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Establishing Risk Assessment from Reclaimed Nekede Mechanic Village Owerri, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AUN and CMA designed the study, performed the statistical analysis and wrote the protocol. Authors COA and CKE managed the analyses of the study and managed the literature searches and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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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 land utilization potential. Analysis of the physicochemical water parameters showed that there was no contamination of boreholes. The high value of COD correlated with the high levels of Fe in soil and water samples. Heavy metals concentrations showed that Fe was very much present in the soil while Pb, Cd and Cu had reduced concentrations. Risk assessment for the soil samples showed that Fe had the highest mean and median value. The highest mean value for water was Cu metal. Highest variance value was Cu in soil while Pb had the lowest value in water. Hazard quotient of water samples showed that hazards existed for Cd, Cu and Pb but at a moderate level for Fe. Estimated daily/weekly water intake values 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. Ecological risk assessments for the heavy metals were at low ecological risk. Potential ecological

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index depicts Fe and Cd at a considerable level of ecological risk. Likewise, contaminants existed at the nearby Otamiri river due to dredging and nearby waste dumps. The anthropogenic activity at the Otamiri river posed a serious environmental concern if not controlled and reclaimed. Hence, the reclamation of Nekede auto mechanic village will not be suitable for agricultural or recreational purposes.

Keywords: Auto mechanic; risk assessment; contamination; pollution; soil and water.

1. INTRODUCTION

The levels of heavy metal (HM) pollution in soils and water vary with seasonal changes irrespective of pollution sources. Studies around electronic waste dumpsite site in Nigeria showed that the concentrations of Pb, Cr, Ni, Cd and Zn varied with the season, albeit concentrations of the metals exceeded maximum permissible limit [1]. These high concentrations of HMs were more pronounced in areas of dumpsites and automobile activities and increased the likelihood of groundwater contamination on the surrounding community [2]. Also, the human exposure to the heavy metals depends on toxicity levels and exposure duration.

In this regard, it has been determined that high levels and duration of Pb, Cd, Cu and Fe are known to cause liver and kidney damage, DNA damage, neuro-symptomatic disorders, and human carcinogens [3,4]. On the other hand, the HMs in the soil are usually absorbed by arable plants and when consumed by humans poses health challenges. Furthermore, the surrounding soil often presents acidic environment that solubilize the metal to ions, hence, increasing the likelihood of bio-accumulation [5]. Certain toxic metals in the soil hinders the biodegradation of organic contaminants and may pose health risks and hazards to humans. Also, when the ecosystem gets contaminated, there is the transmission of contamination through soil, food chain sources, surface water and boreholes. Howbeit, anthropogenic activities are notorious for pollution occurrences [6,7]. These anthropogenic pollution sources are reported to be caused by population growth, unsafe agricultural practices, industrial activities and urbanization [8]. Furthermore, wastewater discharged from industrial and related activities constitute the main component of water pollution due to higher oxygen demand and nutrient availability in the water bodies. Hence, promoting the blooming of toxic algal which disrupts the aquatic ecosystem [8,9]. Research has also shown that high concentrations of some heavy metals are found in urban rivers, together with higher levels of physiochemical contaminants: TDS, COD, BOD and TSS [10]. Thus regular water quality assessments are significant indicators of pollution levels [7] at active anthropogenic areas like the auto-mechanic villages.

