International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Research Article

CONTAMINANT IMPACT ASSESSMENT OF AUTOMOBILE MECHANIC WORKSHOP ON SOIL AND GROUNDWATER RESOURCE IN PORT HARCOURT, NIGERIA

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ABSTRACT

The contaminant impact assessment of Elekahia automobile mechanic workshopin Port Harcourt Metropolis, Nigeria has been analyzed. The objective was to ascertain the level of contamination of the soil and groundwater around the workshop area. Soil samples were collected from the study area (including the control) at the depths of 1m, 2m and 3m. A total of six soil samples were collected from the workshop and controllocated 50m away from the workshopat depths of 1m, 2m and 3m.Groundwater samples were collected from 2(two) boreholes within the workshop and a borehole outside the workshop area as control. Results of and groundwater and soil samples were compared to the World Health Organization (WHO)and Department of Petroleum Resources(DPR) standard for drinking water and soil respectively. Results of the analytical studies of the physicochemical parameters and heavy metals on the soil and groundwater resource from the Mechanic village, Elekahia show that the activities of the workshopdo not really pose a great risk to contamination of groundwater and the subsurface soil.However, the low pH observed suggests the treatment of the water before consumption. The tendency for concentration and bioaccumulation of these contaminants over time is high and therefore continuous monitory of the site is important in order to ascertain pollution status and the effects on humans.

Keywords: Heavy metals, Automobile, Contamination, Soil, Groundwater

INTRODUCTION

Soil and groundwater resourceshave been under threatdue to internal and external agents that tend to compromise their quality.The utilization of these natural resources for any purpose is determined by theirinherent qualityand characteristics (Todd, 2002; Elueze*et al*, 2004). The qualities of these resources are determined by the concentration of chemical, biological and physical parameters as well as environmental and human activities.

Soil and groundwater contamination occurs as contaminants spill onto or leaks into the soil and infiltrate downwards. Generally, the soil acts as proxy to groundwater contamination and the contaminant dose is determined by the petrophysical and lithological characteristics of the overlying soil media.

Groundwater contamination has been grouped into two sources, natural or anthropogenic. Natural sources of groundwater pollution include geologic formations, seawater intrusion and geothermal fluids (Alper, and Golkman. 2011). Anthropogenic sources include urbanization, industrialization, agricultural activities and others.

Auto mechanic workshops or villages have become common sites in Port-Harcourt where the study area is located. The activities often engaged in such mechanic village includes: working with petroleum products, battery, electrolyte, paints, welding and soldering, panel beating and vehicle body works (Adelekan and Abegunde, 2011). Automobile wastes include, paints, hydraulic fluids, lubricants, solvents, oil spills, carbide and batteries (Utang*et al*, 2013).

These wastes are indiscriminately dropped or poured on the bare soil with no regard to possible soil and groundwater contamination,hence a threat to humans and the environment. The need to protect soil and groundwater from contamination is an urgent task that calls for immediate attention. This is due to the fact that once contaminated, it becomes difficult to restore these resources back to their natural useable state.

Therefore ithas become imperative to study the impacts of mechanic workshop on soil and groundwater resources in the study area. This is particularly of great concern due to their long persistence in the soil and groundwater and their tendency to bio-accumulate along the food chain.The basic aim of this study is to assess the impact of mechanic workshop activities on the soiland groundwater resource in the area.

STUDY AREA DESCRIPTION

Elekahia Mechanic workshop lies in Port Harcourt Metropolis. It is locatedbetween Latitudes 04^0 48′ 31.3’’ and 04^0 56’ 01.5’’N and Longitudes 006^0 56’ 34.2’’ and 007^0 09’ 19.9’’E (Fig. 1). The workshop lies within the rain forest zone characterized by heavy rainfall in most periods of the year. The relief is low with an average elevation between 20m and 30m above mean sea level with the land sloping in the NW –SE (Reyment, 1965).

It exhibits a high temperature all the year round with relatively constant humidity (Utang*et al*, 2013).

