderate enrichment for Cu and significant contamination for Fe. The ecological risk assessments for the heavy metals were at low ecological risk. Furthermore, potential ecological index depicts Cu at moderate risk, Pb at low risk and Fe and Cd at considerable level of ecological risk. Hence any significant increase would induce environmental challenges. To this end, we concluded that

although contaminants exist, however reclamation of Nekede mechanic village for agricultural or recreational purposes will constitute further threat to human ingestion or bodily contact.

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