The increasing presence of automobiles in Nigeria, has also been accompanied by a corresponding increase in auto mechanic workshops in cities and towns. Hence, there are the consequential increase in engine oil usage and its unsafe disposal practices [8]. The released pollutants including heavy metals and, oil and grease build up. They seep into the soil, polluting soil and groundwater aquifers [9,10]. Studies on auto-mechanic villages in Nigerian cities revealed that in Abakaliki town, most of the auto-mechanic workshops disposed their used motor oil, lubricants, gear oil and other solvents at workshop area [11]. In Makurdi, the levels of Zn and Cd in two selected auto mechanic villages exceeded WHO standards [12]. While in Ibadan, groundwater was contaminated by higher Cu concentrations [13,14]. Furthermore, research also showed that within Nsukka and Udenu, phyto-assessment of maize survival showed bio-accumulation of heavy metals [15]. In addition, auto-mechanics in Nekede auto mechanic village disposed spent engine oil within the surrounding vicinity and no measures were in place for collection, disposal and clean-up of oil spills. Moreover, the exhaust emissions from gasoline and diesel combustion engines compound the problem [16,17,18]. Consequently, Pb, Cr, Cd, Mn, Ni and Cu, have all been identified by researchers as the abundant metals found in auto-mechanic villages in Nigeria [19,20,21,22] with pollution concern levels. Thus, following the urbanization of Owerri town embarked upon by Imo state government of Nigeria, the Nekede auto-mechanic workshop in Owerri was moved in February 2018. Hence, created the need for risk assessment of the land and to provide data for decision making.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is Nekede Auto-Mechanic Village, located within the Owerri Municipal council in Imo State of Nigeria as shown in Fig. 1. Owerri is in the South eastern region with longitudinal locations 6°32^1 to 7°15^1 East and Latitudinal locations 6°20^1 to 6°35^1 North respectively. It has fairy low topography and undulating land surface. 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 over 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 litres of used oil or 7400 drums of spent engine oil are discharged at the site yearly and other waste products like scrap metals, paints and tires. [17,18,23,24]. Also in Fig. 2 below is the current picture of Nekede auto-mechanic workshop showing an empty land that is bare and unutilized after relocation of the technicians.

2.2 Soil Sample Collection

The surface soils were scooped out and soil samples collected from four sites at the depth of 10.0 cm using a soil auger and spatula. The sites were four different road byways connecting different auto-mechanic service workshops. Collected samples were placed in four different tagged sterile black polythene bags to minimize degradation and then transferred to a proof insulated box to avoid irradiation. Another soil collection was carried out around the waste dumpsite beside the Otamiri river which is about 500 meters away from the road byways. Samples were then taken immediately to the chemistry department laboratory of federal university of technology Owerri for analysis. The soils were air dried for three days, grounded and sieved through a 2.00 mm sieve before soil digestion [21,22]. Loamy soil samples were got from a horticulture garden along Port-Harcourt Road, Owerri Imo state, Nigeria and used as control.

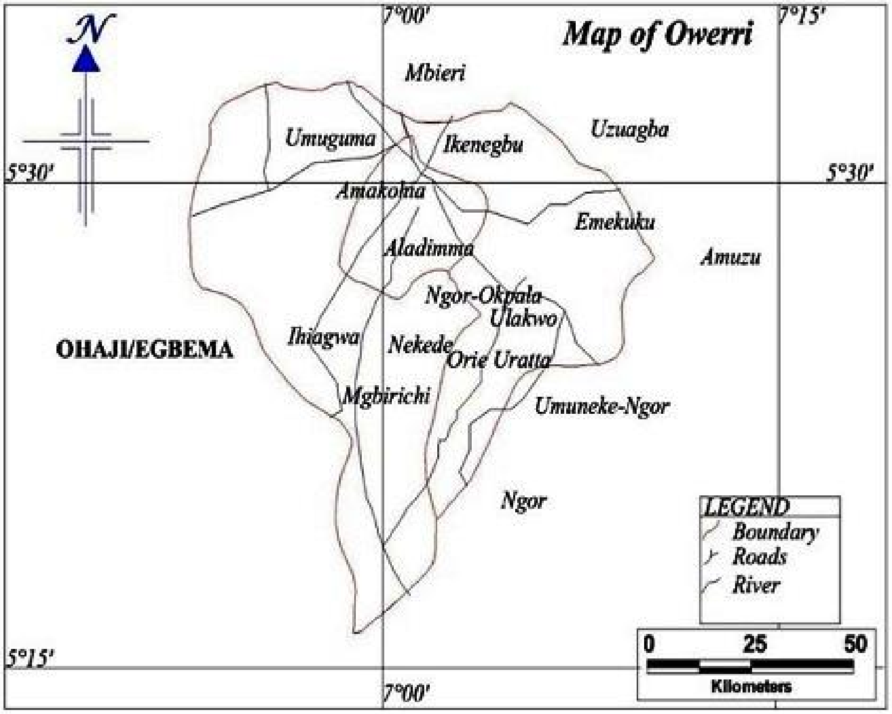

Fig. 1. Geographical location of Nekede mechanic village in Owerri, Imo-state Nigeria