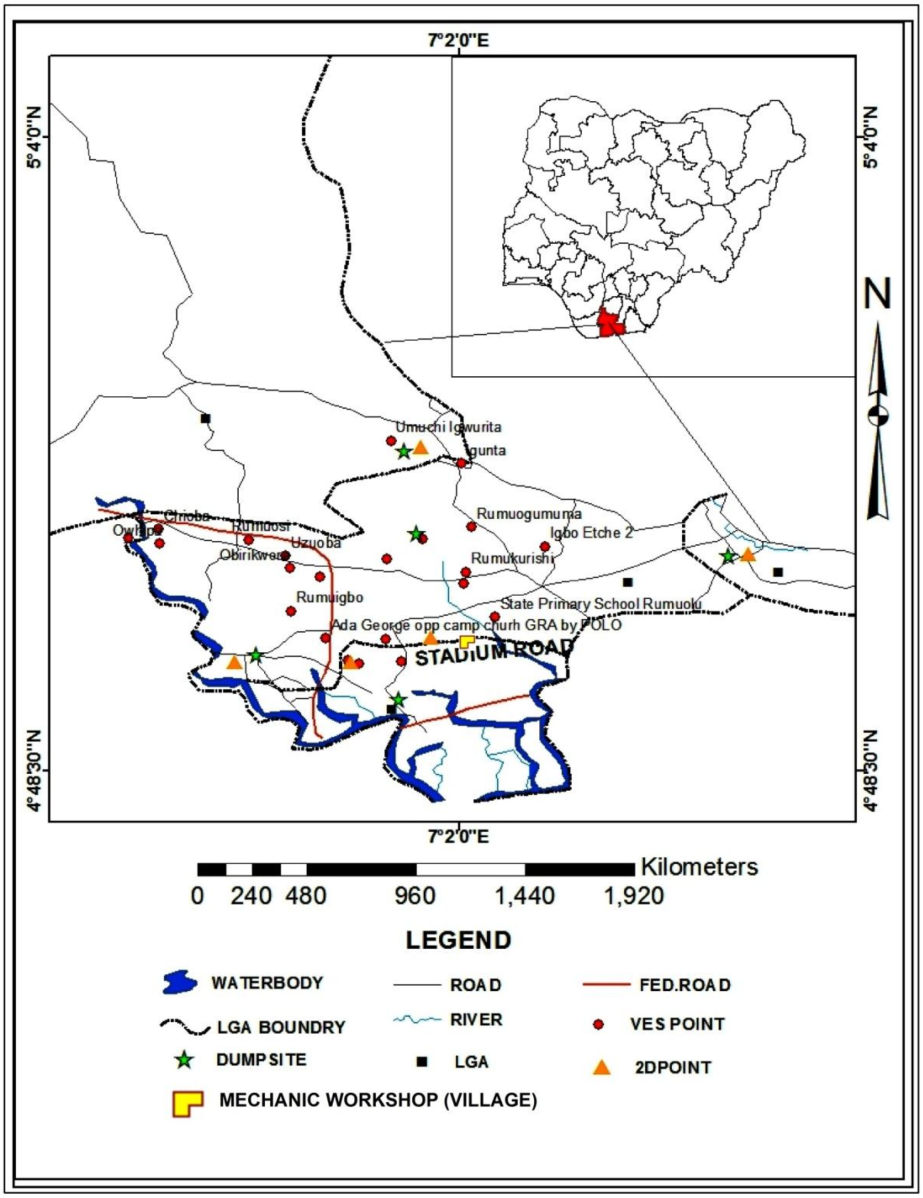

Figure 1: Location Map of the study Area

Geologically, Port Harcourt lies in the Niger Delta Sedimentary Basin. This basin is made up of three (3) lithostratigraphic units: the Benin, Agbada and Akata Formations in the order of increasing age (Short and Stauble 1967). The study area is underlain by the Benin Formation of coastal plain sands. The Benin Formation consists predominantly of sands with little shales both averaging 2100m thick (Reyment, 1965).The Formation is highly porous, permeable and prolific; it is the main source of potable groundwater supply in the area.

The Agbada Formation consists of alternating deltaic sands and shales while the Akata Formation is predominantly marine shales characterized with low density and high pressure.

MATERIALS AND METHODS

Materials:

The following materials were used in the field for water and soil sample collections; sterilized sample bottles, conductivity and pH meter, Ice parked coolers, graduated hand auger, adjustable spanners, grease, hand gloves, hand trowel, Global positioning system (GPS Garmin 72H), permanent markers, masking tapes and camera.

