An Assessment of the Impact of Auto-Mechanic Activities on Groundwater in Diobu, Port Harcourt, Nigeria

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***Abstract*:-An investigation to assess the impact of auto-mechanic activities on the groundwater in Mile 2 Diobu was conducted with the aim to ascertain the level of pollution as well as the portability of the groundwater for human consumption. A total of four boreholes were analyzed for their physicochemical properties (temperature, pH and electrical conductivity) and heavy metal content (Pb, Cd, Fe, Cr, and Zn). Groundwater samples were collected from three functional boreholes within the mechanic village and a control groundwater sample was collected far away from the workshop area. The results of the analysis compared with the WHO guideline values for drinking water quality parameters revealed that all the parameters assessed were within the permissible limit set by the organization except the pH which was low and indicated that the groundwater within the area was slightly acidic as the pH ranged from 6.0 – 6.5. It was therefore concluded from the study that the auto-mechanic activities carried out in the area has not significantly impacted on the groundwater resource. However, the low pH indicated that the water requires minor treatment before human consumption. The recommendations of the study include continuous monitoring of the concentration of Fe in the groundwater resource as well as other contaminants; appropriate regulatory authorities should put in place legislature to manage, regulate and control disposal of the wastes generated from auto-mechanic activities; education of workshop owners on dangers of indiscriminate waste disposal.**

***Keywords:* groundwater, physicochemical parameters, heavy metals, boreholes, assessment**

I. INTRODUCTION

Water after air is regarded as one of the most elementary need of man required for life to continue (Khalifa and Bidaisee, 2018; Nwankwoala and Omemu, 2019). Water is a pre-requisite reactant for many biochemical reactions that occur in the human body or other living systems (Ismaila *et al.,* 2017). Thus, humans need to drink sufficient quantity of water daily, since the body cannot produce enough water by metabolism or acquire the needed amount by food intake (Jéquier and Constant, 2010). Besides drinking, water is also useful for many industrial, agricultural, recreational activities, as well as for household purposes such as cleaning and cooking (Winifred *et al.,* 2014). Water used for the aforementioned purposes could be obtained from seas, oceans, rivers and lakes (surface water) or from the ''hidden'' resource called groundwater. Although the former is readily available in most parts of the world, the latter is usually the preferred source for acquiring drinking water or water for use in any industrial process that requires clean water as a part of its production process. This is due to the fact that groundwater is being thought of as a source of potable water with a lower tendency of being polluted as a consequence of its natural filtration (Abadom and Nwankwoala, 2018).

Groundwater as reported by Ismaila *et al.* (2017), serves as the major source of drinking water for more than half of the global population. A safe and readily accessible source of potable water supply is vital for the maintenance of human health and also a critical step towards the reduction of poverty and improvement of living standards worldwide (Enukorah and Ozuah, 2018; Hunter *et al.,* 2010). Hence, the quality of groundwater is a major public health concern as it is directly interconnected with human health and welfare. Despite its well established importance, humans mostly neglect some of the activities that take place on the land surface that could lead to groundwater pollution.

Mostly in the developing countries, many people understand the necessity of water but fail to fully understand the need of water being clean. The quality of groundwater is being modified by factors such as the geology of the environment, quality of recharge and the content and quantity of wastes generated on the land surface as well as the method used for their disposal (Ganiyu *et al.,* 2016). Thus, the two chief sources of groundwater pollution are natural and anthropogenic sources. Groundwater quality may be modified even if the water may have not been affected by human activities due to contamination from natural sources such as the rock and soil media of the environment through which the rain water percolates to recharge groundwater, sea water intrusion, weathering of bedrocks and natural leaching of soil organic matter and minerals in rocks (Nebo *et al.,* 2018).

Examples of sources of groundwater pollution from anthropogenic sources include heavy use of fertilizers, animal manure and metal-based pesticides on farmlands, careless disposal of hazardous industrial wastes, abattoir wastes, sewage systems, leachate from landfills and open dumpsites, as well as indiscriminate disposal of household wastes (Peter-Ikechukwu *et al.,* 2015).