Source: Department of Surveying and Geo-informatics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria 2016

Fig. 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

2.3 Water Sample Collection

The water samples were collected from boreholes, a nearby river and bottled water. The water sample was fetched in a new labelled plastic bottle that had been washed and air dried for 24.0 hours. Afterwards, they were then placed in a black light proof insulated box for preservation and protection from UV radiation. Water samples then taking to the laboratory for analysis. The first water collection site were four boreholes at the byways connecting the four selected sites of the auto-mechanic service workshops. Second collection point was at the Otamiri river beside the Nekede auto mechanic village as shown in Fig. 1d. Third collection point was from a borehole in Emmanuel college Owerri at a distance of about 1500 metres from Nekede auto mechanic village. The Coca Cola bottled Eva water was used as Control sample and for comparative purposes.

2.4 Soil-Water Analyses

Using a thermometer, the water temperatures were measured in-situ to get a stable reading. The pH was determined using JENWAY pH meter and conductivity was measured using Hanna instrument (DDS). 22°C. Physio-chemical parameters measured were dissolved oxygen (DO) and biological oxygen demand (BOD) using JPB-607A portable DO_2 meter and carried out in the laboratory. DO 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). Photometric method determined turbidity using HACH DR/2010 spectrometer [8,9]. Soil pH was determined by gravimetric analysis, and the solvent hexane used for the extraction of oil and grease in the soil. The Jenway 6305 was also used for Cl^- analysis with wavelength range of 320 to 1000 nm, band width of 8.00 nm and wavelength resolution of 1.00 nm. The common anions of PO_4^{3-}, NO_3^- and SO_4^{2-} were determined by using spectrophotometer type JASCO-V-570 spectrophotometer. The instrument was calibrated and routine testing procedures ran within the wavelength range of 200 to 850 nm on bandwidth of 0.500 nm, data pitch at 0.0250 nm and scanning speed of 10.00 nm/min. The soil and water analytical protocol was adapted from American public health association (ALPA) standard methods as modified by previous researchers. Some of the adapted methods were approached using modern spectrophotometric, gravimetric, titrimetric and photometric analyses [25,26].

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

Parameter	Formulae	Description
Hazard Quotient [28]	$HQ = EEC/Screening\ benchmark$	Estimates how much contaminant in sediment of water
Estimated daily Intake [29]	$EDI = \frac{MC\ X\ FDC}{BW}$	Estimates concentration of Metal with respect to consumption
Estimated weekly intake [28]	$EWI = (Cm\ X\ ConsR)/BW$	Estimates Amount of contaminants ingested over a lifetime with no significant risks
Enrichment Factor [7]	$EF = \frac{(Ci/CAi)_{sample}}{(Ci/CAi)_{background}}$	Shows the disturbance degree of Human activities on the natural environment
Ecological Risk [7]	$Er = Tr\ X\ Cf = Tr\ X\ (Cs\|Cn)$	Estimates potential; ecological risk
Potential ecological risk index [30]	$PERI = \sum_{i=1}^{m} Eri$	Estimates sum of potential risk of individual metals

BW: average human body weight at 65 kg adult; Cm: concentration of the metal in water; ConsR: weekly consumption of water at 20 L per week; Ci: concentration of element being determined; CAi: concentration in the topsoil sample; ; Cf: contamination factor; Cn: evaluation of reference value for the metal i, Cs: measure concentration for the heavy metal, EEC: estimated environmental contaminant concentration at the site; Er: potential risk of individual element, FDC: average water daily intake (3 L/day/person); Screening bench mark: generally a no-adverse effects level concentration level; MC: average concentration of metal in water (mg/l); level m; metal; Tr: toxic response factor for the given element ie toxicity.