Methods:

Water Sample Collection / Analysis:

A total of three groundwater samples were collected from three boreholes: Two at the mechanic workshop and one at the Elekahia Housing Estate,50m away from the workshop as control. All sampling bottles were washed and rinsed with distilled water as a quality control measure prior to collection of the water samples. Samples were collected after the boreholes werethoroughly flushed for about 5minutes, to ensure collection of representative samples. Sample bottles were rinsed twice with the groundwater to be sampled before filling the containers to the brim with thesamples and labeled properly at the point of collection. The samples were stored in iced packed cooler and transported to the laboratory for analysis within 24 hours. All sampling points were geo-referenced through the use of the Geographical Positioning System (GPS). The samples werecoded BH1 and BH2 for samples from the mechanic workshop and BH3C for sample from the control site.

The following physicochemical parameters were analyzed: temperature, pH, turbidity, Total Dissolved Solids(TDS), Dissolved Oxygen (DO), Electrical conductivity, Total hardness, Calcium, sulphate nitrate, chloride, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), alkalinity and heavy metals including Nickel (Ni) Zinc (Zn), Cadmium (Cd), Iron (Fe) Lead (Pb) Copper (Cu), Chromium (Cr), Barium (Ba), Arsenic (Ar) and Mercury (Hg). The analytical methods used are summarized in Table1.

Parameter	Measurement Method	Standard
Turbidity (NTU)	Turbidimeter	APHA2130B
Total Hardness (mg/l)	Titration	APHA2540C
Total Suspended Solids (mg/l)		APHA2540D
Total Dissolved Solids (mg/l)	ASTM 1868D	APHA2520
Sulphate (mg/l)		APHA4500
	ASTMD516	
Chloride (mg/l)		APHA4500Cl-B
	ASTMD512	
Alkalinity (mg/l)		APHA2320
Fe, Ca, Cu, Pb, Cd, Zn, Mg, Ni, Hg, Mg, As,	Atomic Absorption Spectrometer	APHA3111B
pH	Horiba multi parameter water Checker	APHA4500H-B
Conductivity		APHA2510A
	ASTMD1125	
Dissolved Oxygen mg/l		APHA 4500B
Nitrate (NO^3) mg/l		APHA4500
Nitrite (NO^2)mg/l		APHA4500B
BOD (mg/l)		APHA5210D
COD (mg/l)		APHA5220

Table1: Analytical Methods used in the study for Water Sample

Soil Sample Collection / Analysis:

A total of six soil samples comprising of three samples at the mechanic workshop and three (3) at the Elekahia Housing Estate about 50m away from the workshop as control were collected. The soil samples were collected at the depth of 1m, 2m, and 3m,from each borehole at the same sampling point, with a hand auger and stored in the sample bags. The samples were then taken to the laboratory for analyses. The soil samples were labeled SS1 and SS2C for the samples at the mechanic workshop and control site respectively. The soil samples were digested and analyzed using Atomic Absorption Spectrophotometer (AAS). The ASTM and APHA (2005) analytical methods was adopted in the soil analysis in the present study.

RESULTS PRESENTATION

Groundwater:

The results of the groundwater samples from the auto mechanic workshop and control site are presented in Table 2. The pH values at the mechanic workshops for BH1 and BH2 are 4.83 and 5.01 and 5.87 for BH3C respectively. The pH values for all the boreholes were all below the WHO (2004) limit 6.5- 8.5 for potable groundwater. From the results, the groundwater at the mechanic workshop is moderately acidic with BH1 and BH2 being more acidic than the control, which could be attributed to the impacts of the auto mechanic workshop on the groundwater. The difference in pH between the mechanic workshop and the control is probably due to the fact that in mechanic workshops, the biodegradation of oil impacted soil result to the production of CO_2, H_2O and organic acids. The organic acids react with the soil generating more CO_2 (Ehirim et al, 2016). This increase in CO_2 results in the low pH observed in the workshops.

The groundwater temperature readings at the mechanic workshops for BH1, BH2 and BH3C are 24.95^oC and 24.97^oC and 25.80^oC respectively. The temperatures of the water samples in the workshop for BH1 and BH2 are lower than WHO (2004) and Nigerian Standard for drinking water quality NSDWQ (2007) standard of 25^oC for drinking water, while that of the control BH3C is above the WHO and NSDWQ standard. The temperature observed at the control compares well with that reported for groundwater temperatures in the Niger Delta (NDES, 1997).