Owing to the oil and gas exploration activities in Rivers State, there has been an increase in urbanization rate in conjunction with increase in population, industrial activity, inappropriate use of resources and eventually indiscriminate dumping of both industrial and municipal wastes, especially in the State capital, Port Harcourt. One of the numerous consequences of the aforesaid, is the ever-increasing demand of vehicles for commercial and private use, most of which are fairly used vehicles that require regular servicing, maintenance and repair which are carried out in auto-mechanic workshops. A common practice in most Nigerian urban areas is to allocate portions of land to be used for a cluster of auto-mechanic workshops called a mechanic village (Usman *et al.*, 2013).

Some of the activities conducted in these workshops include the sale of automobile spare parts and engine oil as well as servicing and repair of various car parts, which usually involves spraying or painting, welding, soldering, battery recharging and repairs, panel beating, rewiring and other electrical works, routine servicing operations and change of tyres (Adelekan and Abegunde, 2011; Amukali *et al.*, 2018). Hence, the wastes generated by the aforesaid activities include used battery, battery electrolyte, metal scraps, wastes engine oil, paints, lubricants, solvents, contaminated petrol and diesel, hydraulic fluids, used tyres and other wastes materials which may contain heavy metals (Ibrahim *et al.*,2019; Owoso*et al.*,2017).

With respect to the fact that there are hardly any laws regulating the management and disposal of the wastes generated from auto-mechanic activities, the operators carry out their daily activities and often times deliberately discard of their wastes indiscriminately on the bare ground. These wastes may either be washed by storm water into nearby water bodies or may infiltrate the soil and eventually make its way into groundwater (Adewoyin *et al.*, 2013; Ogundapo and Tobinson, 2018). Leachates from these wastes can pollute groundwater with heavy metals such as copper (Cu), lead (Pb), cadmium (Cd), zinc (Zn), and manganese (Mn) which are venomous to human health. Ibrahim *et al.*(2019) reported that indecorous handling of wastes from auto-mechanic workshops has been one of the principal sources of that has led to a rise in the level of heavy metals in the environment in most Nigerian cities.

Some heavy metals such as zinc, copper, iron manganese and selenium are micronutrients required in trace amounts for proper functioning of various biochemical and physiological activities in living systems. This is due to the fact that they are a major component of proteins and other biomolecules and their scarcity in the human body could lead to several deficiency diseases in biological systems (Adelekan and Abegunde, 2011). However, their presence in living systems at levels higher than the required amount can lead to deleterious health effects such as vomiting, skin lesions, erectile dysfunction, miscarriage and preterm delivery in pregnant women, gastrointestinal disease, diabetes, cardiovascular disease, cancer, mental retardation and behavioral disorders, bone deformities, damage to liver, kidney and other vital organs and consequently death (Tchounwou *et al.*, 2012).

Groundwater is the major source of drinking water for people in the study area. They gain access to this resource through hand-dug wells and mostly boreholes, to complement the usually unavailable pipe-borne water supply by the government. Groundwater therefore, requires continuous monitoring and assessment as deterioration of its quality is harmful to human health and yet difficult to detect, clean-up and restore back to its natural state. Therefore, there is a need to thoroughly examine the impacts of the auto-mechanic activities on the groundwater within the area and hence, the aim of this study. This research is very important as it will help create public awareness and also serve as a guide to policy makers in the health, water resource and environment ministries and the local government authority on the need to monitor the methods of waste disposal within the auto-mechanic cluster area and as well put in place laws guiding the disposal of such wastes.

II. MATERIALS AND METHODS

Description of Study Area

This study was carried out in Mile 2 Diobu which is one of the three main extensions of Diobu, in the Port Harcourt Local Government Area of Rivers State. It has geographical coordinates 4˚47’24″N and 6˚59’36″E with longitude 6.994514 and latitude 4.772152. The area is characterized by two distinct seasons which are the wet and dry seasons. The area is known to be one of the major sites for the sale, servicing and repair of various car parts and generators. Thus, the major activities carried out in the area include panel beating, spray painting and polishing, welding, vulcanizing, battery recharging and repairs and other mechanic works.

Sample Collection

The process of sample collection for analysis started with a reconnaissance survey of the study area to identify the most frequently used boreholes and to obtain permission to collect groundwater samples from the borehole owners. Three functional boreholes were identified within the mechanic workshop cluster in Mile 2. A total of four groundwater samples were collected from spatially located boreholes: three within the mechanic workshop cluster and one from a borehole at Timber Street, which is far from the workshop area to be used as the control. The sampling was done in the month of September using 1.5L polyethylene bottles. Before sampling, the sample containers were washed with detergent and rinsed thoroughly with distilled water. The containers were labelled as BHWS1, BHWS2, BHWS3 and control, represent the four sampling locations. Prior to each sample collection, water was allowed to flow through the borehole heads for about three two minutes so as to obtain groundwater with a constant composition representing that of the aquifer from which it was collected. The containers were also rinsed twice with the borehole water sample to be collected.

