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HEAVY METAL CONTAMINATION OF SOIL AND GROUND WATER AT AUTOMOBILE MECHANIC WORKSHOPS IN BORNO STATE, NIGERIA

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ABSTRACT

Environmental impact of two major automobile mechanical workshop areas, Dugja and Kenken wards in Biu Local Government Area (LGA), Borno State, Nigeria, was carried out by investigating levels of some selected heavy metals (Cr, Zn, Pb, Mn, Ni and Cd) in the soil and ground water samples. Results of the atomic absorption spectroscopy (AAS) of the samples were: (1) Dugja ward: Cr - 149 to 163.3 mg/kg; Pb - 89.8 to 101.2 mg/kg; Zn - 43.24 to 63.4 mg/kg; Mn - 47.7 to 58 .8 mg/kg; Ni - 28.09 to 38.8 mg/kg; Cd - 0.88 to 1.13 mg/kg; Cu - 28.8 to 38.8 mg/kg; (2) Kenken ward: Cr - 81.4 to 162 mg/kg; Pb - 80.2 to 92.43 mg/kg; Zn - 49.93 to 58.89 mg/kg; Mn - 55.5 to 60.18 mg/kg; Ni - 37.1 to 40.1 mg/kg; Cd - 0.89 to 1.31 mg/kg and Cu - 38.91 to 50.13 mg/kg. Indices of contamination showed that the contamination was mostly due to anthropogenic activities. The order of contamination factor was Cu (7.535) > Cr (2.719) > Zn (2.516) > Cd (2.36) > Ni (1.970) and Zn (2.702) > Cd (2.434) > Cr (2.075) > Ni (1.92) > Cu (1.827) >Pb (1.825). The order of Quantification of soil contamination (QoC) was Cu (86.73 %) > Zn (63.23 %) > Cr (60.24 %) >Pb (49.24 %) > Ni (44.13 %) and Zn (62.99 %) > Cd (58.92 %) > Cr (51.79 %) > Ni (47.97 %) > Cu (45.26) >Pb (45.21 %). The order of Pollution load index (PLI) was Zn (2.693) > Cr (2.513) > Cd (2.344) >Pb (1.968) > Ni (1.778) > Cu (1.495) and Zn (2.690) > Cd (2.405) > Cr (2.00) > Ni (1.915) >Pb (1.820) > Cu (1.819) at Dugja and Kenken wards respectively. The results showed that there was strong relationship between the mean concentrations of the heavy metals at the mechanic workshops and the Well water in some proximity to the study area.

Keywords: Contamination; heavy metal; pollution; soil and water

INTRODUCTION

Pollutants are harmful substances introduced into the environment usually through urbanization, industrialization and anthropogenic activities. These harmful substances are introduced to the environment through agricultural chemicals such as pesticides, insecticides, fertilizer, weedicides and other agro-chemicals, accidental spills and leakages of oils and chemicals, automobile mechanic workshops etc [1].

Heavy metals are usually essential to living things at desired or limited levels but excess of it is usually associated with health problems, pollution and toxicity. Heavy metals are usually adopted from metals and metalloids [2]. These elements are in various concentrations naturally in soils and rocks. They are also commonly found in sediments, ground and surface water bodies [3].

In automobile workshops, wastes are usually generated due to the artisan activities such as dumping metal scraps, worn-out vehicle parts, sulphuric acid in used batteries, hydraulic fluids, engine oils, power steering pump oil, lubricants, fuels, cleaning and brushing which may contain heavy metals [4, 5]. Artisan activities if not properly monitored and managed, may result in soil pollution with heavy metals and hydrocarbon which is a major concern due to their toxic effects, and threat to human and the environment [6]. Auto mechanic workshop has been one of the major sources of increasing heavy metal concentration of Nigerian ecosystem [7]. Auto mechanic workshops are mostly found in rural, urban towns and cities at open plots of land [8]. Around the workshops, various people specialize in various activities such as those engaged in brakes and steering activities, electrical works, engine transmission, painting, batteries recharge, soldering and welding, panel beating, polishing etc. Each of these activities can generate several wastes like gasoline waste, diesel, engine oil, paint etc. which can affect nearby surrounding and bushes. In spite of the harmful nature of the waste produced from auto mechanic workshop in Nigeria, it has received little or no attention. The nature, volume, harmful effects, method of disposals and the impact on the environment must be continually monitored and managed [9].Copper, lead, zinc, cadmium, manganese and nickel which pose health hazard to human and the environment are mostly the heavy metals found in the mechanic workshop waste.