The electrical conductivity values of the water samples in the mechanic workshop for BH1, BH2 and BH3C are 84.00µS/cm, 71.00µS/cm and 43.00µS/cm respectively. Both conductivity values for BH1 and BH2 are greater than the control. Electrical conductivity is the ability for water to conduct electric current and is also a function of the number and types of dissolved solutes in the water. The reduced pH in the workshop results in greater availability of H^+ ions thus making more cations Ca^{2+}, Mg^{2+}, Na^+, $Fe^{2+}$and Mn^{2+} soluble in the water. These results in elevated levels of total dissolve solids (TDS) in the soil and ground water. These increases in TDS will result to increased electrical conductivity.

S/N		BH1	BH2	BH3-CONTROL	WHO (2004)	NSDWQ (2007)
	GPS Location	N04^{0}56'0.39" E07^{0}1'39.53"	N04^{0}55'53.79" E07^{0}02'20.58"	N04^{0}55'53.72" E07^{0}02'38.62"		
	Parameter					
Physico-Chemical:						
1.	pH	4.83	5.01	5.87	6.5-8.5	6.6-9.0
2.	TEMP (^{0}C)	24.95	24.97	25.80		
4.	COND (µs/cm)	84.00	71.00	43.00	1000	1000
5.	TDS (mg/l)	42.00	46.00	22.00	500	500
6.	Total Hardness (mg/l)	0.186	0.302	0.133	100	500
7.	Nitrate (mg/l)	0.530	0.500	<0.01	50	50
Heavy Metals						
8.	Nickel (mg/l)	<0.001	<0.001	<0.001	0.02	0.02
9.	Iron (mg/l)	0.013	0.007	0.010	0.3	0.3
10.	Lead(mg/l)	<0.001	0.001	<0.001	0.01	0.01
11.	Copper (mg/l)	0.002	0.004	0.004	1.5	1.5
12.	Chromium (mg/l)	<0.001	<0.001	<0.001	0.05	0.05
13.	Zinc (mg/l)	0.011	0.008	0.010	3	3
14.	Cadmium (mg/l)	<0.001	<0.001	<0.001	0.003	0.003
15.	Barium (mg/l)	<0.001	<0.001	<0.001	0.3	0.3
16.	Arsenic (mg/l)	<0.001	<0.001	<0.001	0.01	0.01
17.	Mercury (mg/l)	<0.001	<0.001	<0.001	0.006	0.006

Table 2: Physicochemical result of analyzed water samples

The Total Dissolved Solids (TDS) of the water samples for BH1, BH2 and BH3C are 42.00mg/l, 46.00mg/l and 22.00mg/l respectively. The TDS for both water samples in the mechanic workshop were higher than the control. This difference could be attributed to the increase in TDS coupled withthe various activities such as metal plating which produce acidic wastes. (Uchendu and Ogwo, 2014). However all TDS values of water samples for mechanic and control are generally low and fall below the acceptable W.H.O(2004) and NSDWQ(2007) for drinking water.

The nitrate values of the groundwater sample for BH1 and BH2 are 0.53mg/l and 0.50mg/l while the nitrate value of BH3C is below detectable limitrespectively. The nitrates values for the mechanic workshop show higher values than the control. The nitrate content shows a reducing trend from the mechanic workshop to the control. Nitrates in groundwater are usually attributed to sources related to the urban development and from chemicals used in the workshop.

The heavy metals Nickel, Cadmium, Lead, Chromium, Barium, Arsenic and Mercury all have their concentration below the detectable limit in the mechanic workshop and the control site. It was also observed that the heavy metals Iron, Copper and Zinc had concentrations ranging from 0.002mg/l to 0.01mg/l. The total hardness for the groundwater sample for BH1, BH2 and BHC are 0.186mg/l, 0.302mg/l and 0.133mg/l respectively. These all fall within the permissible limit of WHO of 100mg/l with the control having lower value than the mechanic workshop.