The water samples collected were tested for their temperature, pH and conductivity before addition of few drops of Trioxonitrate (v) acid (HNO_3) to reduce the pH to about 2.0. The acid was added to the water samples to hinder metal precipitation and adsorption to the container walls (Kaizer and Osakwe, 2010). The samples were stored in a cooler packed with ice and transported to the laboratory for analysis. On arrival at the laboratory, the samples were refrigerated at a temperature of 4˚C prior to analysis to prevent significant changes in the composition of the samples (Njar *et al.*, 2012).

Physicochemical Analysis of Borehole water samples

Unstable parameter such as temperature, pH and conductivity of the water samples were each measured in-situ. The temperature was measured using a mercury in glass thermometer and the pH using a portable field digital pH meter. The conductivity of the water samples was measured using a multimeter by shifting the buttons on the instrument to the measurement of electrical conductivity. Then, the electrode of the meter was rinsed thoroughly with distilled water and subsequently immersed in a beaker containing a portion of the water. The electrode was shaken many times in the water sample to remove air bubbles and the electrical conductivity reading displayed in mg/L was recorded. The electrode was rinsed thoroughly with distilled water after each measurement. This same procedure was followed for all the water samples (Reda, 2016).

Heavy Metal Analysis

Prior to heavy metal analysis at the laboratory, the borehole water samples were digested. This was done so as to destroy the capable of interacting with the heavy metals present in the sample and making them unavailable for analysis. Digestion therefore converts the trace metals into forms easily detected by the instrument.

In order to digest the water samples, 100mL of the water sample was measured and transferred into an evaporating dish, 10mL of concentrated HNO_3 was added to it. The solution was placed on a hot plate and evaporated until the volume reduced to about 15mL, ensuring the solution does not boil. The digest was allowed to cool and then filtered into a 100mL volumetric flask and made up to the mark with distilled water and subsequently transferred into plastic sample bottles ready for analysis. The samples were analyzed in the laboratory or lead (Pb), cadmium (Cd), iron (Fe), chromium (Cr) and zinc (Zn) using an atomic absorption spectrophotometer (Itodo *et al.*, 2011).

Data Analysis

The data obtained in this study were subjected to descriptive statistical analysis using Microsoft excel software to derive the mean, standard deviation and variance. The concentration of the heavy metals analyzed were compared with the WHO (2011) recommended guideline values for drinking water quality.

The contamination factor (CF) and pollution load index (PLI) models were used to evaluate the extent of heavy metal contamination and pollution status of the groundwater within the study area.

Contamination factor (CF) was calculated using equation (1)

$$CF = \frac{Cs}{Cr} \quad (1)$$

Where Cs = concentration of heavy metal in the given sample and Cr = standard or reference ×concentration of that particular metal. In this study, the WHO guideline values for each metal was used as the reference concentration.

Pollution load index (PLI) gives a general picture of the overall level of pollution of groundwater at a particular sampling site. It was computed using equation (2) (Nwankwoala and Ememu, 2018).

$$PLI = \sqrt[n]{CF1 \times CF2 \times CF3 \times .... \times CFn} \quad (2)$$

Where CF is the contamination factor for each individual metal and n is the number of metals analyzed.

The classification scheme for CF is presented on Table 1 and the categorization of PLI values on Table 2.

Table 1: contamination factor values and their significances

Contamination Factor	Pollution Level
CF < 1	Implies low contamination
1 ≤ CF< 3	Implies moderate contamination
3 ≤ CF < 6	Implies considerable contamination
6≤ CF	Implies very high contamination

Source: Duru *et al.*, 2017.

Table 2: Categorization of PLI values

Pollution Load Index values	Indication
PLI < 1	No pollution
PLI = 1	Contamination load close to baseline value
PLI > 1	Polluted

Source: Sisira *et al.*, 2018

III. RESULTS

Groundwater temperature within the auto-mechanic workshop cluster and the control ranged from 24.7˚C to 25.4˚C as presented on Table 3. The values recorded for temperature for BHWS1, BHWS2 and BHWS3 were respectively 25.1 ˚C, 24.7 ˚C and 25.4 ˚C while the control water sample recorded a temperature of 24.8 ˚C.