Therefore, there is a need to assess the pollution risk of the surrounding and near mechanic workshops, monitor the level of the waste disposal of the heavy metals in mechanic workshops in Biu, especially those located some few ranges to well water supply.

MATERIALS AND METHODS

Study area description

This study was carried out in different mechanic workshops situated in Biu Local Government towns, Borno state. Biu is located on latitude 10°36'39.96"N and longitude 12°11'42.00”. The LGA is mostly located in the northern Guinea savannah (NGA) agroecological zone (Amaza), with a small portion in the northeast, the Kimba area, lying in the dryer Sudan savannah zone (Amaza). These areas have two seasons, wet season (May – October) and dry season (November – April) [10].

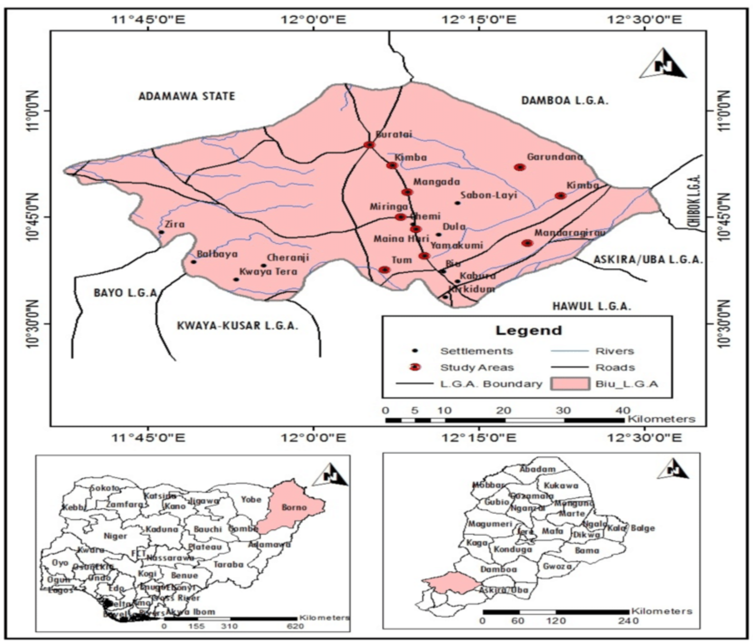

Figure 1: Map Showing the Study Area

Soil samples were collected in ten different mechanic workshops in triplicates at each site at depths of 0 to 15cm; 15 to 30cm; 30 to 45cm and 45 to 60 cm using a depth calibrated soil auger. Shovel which was washed with soap and distilled water was used for the sampling. The sampled soils were stored in black polyethylene bag, labelled and transported to laboratory for further analysis.

Sample preparation and analysis

Heavy metal analysis

The soil sample was spread on a clean sheet and air-dried in the laboratory for two weeks at room temperature and sieved using 2 mm sieve. 5 g of the prepared sample was placed in a beaker and 10 ml of nitric/perchloric acid, ratio 2:1 was added. The sample was digested at 105 ºC. Hydrochloric acid and distilled water at ratio 1:1 was added to the digested sample and the mixture transferred to the digester again for 30 min. The digested sample was then removed from the digester and allowed to cool to room temperature. The cooled digest was washed into a standard volumetric flask and was made up to the mark with distilled water. Determination of the heavy metals was done in an atomic absorption spectrophotometer (Model 210 VGP).

Determination of physiochemical properties of the soils

Physicochemical properties of soil: pH, organic matter (OM), cation exchange capacity (CEC), moisture content and particle size distribution were determined. The physiochemical properties of the soil samples were determined using routine methods [11, 12].