Soil:

The physicochemical characteristics of soil sample obtained in the study area are presented in Table 3. All analyzed parameters were compared with the Department of Petroleum Resources (DPR) (2002) standard for soils.The pH values for soil samplesSS1at the mechanic workshop at 1m, 2m and 3m depths are 5.45, 5.30 and 5.78 respectively and 5.29, 5.31 and 5.64mg/kg respectively for the control SS2. The pH for SS2 follows a reducing acidity with increasing depth from 1m to 3m. The pH results of the soilat the mechanic workshop are moderately acidic. This could probably be related to the impacts of the mechanic workshop on the soil. The pH difference in the workshop is likely due to the biodegradationactivities of the impacted soil with the resultant production of CO_2, H_2O and organic acids. More $CO_2$are produced from further reactions with the soil and the organic acids thus resulting in low pH observe in the mechanic workshop. (Ehirim et al, 2016).

The nitrates content for soil samples at SS1 at 1m, 2m and 3m are 110.20mg/kg, 102.00mg/kg and 71.10mg/kg respectively and 60.20mg/kg, 65.00mg/kg and 50.20mg/kg at 1m, 2m and 3m depth for SS2 respectively. The concentration of nitrates followed a reducing trend as depth increases at the mechanic workshop and the nitrates value are higher than the control. High nitrates concentration in the mechanic workshop could be as a result of chemicals present in various products used in the workshop.

S/N		Mechanic Workshop N04⁰49'26.4" E07⁰01'33.1"			Control Site N04⁰49'47.4" E07⁰01'50.4"			DPR (2002)	
	Sample Points	SS 1			SS2				
	Depths	1 m	2 m	3 m	1 m	2 m	3 m		
	Parameter							Target	Intervention
Physicochemical:									
1.	Colour	Grey	Dark Grey	Dark Grey	Grey	Grey	Grey	NA	NA
2.	pH	5..45	5.30	5.78	5.29	5.31	5.64	NA	NA
3.	Nitrate (mg/kg)	110.20	102.00	71.10	60.20	65.00	50.20	NA	NA
Heavy Metals:									
4.	Nickel (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	35	210
5.	Iron (mg/kg)	18.15	21.50	15.72	14.63	12.49	10.11	NA	NA
6.	Lead (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	85	530
7.	Copper (mg/kg)	0.551	0.47	0.40	1.05	0.71	0.15	36	190
8.	Chromium (mg/kg)	0.027	<0.001	<0.001	<0.001	<0.001	<0.001	100	380
9.	Zinc (mg/kg)	4.112	3.370	3.150	4.750	2.510	2.810	140	720
10.	Cadmium (mg/kg)	0.026	0.017	<0.001	0.051	<0.001	<0.001	0.8	12
11.	Barium (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	200	625
12.	Arsenic (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	29	55
13.	Mercury (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.3	10

Table 3: Physicochemical result of analyzed soil samples

The concentrations of Nickel, Lead, Barium and Arsenic were all below equipment detectable limit at all depth in the mechanic workshop and control. This is probably due to the mobility of these metals in the subsurface.

Iron values for SS1 at 1m, 2m and 3m are 18.15mg/kg, 21.50mg/kg and 15.72mg/kg respectively and that of the control had values of 14.63mg/kg, 12.49mg/kg and 10.11mg/kg at 1m, 2m and 3m respectively following a reducing trend with increasing depth. Iron values at all depth are higher than the control, however all Iron values are below the DPR standard. High value of Iron in the mechanic workshop could be linked to the dumping of Iron scraps, unused body parts of vehicle, solvents and hydraulic fluid at the mechanic workshop.

Zinc values for SS1 are 4.112mg/kg, 3.370mg/kg and 3.150mg/kg at depths of 1m, 2m and 3m respectively. The control values at 1m, 2m and 3m are 4.750mg/kg, 2.510mg/kg and 2.810mg/kg. All concentrations were below the DPR standards for soil. The sources of Zinc in the workshop are brake linings, combustion of engine oil and vehicle tyres.

Chromium concentration of 0.027mg/kg was observed at 1m at the mechanic workshop and had concentration below detectable limit at all other depth in both sites. It was noted that all the values were within the acceptable standard of 100mg/kg. The Chromium concentration observed at 1m at the mechanic workshop could be attributed to the non- degradability of chromium, its persistence in the environment and once mixed in the soil it undergoes transformation into various mobile form before ending into the environment sink (Bartleft, 1998).

Cadmium values were observed in SS1 at 1m and 2m to be 0.026mg/kg and 0.017mg/kg but below detectable limit at 3m. The same trend was observed at the control where the value of 0.051mg/kg was observed at 1m and below detectable limit at 2m and 3m respectively. The control value of 0.051mg/kg is higher than the mechanic workshop. However all values were below the 0.8mg/kg standard.