2.5 Soil Digestion

The soil samples were sieved through a 2.00 mm mesh size, and 1.00 g was weighed into 100 mL beaker and 10.0 mL of concentrated HNO_3 diluted to 5% was measured and added to each sample. The suspension was heated in an oven for 7 hours to obtain supernatant liquid with several additions 10.0 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 analysed for Fe, Cu, Cd and Pb using Atomic absorption spectroscopy model AA 500 Pg Instruments [22,27]. This sampling was done in triplicates and average values were reported for this work.

2.6 Risk Assessment

The risk assessment for water was evaluated by calculating the hazard quotient (HQ), estimated daily intake (EDI), and estimated weekly intake (EWI). The enrichment factor (EF), ecological risk (ER) and potential ecological risk index (PERI) were employed to calculate the risk assessment for the soil. Their formulae and expressions are given in Table 1.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Analyses

The physicochemical results are shown in Fig. 3 below while the WHO standards for drinking water is presented in Table 2. The plot in Fig. 3 showed the four samples (A, B, C and D) and the control sample. Most of the analysed water parameters in Nekede auto mechanic village: oil and grease, turbidity, TS, TDS, TSS, TH and TA were all below maximum contamination levels. Hence, they showed minimal contamination of water from the boreholes. Water temperature values were within ambient levels, hence suggests no significant active microbial or chemical activity. The pH values ranged from 5.10-5.40 which implies that all sampled water was slightly acidic compared to control samples at 7.00 neutrality. Water sample acidity may have resulted from the enormous acid discharged from motor batteries in the mechanic workshops before relocation.

The sampled water from Emmanuel college borehole showed a pH of 6.20 and with lower conductivity, COD, BOD, and SO_4^{2-} when compared to Otamiri dredging site. Hence, negligible bio-chemical activity when compared to water samples from mechanic village boreholes. However, other physiochemical parameters for Emmanuel college borehole were below WHO standard. The existence of higher levels of PO_4^{3-} and NO_3^- in the dredging/Otamiri river site may indicate a possible chemical usage at the site or industrial effluent leaching within the site that is seeping into the borehole/ underground water. The Cl^- level at the Otamiri dredging site was 17.0 mg/L, an indication of sewage contamination from nearby dumping site. While TH and COD were 50.0 and 135 mg/L respectively and correlated with acidic soil pH of 4.10. This showed that they polluted Otamiri dredging site and the river is unsafe for utility or portable usage. Likewise, the high acidity indicates pollution and correlated with the high levels of TH, TSS, Cl^- and COD. Then again, the nearby waste dumpsite at the Otamiri river is responsible for leaching of (ions) contaminants into the water body.

On the contrast, the borehole water from Emmanuel College had a comparative result with the mechanic village borehole water sampling results. However, the dumpsite and dredging activity at the nearby Otamiri river is a serious environmental contamination activity that will increasingly pollute the Otamiri river if not controlled and reclaimed.

Additionally, the emission of carbon dioxide from motor exhaust fumes, when absorbed as acid rain will eventually lower the pH levels of the soil. The conductivity of all the samples was low compared with WHO 100 (μs/cm) threshold. The COD values observed were high, a sign of solubility of some metal involved in oxygen transport. However, it may also be caused by low DO level in the samples, an indication of metallic activity like oxidation of iron to a ferrous and ferric ion which increases the COD.

The analysis found the BOD value in the range of 0.100 to 0.500 mg/L, which is low compared to WHO standard. The TH value observed for all samples varied from 0.001 mg/L to 0.002 mg/L while the control sample had 0.0015 mg/l hence below WHO 50.0 mg/L standard. Also, the concentration of the heavy metals: Cd, Cu, Pb and Fe were all below detectable limits in the water samples [24,27,28,29].