Water sampling and analysis

The water samples were obtained from Wells, some few meters from the mechanic workshop, following standard sampling procedure. The samples were collected in washed plastic bottles, closed tightly and placed in ice coolers for transportation to laboratory for further analysis in which some analysis commenced immediately. The methods used are all detailed in APHA, AWWA, and WPCF [13].

Statistical analysis

The data collected were subjected to statistical analysis at significance level of 0.05 using Microsoft excel (2010) and Statistical package for social science (23). The mean comparison between the heavy metals of each workshop was conducted using Analysis of variance (ANOVA). The relationship between the mean concentration of the heavy metals of the mechanical workshop and well water in some proximity to the mechanical workshop was carried out using Pearson's correlation and regression.

Assessment of the impact of the auto mechanic workshop

Various quantitative indices namely: (i) contamination factor (CF) (ii) index of geoaccumulation (iii) quantification of anthropogenic concentration of metal (QoC) have been employed to assess the impact of human activities on the concentration toxic trace metals in the soil.

Contamination factor (CF)

Contamination factor was calculated from the mean concentrations of the heavy metals from the study area along with one from control or reference sample. According to Akoto *et al.* [14], contamination factor value is classified based on the causes of the pollution. Contamination factor with value between 0.5 and 1.5 suggest the pollution emanate from natural processes while greater than 1.5 is more likely to be from anthropogenic activities.

Contamination factor is calculated according to equation (1.0) [15, 6]

$$\text{Contamination factor (CF)} = \frac{Concentration\ of\ metal\ in\ sample\ from\ the\ area\ of\ study}{Concentration\ of\ metal\ in\ control\ or\ reference} \qquad (1.0)$$

Geoaccumulation index

The geoaccumulation index was calculated from the equation (1.1) [17 - 20]

$$\text{Geoaccumulation index} = \log_2(\text{Cmetal}/1.5\ \text{Cref (control)}) \qquad (1.1)$$

Where Cmetal = concentration of heavy in the sample soil; Cref = concentration of heavy metal in control or reference sample; 1.5 = constant to minimize the possible variation in the control value which may be attributed to lithogenic

Quantification of anthropogenic concentration of metal (QOC)

The QOC is calculated according to equation (1.2) [21]:

$$\text{Quantification of anthropogenic metal} = \frac{\bar{y} - \bar{y}_c}{\bar{y}} \qquad (1.2)$$

where $\bar{y}$ = average concentration of metal in the soil under investigation;

$\bar{y}_c$ = average concentration of the metal in the control sample

Pollution load index (PLI)

The extent of heavy metal concentration of ten samples from automobile mechanic workshop obtained in Dugja and Kenken wards in Biu LGA was calculated using equation (1.3)

$$PLI = (CF1\times CF2\times CF3\times........CFn)^{1/n} \qquad (1.3)$$

RESULTS AND DISCUSSION

Table 1a: Physicochemical Properties of Soil from Selected Mechanic Workshop at Dugja Ward, Biu, Borno State

Properties	D1	D2	D3	D4	D5
pH	6.01±0.27	6.91±0.48	6.32±0.31	6.41±0.42	6.83±0.49
CEC (cmol(+)/kg)	4.23±1.24	5.71±1.09	6.02±1.31	6.15±1.38	7.31±1.47
Organic Matter	4.21±1.39	6.0±1.47	5.4±1.23	4.47±1.40	5.3±1.43
Moisture content	9.01±4.31	10.02±4.81	9.04±4.41	9.01±4.33	12.3±4.91
Sand (%)	73.5±4.81	81.14±5.01	86.7±5.31	87.0±5.31	80.13±4.11
Clay (%)	5.73±4.13	6.91±4.32	10.69±4.42	6.80±4.29	6.0±4.14
Silt (%)	3.61±1.70	3.72±1.77	4.12±1.77	3.62±1.70	3.61±1.69

Table 1b: Physicochemical Properties of Soil from Selected Mechanic Workshop at Kenken Ward, Biu, Borno State