DISCUSSION OF RESULTS

The pH rangeof 4.83 to 5.87for groundwater was obtained in this study. The results show moderately acidic water. These range of acidity were slightly lower than the values(6.33-7.10) observed by (Adewoyin *et al*, 2013) of shallow wells within the mechanic workshop in Ibadan and also lower than the values(3.7-4.2) observed by (Ugwoha*et al*, 2017) in Gokana L.G.A of River State.

The Total Dissolved Solids (TDS) of groundwater ranging from 22.00mg/l to 46.00mg/lwas obtained in this study.The increase in TDS has been attributed to the low pH in the workshops which resulted in dissolution of more cationsas Na^{+}, $Ca^{2+}$and Mg^{2+}. With regards to Fetters (1990) classification of water based on TDS, the groundwater sample is said to be fresh water (TDS < 1000mg/l). The TDS values observed are within the range reported by (Elueze*etal*, 2004) with a range of 23.4 to 763.20mg/l.

Thetotal hardness for groundwater ranged from 0.133mg/l to 0.302mg/l in this study and is less than 50mg/l thus indicates soft water. This is in agreement with Udom *et al* (1990) that the groundwater within the study area is usually soft and low in dissolved constituents.

The pH of the soil ranging from 5.29 to 5.78 in this work indicates acidic soil. Low pH at the mechanic workshop has been attributed to increasing production of CO^2produced as the acidic rainwater infiltrates into the impacted soil and further reacts with the soil thus reducing the pH as compared to the control (Ehirim et al 2016). This is slightly lower than the values (7.3-8.4) obtained byEdoriand Edori, (2012) from two (2) Mechanic villages in Port Harcourt. The results reveal reducing pHwith increasing depth from the surface to depths of 30cm. This implies more reduced pH values would be encountered at greater depth above 1m as observed in this work.

Iron values of the soil ranging from 10.11mg/kg to 21.50mg/kg in this study are lower than the control. This difference could be as result of the dumping of Iron scraps, unused body parts of vehicles, solvents and hydraulic fluid at the mechanic workshop. Iron values obtained in this work is lower than (0.015mg/kg- 112mg/kg) observed by (Adebayo *et al*, 2017), and (1412.5mg/kg-13162.5mg/kg) by (Edori and Edori, 2012)

The Zinclevels of 2.510mg/kg to 4.750mg/kg obtained in this study is higher than (0.07mg/kg - 1.76mg/kg) obtained by (Adebayo *et al*, 2017) and lower than (495.5mg/kg - 553.3mg/kg) reported by (Pam *et al*, 2013). Sources of Zinc include brake linings, combustion of engine oil and vehicle tyres.

Cadmium (Cd) concentrations ranging from 0.017mg/kg to 0.051mg/kg was detected at depth of 1m and 2m.The low occurrence of (Cd) at greater depth could be attributed to its mobility through the soil layers. Cadmium tends to more mobile in soil system than many other heavy metals (Alloyway, 1995).Similar results (0.01mg/kg - 0.12mg/kg) were reported by (Adebayo *et al*, 2017) and lower than (0.33 - 48.0mg/kg) reported by (Iwegbue*et al*, 2006). The presence of only traces amount of (Cd) in subsoil indicate negligible leaching to lower soil horizons and little risks of groundwater contamination. Cadmium is highly toxic and can enter the human body through metal handling and drinking water from contaminated sites.

An appreciable level of Chromium 0.027mg/kg was observedat the 1m depth in the mechanic workshop. This in line with (0.01-0.42mg/kg) reported by (Adebayo *et al*, 2017) and lower than (5.20mg/kg - 21.1mg/kg) obtained by (Iwegbue*et al,* 2006).

CONCLUSION

Elekahia Auto Mechanic workshop is engaged in various activities and processes which have the potential to be sources of contamination to groundwater and soil. Contrary to the generally accepted view, the results of the analytical studies of the physicochemical parameters and heavy metals on the soil and groundwater resource from the Mechanic village,shows that the activities of the workshop do not really pose a great risk to contamination of groundwater and the subsurface soil. However, the low pH observed suggest the treatment of the water before consumption.The tendency for concentration and bioaccumulation of these contaminants over time is high and therefore continuous monitory .of the site is important in order to ascertain pollution status and their effects on humans.

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