Table 2. Results from sampling sites compared to WHO standards for drinking water [24]

Parameter/ Unit	Temperature (^oC)	pH	Oil and grease	Conductivity (µs/cm)	Turbidity (mg/L)	DO (mg/L)	COD (mg/L)	BOD (mg/L)	TA (mg/L)	TH (mg/L)	TSS (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	NO_3^- (mg/L)	PO_4^{2-} (mg/L)
WHO drinking water standard	20-30	6.5-8.5	BDL	100	50	4.0	NA	50	NA	50	35	250	250	45	1
Otamiri Dredging/ Site	28.0± 0.206	4.10± 0.0113	BDL	50.0± 1.58	5.00 ± 0.707	20.0± 2.61	135± 4.82	0.600 ± 0.0847	3.50 ± 0.212	50.0 ± 1.581	15.0 ± 0.684	0.0500 ± 0.0122	17.0 ± 1.581	0.800 ± 0.102	0.500 ± 0.0230
Emmanuel College borehole	27.0± 0.301	6.20± 0.141	BDL	10.0± 1.00	0.0500± 0.00790	10.0± 2.07	50.0 ± 0.836	0.0200± 0.00187	0.00400± 0.00216	0.0500± 0.0167	0.00800± 0.00102	0.00100± 0.000114	0.00100± 0.00439	0.00800± 0.00158	0.00700± 0.00158
Sampling site	27.0± 0.596	5.20± 0.112	BDL	15.0± 1.58	0.0250 ± 0.00612	8.00 ± 1.58	90.0± 1.92	0.500± 0.0339	0.00500± 0.00224	0.00300± 0.00158	0.00400± 0.00234	0.00200± 0.00122	0.00100± 0.000526	0.00300± 0.00100	0.00200± 0.00103
Control	28.0± 0.178	7.00± 0.158	BDL	10.0± 0.628	0.0200± 0.00587	8.00± 1.52	100± 3.21	0.400± 0.158	0.00200± 0.000200	0.00100± 0.000449	0.00200± 0.000534	0.00200± 0.00122	0.00200± 0.00123	0.00100± 0.000394	0.00100± 0.00043

BDL: below detectable limit

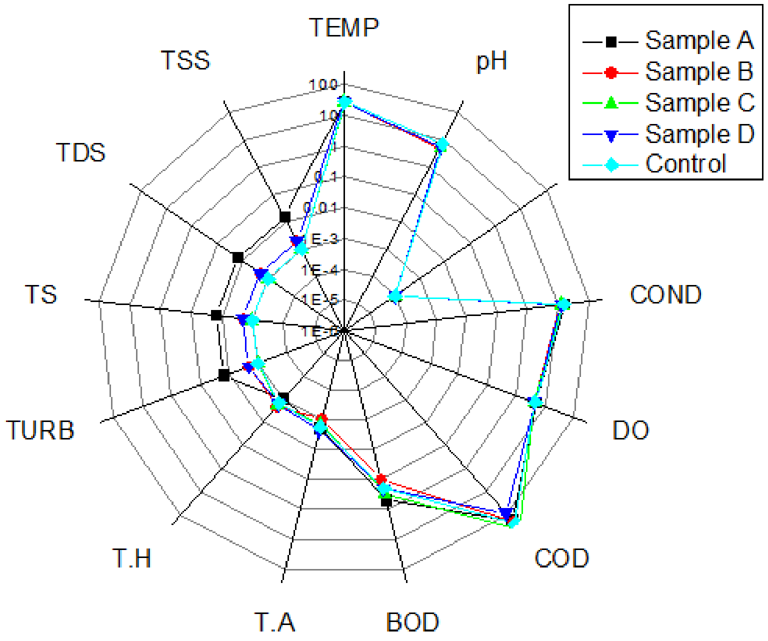

Fig. 3. Radial plot showing the physio-chemical values of water samples in Nekede Mechanic village

Furthermore, researchers had reported negligible concentrations of anions within the Nekede auto mechanic village sampling site. However, analysis performed for SO_4^{2-}, Cl^-, NO_3^-, PO_4^{3-} were all ≤ 0.003 mg/L, hence a correlation with previous results [17,18,19,20].