Properties	K1	K2	K3	K4	K5
pH	6.41±0.35	7.01±0.43	6.00±0.29	6.20±0.39	6.80±0.48
CEC (cmol(+)/kg)	6.62±1.81	6.69±1.81	8.40±2.01	6.51±1.18	6.52±1.78
Organic Matter	7.80±1.27	5.31±1.20	6.71±1.23	8.40±1.34	5.52±1.20
Moisture content	6.06±2.07	8.10±2.17	8.10±2.17	9.90±2.21	6.06±2.07
Sand (%)	73.2±3.67	78.70±3.81	77.45±3.77	81.1±3.78	77.4±3.71
Clay (%)	16.3±3.99	16.32±4.00	20.10±4.18	16.91±4.09	17.17±4.08
Silt (%)	5.78±2.77	6.80±3.01	6.9o±3.03	5.71±2.71	9.10±2.69

Table 2: Permissible Limits for Heavy Metals in Plant and Soil

S/N	Element	Target value of soil (mg/kg) [22]	Permissible value of plant (mg/kg) [23]
1	Cd	0.8	0.02
2	Zn	50	0.60
3	Cu	36	10
4	Cr	100	1.30
5	Pb	85	2
6	Ni	35	10

Target value are specified to indicate desirable maximum level of elements in unpolluted soils

Table 3: Permissible Limits of Drinking Water [23]

S/N	Parameters	USEPA	WHO
1	Ph	6.5 -8.5	6.5 – 8.5
2	Turbidity (NTU)	_	_
3	Conductivity (µs/cm)	_	_
4	Alkalinity (mg/L)	_	_
5	Total hardness (mg/L)	_	500
6	Iron (mg/L)	_	0.1
7	Chloride (mg/L)	250	200
8	Nitrate (mg/L)	_	_
9	Sulfate (mg/L)	_	_
10	Calcium (mg/L)	_	75
11	Magnesium (mg/L)	_	50
12	Copper (mg/L)	1.3	1.0
13	Fluoride (mg/L)	4.0	1.5
14	Mercury (mg/L)	0.02	0.001
15	Cadmium (mg/L)	0.005	0.005
16	Selenium (mg/L)	0.005	0.01
17	Arsenic (mg/L)	0.05	0.05
18	Lead (mg/L)	_	0.05
19	Zinc (mg/L)	_	5.0
20	Chromium (mg/L)	0.1	_

Table 4a: Concentration of Heavy Metal (mg/kg) in Soil at Mechanical Workshop in Dugja Ward, Biu, Borno State

Parameters (mg/kg)	D1	D2	D3	D4	D5
Cr	149.0 ±4.83	155.43±8.24	163.33±4.28	155.43±8.02	156.7±5.32
Pb	89.8±4.23	92.4±5.02	91.14±4.92	101.2±5.22	98.2±4.41
Zn	55.4±5.23	59.4±4.92	43.24±3.98	62.4±5.31	50.14±4.98
Mn	58.8±4.78	47.7±4.12	49.9±3.99	58.1±3.81	58.12±3.87
Ni	36.7±1.90	28.09±1.86	38.8±2.38	37.6±1.45	37.8±1.89
Cd	0.9±0.02	0.89±0.03	1.03±0.04	1.13±0.041	0.88±0.02
Cu	37.7±1.93	30.2±1.83	28.8±1.98	38.8±1.43	37.8±1.93

Table 4b: Concentration of Heavy Metal (mg/kg) in Soil at Mechanical Workshop in Kenken Ward, Biu, Borno State

Parameters (mg/kg)	K1	K2	K3	K4	K5
Cr	81.40±3.29	138.8±4.23	155.4±3.99	162.0±4.21	105.5±4.24
Pb	83.34±4.32	92.43±3.99	80.2±2.89	89.9±4.19	92.2±4.23
Zn	53.2±5.41	58.89±4.52	56.67±5.24	49.93±4.82	50.14±3.89
Mn	55.5±1.39	59.9±2.38	60.18±1.87	55.5±1.28	57.7±3.81
Ni	37.1±1.48	40.1±2.93	38.8±1.97	38.8±1.92	36.81±2.82
Cd	0.89±0.03	0.91±0.04	0.99±0.03	0.89±0.03	1.31±0.04
Cu	40.14±2.89	50.13±2.83	41.18±2.17	39.71±1.99	38.91±2.98

Table 5a: Concentration of Heavy Metal (mg/kg) of Water from Dug Well in Near Mechanical Workshop in Dugja Ward, Biu, Borno State

Parameters (mg/L)	D1	D2	D3	D4	D5
Pb	0.06±0.01	0.048±0.02	0.059±0.01	ND	0.031±0.02
Cu	1.34±0.20	1.44±0.100	1.02±0.200	ND	0.90±0.100
Cd	ND	0.006±0.001	0.006±0.0011	0.006±0.0012	ND
Cr	0.19±0.12	0.17±0.01	0.19±0.014	ND	ND
Ni	0.03±0.01	ND	ND	0.04±0.02	0.03±0.001

Table 5b: Concentration of Heavy Metal (mg/kg) of Water from Dug Well Near Mechanical Workshop in Kenken Ward, Biu, Borno State

Parameters (mg/L)	K1	K2	K3	K4	K5
Pb	0.053±0.01	0.041±0.02	ND	0.038±0.002	ND
Cu	0.89±0.10	0.93±0.011	0.84±0.022	0.88±0.021	0.97±0.032
Cd	0.0071±0.013	0.0063±0.013	0.0043±0.0014	0.0028±0.0013	0.0038±0.0014
Cr	0.09±0.01	0.089±0.01	1.01±0.012	1.14±0.015	ND
Ni	ND	ND	ND	0.08±0.0014	ND

Table 6: Contamination Categories of Contamination Factor [15, 16]

Contamination factor	Category
Cf<1	Low contamination factor, indicating low
1<Cf<3	Moderate contamination factor
3<Cf<6	Considerable contamination factor
6<Cf<7	Very high contamination factor

Table 7: Average Contamination factors (CF), Geo- accumulation index (I-geo), Quantification of Contamination (QoC) and Pollution Load Index (PLI) of heavy metals in soils at Mechanic Workshops in Biu LGA: Dugja ward and Kenken ward

Sample	Cr	Pb	Zn	Ni	Cd	Cu
CF	2.516	1.970	2.719	1.789	2.360	7.535
Igeo	0.505	0.395	0.546	0.359	0.473	1.512
QoC(%)	60.24	49.24	63.23	44.13	57.56	86.73
PLI	2.513	1.968	2.693	1.778	2.344	1.495
			Kenken ward			
CF	2.075	1.825	2.702	1.920	2.434	1.827
Igeo	0.416	0.366	0.542	0.386	0.488	0.367
QoC(%)	51.79	45.21	62.99	47.97	58.92	45.26
PLI	2.001	1.820	2.690	1.915	2.405	1.819

Soil matrixes are usually influenced by physicochemical properties of the soil such as the pH, organic matter (OM), Cation exchange capacity (CEC), moisture content and particle size distribution which lead to interaction of the metals within the soil. Results of physicochemical properties of ten soil samples from Biu LGA are shown in Tables 1a and b.

The soil pH of some selected mechanic workshops in Dugja ward and Kenken wards, Biu, ranges from 6.0 to 7.01 in deionized water respectively (Table 1a and b). This implied that the soils are moderately acidic with the exception of sample K2 that tends to be slightly alkaline at pH 7.01 above 7.0. These values were also observed in the works of Aloysius et al [24] and Banjoko and Sobulo [25] which suggested that the normal pH range of soils for the growth of plant and survival of micro-organism in Nigeria are in the range of 5.70 -6.50. Acid soils have a pH below 7 and alkaline soils have pH above 7. Ultra-acidic soils (pH 3.5) and very strongly alkaline soils (pH >9) are rare [26]. Soil pH affects many chemical processes in the soil by influencing chemical reactions. The optimum pH range for most plants is between 5.5 and 7.5 [26].