The heavy metals concentration with error bars was plotted in Fig. 4. All the metals detected in the control samples were well below the concentration found at the four sites. The result shows that Fe had the highest concentration among the metals in each of the four sampling sites. Cu metal showed an increase in site A, B and decreased again in site C and D. However, Pb and Cd remained low and of similar concentration at the four sampling sites. These results were compared to Nigerian NESREA environmental standard (Cu = 1.00 mg/L, Cd = 1.00 mg/L, Pb = 1.00 mg/L and Fe = 20.0 mg/L) and was below the Nigerian standard [24]. However, the high levels of Fe were also established in similar work carried out at Nekede mechanic village by several researchers. [1,18,23 and 29]. Although previous research detected Fe at high concentrations a decrease in heavy metal concentrations is expected following the relocation and ongoing environmental clean-up. Moreover, natural soil purification and remediation will aid faster soil recovery [18,29]. Then again, the levels of Cd were comparable to similar results obtained by researchers, however, at a lower level. Cu and Pb showed no correlation with the present work. It can then be inferred that the absence of anthropogenic pollution sources at the site has started a gradual reduction of the land contamination at Nekede mechanic village.

The plot below shows the concentrations of the heavy metals and their error bars. The values were below the WHO standards for all soil and water samples. Fe concentration had the highest while Pb had the lowest soil concentration. 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 affected the concentration levels of Cd, Cu and Pb at the sampling sites.

The metal concentrations in the soil and water at the four different sites showed minimal variation. Hence, the averages of all the mean from the four sites for each metal was used for risk assessment calculation. Background reference soil samples contained Fe = 15.0 mg/L, Cd = 7.00 mg/L, Cu = 3.00 mg/L and Pb = 7.00 mg/L.

The toxic response factors used were Cd = 30.0, Cu = 5.00, Pb = 5.00 and 1.50 for Fe. Other reference calculations for experimental data was performed based on previously reported publications [7,28,29,30,31,32,33].

The soil pH was average of 4.10 for three replicates of soil samples taken from the waste dumpsite beside the Otamiri river. The plot for heavy metals concentration with error bars near the waste dumpsite is shown in Fig. 5.