Cation exchange capacity (CEC) of the soil samples ranges from 4.23 to 8.40 (cmol (+)/kg). Cation exchange capacity influences the pH nature of soil. From the results, Kenken ward soil sample K3 was observed to have the highest CEC (8.40 (cmol(+)/kg)) and the lowest value was at Dugja ward soil sample D1 (4.23 (cmol(+)/kg)) shown in Table 1a and b. Cation exchange capacity is the measure of the soil's ability to hold positively charged ions. It is an important factor that influences the soil structure stability, nutrient availability, soil pH and reaction to fertilizers and other minerals [27]. Electrostatic force help in adsorbing and holding positively charged ions (cations) of clay minerals and organic matter which have negatively charged sites on their surface. These soils tend to be more fertile because they retain more cations [28]. However, this suggests that low CEC soil support posture and crop growth. Exchangeable cations calcium (Ca^{2+}), magnesium (mg^{2+}), sodium (Na^{+}) and potassium (K^{+}) are the main ions associated with CEC [29].

The organic matter of the soil samples obtained at Dugja and Kenken wards ranges from 4.21 % to 8.42 % which was observed to have highest value at Kenken ward of soil sample K4 and lowest value at Dugja ward of sample D1. Soil organic matter impacted positively on the soil physical and chemical properties [30]. The soil organic matter is particularly important for soil functions and qualities [31]

The concentration of soil organic matter generally ranges from 1 % to 6 % of the total topsoil mass for most upland soils. Desert areas are limited to soil organic matter of about 1 %, low lying or wet areas contain as high as 90 % soil organic matter while organic soils contain 7 -18 % soil organic matter. In the study area, mechanic workshops at Dugja ward can be regarded as upland soils since its values ranges from 4.21 to 6.0 %, while the mechanic workshop soil samples obtained at Kenken ward can be regarded as mixture of upland and organic soil with the ranges of 5.31 to 8.42 % [32].

The particle size distribution is the classification of the soil sandy, loamy or textural classification. The particle size distribution of sandy soil shows that it has low sorption capacity for metal ions. The leaching of the surface may increase the sorption capacity of the elements of interest, Pb, Cu, Zn, Mn, Ni and Cd. Therefore the sorption increase with increase in depth of the soil [33].

Chromium was present in all the soil samples obtained at the studied mechanic workshops. They were found to be above the permissible limits set by World Health Organization (WHO) (Table 2) with the exception of sample K1 from Kenken ward with value of 81.40 mg/kg (Table 4a) and highest value of 163.33 mg/kg at Dugja ward sample D4 (Table 4b). Chromium is one of the most abundant elements in the earth surface and is found to be the 17^{th} [34]. It occurs either naturally or in complexes with other metals under the earth surface and rocks [35]. Chromium in soil may vary because of the nature and composition of the soil and the surrounding rocks [36]. The level of chromium in the soil usually increases due to human and anthropogenic activities [37], also dumping of chromium bearing liquids and solids wastes as chromium byproducts, slag, plating bath [35]. This signified that the mechanic workshops wastes contained paints, plating and alloys.

The mean value of lead obtained in the mechanic soil samples were all above the permissible limits set by WHO (Table 2) with the exception of samples K2 and K4 with values of 83.34 and 80. 2 mg/kg respectively with highest value at sample D4 in Dugja ward mechanic workshop (Table 4a and b). The values of the lead obtained in the study were lower than that reported for auto mechanic workshop in Owerri, South-East, Nigeria [8]. Some of the values are in line with the work of Aloysius et al. [24]. The permissible limits of lead in soil vary differently with different countries in the world [38]. This suggested that the mechanic workshops were the soil samples were obtained contained lead cell batteries, waste oil, and presence of automobile emissions. e.t.c.

The zinc content in the soil samples obtained were all above the permissible limits set by the WHO (Table 2) with the exception of sample D3, at 43.24 mg/kg with highest value at sample D4 obtained at mechanic workshop from Dugja ward (Table 4a and b). The mean concentrations of the zinc obtained in this study were found to be low in comparison to previous studies [8, 39]. The soil contamination due to the presence of zinc can be attributed to anthropogenic activities like dumping lubricating oil because the element is usually used as part of additive to the lubricating oil since no industrial activities existed within or near the mechanic workshops of the study.