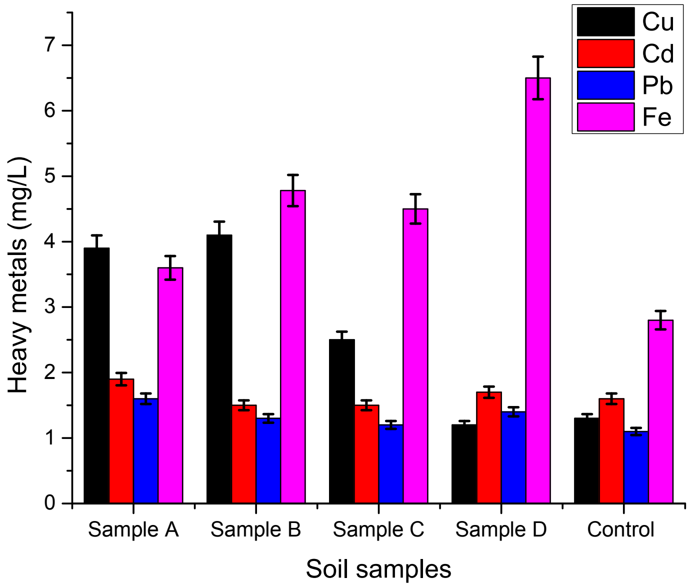

Fig. 4. Concentration of heavy metals in the soil samples

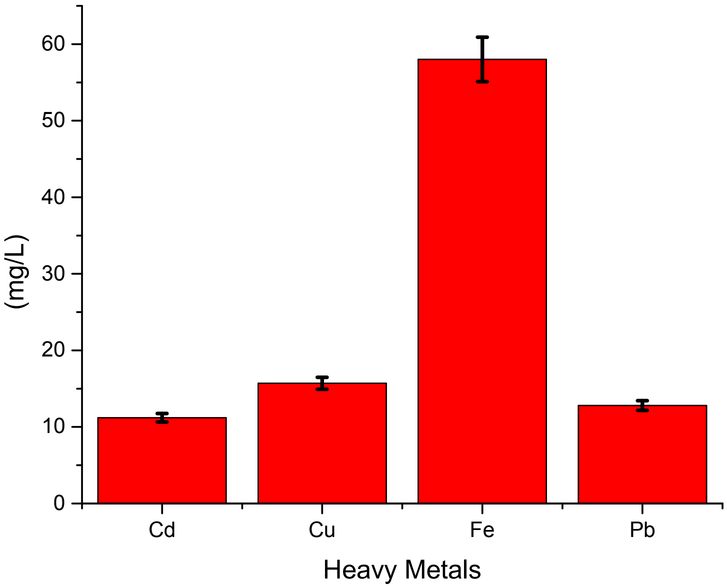

Fig. 5. Heavy metal concentration levels near the waste dumpsite

According to Xingmei et al. [5] this high acidity present in the soil causes increased solubilisation of metals and oxygen transport. Hence, the seep into the soil polluting the soil and water aquifers [9,10,11]. This result correlated with the high levels of water acidity (pH at 4.10) and COD (135 mg/L) from the Otamiri river. On the contrary, heavy metal concentration levels almost tripled their corresponding soil concentrations from the auto mechanic village byways except Fe that was very high which showed the presence of metal scraps.

However, although the heavy metal concentrations were high around the waste dump site, the soil concentration levels were yet to reach target value and intervention value. Hence, eventual pollution can be prevented by using remediation such as isolation, physical extraction chemical immobilization and phyto remediation [34].

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, they values were within the 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 indicating that the hazard is at moderate level. The estimated daily intake and weekly intake were compared to WHO/FAO recommended guidelines standards estimated. At 1.17 mg/ 2.85 L /day, Cu was below WHO/FAO standard of 2.00 mg/L/day, Cd was determined to be 3.57 mg/ 20L /week and shows that it was lower compared to WHO/FAO standard of 25.0 μg/kg/day solid ingestion; since 1.00 μg/L = 0.001 mg/L. The Pb Estimated Daily Intake at 0.132 mg/2.85L/day was lower than 3.00 μg/kg/day of WHO/FAO standard. Also Fe at 1.46 mg/2.85 L/week was lower than 17.0 mg/day for males and 9-12 mg/day for females. [34,35] All heavy metals were significantly lower than acute and toxicological reference points.

3.3 Soil Risk Assessment

The soil risk assessment is presented in Table 3. The lowest mean and median levels of heavy metal concentrations in the soil were found in Fe while Pb had the lowest mean and median value. The highest value for variance was shown by Copper and cadmium, while Fe and Pb had the lowest variance. However, Standard deviation for Fe and Pb were below 4.00 while that for Cu and Cd exceeded 7.00. 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 1.33 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 5.35 for Fe, it belonged to class 3 showing significant contamination. Thus Fe level is at a level of concern to the environment. Ecological risk assessment of the four metals, Fe, Pb, Cd and Cu were below *ER* 40.0, 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 1.50, while any significant increase in cadmium level can induce health challenges to surrounding community. [7,31,32,33]

Table 3. Tabular presentation of risk assessment of heavy metal contents in water and soil from Nekede Mechanic village

Soil	Fe	Pb	Cd	Cu	Water	Fe	Pb	Cd	Cu
Mean	80.2	3.98	9.28	6.93	**Mean**	0.0350	0.00300	0.0125	0.0500
Median	80.3	2.40	8.95	4.10	**Median**	0.00250	0.00240	0.0100	0.0320
Variance	15.8	13.7	49.4	66.5	**Variance**	0.00440	0.00000350	0.0000250	0.000200
STDEV	3.97	3.71	7.03	8.16	**STDEV**	0.0700	0.00200	0.00500	0.0300
EF	5.35	0.567	1.34	2.308	**HQ**	6.80	0.600	0.666	0.200
ER	8.02	2.84	39.8	11.5	**EDI**	1.46	0.132	0.508	1.17
PERI	375	350	300	6.25	**EWI**	10.2	0.928	3.57	8.21

4. CONCLUSION

The results showed that soil and water pH was slightly acidic within Nekede auto mechanic village. The COD was high compared to WHO standard. The results for DO, BOD, TS, TH, TDS, TSS and TA were below toxic levels. 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 dumpsite and dredging activity at the nearby Otamiri river may in due course pollute the Otamiri river and the soil if not controlled and reclaimed. 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 [35]. 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 the reclamation of Nekede mechanic village for agricultural or recreational purposes will constitute further threat to human ingestion or bodily contact.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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