The mean concentration of nickel in the soil samples investigated were observed to be above the permissible limits set by WHO with the exception of sample D2, at 28.09 kg/mg in the mechanic workshop from Dugja ward, with the highest value of 40.1 kg/mg fro sample K2, Kenken ward (Table 4a and b). Several studies show that adequate amount of nickel not above permissible limits are essential for growth of plants [40]. The presence of the nickel at the mechanic workshops can be due to the disposals of spent automobile batteries, disposal of paints or spray.

The mean concentrations of the cadmium obtained at the various workshops were all above the standard permissible limits set by WHO (Table 2) which has highest value at sample K5 Kenken ward mechanic workshop (Table 4a and b). The results obtained were in the ranges of previous work [24].

The analysis of the heavy metals of Well waters in some proximity to the mechanical workshop of the area of study using Microsoft excel and SPSS revealed that $R = 5.53 \times 10^{-7} < 0.05$, $R^2 = 0.995$ and pearson's correlation, 0.998>0.05, signifies that there is strong relationship between the mean concentration of the heavy metals at the mechanical workshop and Well water in some proximity to the automobile mechanical workshop (Figure 1a, b and c).

Contamination factor is very important as it is used to differentiate between origination of the heavy metal, whether originated from natural processes or anthropogenic processes and also assess the degree of anthropogenic influences [41]. Contamination categories of contamination factor are shown in Table 6. High contamination factor suggests anthropogenic influence. The results (Table 6) show that all the heavy metals contamination in the mechanic workshop were above 1.5 contamination factor which suggests that the pollution emanates from anthropogenic activities. The contamination value (CF) (Table 7) showed highest contamination factor of lead and chromium at Dugja ward automobile mechanic workshops, while zinc and cadmium had highest contamination at Kenken ward automobile mechanic workshop. The order of anthropogenic source metals indicated in the study is Cu> Cr > Zn > Cd > Ni at Dugja ward mechanic workshop; and Zn > Cd > Cr > Ni > Cu >Pb at Kenken ward mechanic workshop. Geo-accumulation index of the soil samples are also shown in Table 7 which shows that the environment is highly polluted with copper, zinc, chromium and cadmium while lead and nickel at lesser degree of the two sampled areas: Dugja and Kenken ward.

Quantification of soil contamination (QoC) shows the order of contamination as follows: Cu (86.73 %) > Zn (63.23 %) > Cr (60.24 %) >Pb (49.24 %) > Ni (44.13 %) and Zn (62.99 %) > Cd (58.92 %) > Cr (51.79 %) > Ni (47.97 %) > Cu (45.26) >Pb (45.21 %) at Dugja and Kenken wards automobile mechanic workshop respectively. The results showed that the contamination originate from anthropogenic activities

Pollution load index assess the soil site by means of comparison. Where PLI <1 denotes perfection, PLI>1 denotes deterioration, PLI = 1 denotes only baseline levels of pollutants are present. The results (Table 7) showed the value of the heavy metals greater than 1 which indicates deterioration of the soil quality. The order of deterioration of the soil quality with the heavy metals in the area of the study is as follows: Zn (2.693) > Cr (2.513) > Cd (2.344) >Pb(1.968) > Ni (1.778) > Cu (1.495) and Zn (2.690) > Cd (2.405) > Cr (2.00) > Ni (1.915) >Pb (1.820) > Cu (1.819) at Dugja and Kenken ward automobile mechanic workshop respectively.

CONCLUSION

The study showed that automobile mechanic workshops of the sample areas: Dugja and Kenken wards, were highly polluted with heavy metals (Cr, Pb, Zn, Mn, Cd and Cu) which were confirmed with indices of contamination: Average Contamination factors (CF), Geo-accumulation index (I-geo), Quantification of Contamination (QoC) and Pollution Load Index (PLI). The pollution has significant negative impact on the environment that also has a direct relationship with Well waters around the mechanic workshops

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