The pH of the groundwater samples of the borehole water samples analyzed recorded a maximum value of 6.2 and a minimum value of 6.0 (Table 4). The values of pH recorded for BHWS1, BHWS2, BHWS3 and the control were 6.1, 6.2, 6.0 and 6.0 in that order. The pH values of the water samples analyzed were slightly below the WHO (2011) guideline value of 6.5 – 8.5 (Table 3). The result of the analysis proved that the groundwater at the auto-mechanic workshop cluster was slightly acidic, with BHWS1 and BHWS2 being more acidic than the control. This difference in pH could be attributed to indiscriminate disposal of battery water and cleaning solvents as these wastes when poured on the bare ground (most of the workshops within the study area are not cemented) may percolate through the soil and eventually pollute the groundwater in the area.

The electrical conductivity of the water samples analyzed were low and below the allowable limit of 500µS/cm set by WHO as shown on Table 1. The values recorded were 62µS/cm, 26µS/cm, 24µS/cm and 20µS/cm for BHWS1, BHWS2, BHWS3 and the control in that order. The conductivity value of BHWS1, BHWS2 and BHWS3 were higher than that of the control. Electrical conductivity is a measure of the ability of a solution to conduct an electric current as a result of the presence of dissolved ionic species in that solution (Reda, 2016). The difference in electrical conductivity between the groundwater samples within the mechanic workshop cluster and the control could be as a result of the lower pH of the former.

The concentration of lead and cadmium in all the groundwater samples analyzed including the control were all <0.001mg/L (below detection limit). The concentration of iron in BHWS2, BHWS3 and the control were <0.001mg/L but BHWS1 recorded a value of 0.290mg/L, which was higher than the control but slightly lower than the WHO prescribed maximum value of 0.3mg/L for drinking water (Table 3). The level of chromium in BHWS1, BHWS3 and the control were below detection limit (<0.001mg/L) while in BHWS2, a chromium concentration of 0.004mg/L was recorded. The chromium content of all the groundwater samples from the mechanic workshop area and the control were all far below the WHO permissible limit of 0.05mg/L. The concentration of zinc in BHWS1 and BHWS2 were below detection limit. A maximum concentration of 0.184mg/L was recorded for BHWS2 and the control recorded a value of 0.143mg/L. The concentration of zinc in all the borehole water samples analyzed were below the 3.0mg/L maximum tolerable limit set by WHO for potable drinking water.

IV. DISCUSSION

The groundwater pH which is a measure of the degree of acidity or alkalinity of a solution ranged from 6.0 – 6.2 (Table 4) indicating that the groundwater was slightly acidic. The pH values recorded in this study were slightly different from that observed by Duru*et al.*, (2017) in an investigation to assess the quality of borehole water within Orji mechanic village in Imo state in which the pH ranged from 5.51 – 6.07 and also lower than the values (4.83 – 5.87) observed by Nebo *et al.*, (2018) during an assessment of the impact of automobile mechanic activities of soil and groundwater within the vicinity of the Elekahia mechanic workshop area in Port Harcourt. Prolonged exposure to water of low pH have been reported to cause irritation to the eyes, skin and mucous membrane (Duru *et al.*, 2019). At a low pH, the dissolution and solubility of minerals in rocks within an aquifer increases and thus the water becomes contaminated.

The findings of the study revealed that the temperature of the water samples analyzed were low and ranged from 24.7˚C to 25.4˚C. These values are similar to those observed by Nebo *et al.*, 2018 in which the temperature ranged from 24.97˚C – 25.80˚C. There is no set guideline value for drinking water temperature. Hence, the best water temperature is left to the discretion of the consumers and based on the individuals taste and preference although water at a high temperature has a reduced oxygen content and may also have odor (Edori and Kpee, 2016).

Electrical conductivity denotes the ability of a solution to carry an electric current. It is an indirect measure of the amount of dissolved solids present in a solution (Reda, 2016). It varies both with the ionic strength and types of ions present in a solution (Davendra *et al.*, 2014). The conductivity levels of all the water samples investigated in the study were lower than the WHO guideline upper limit of 500µS/cm. These values are different and lower than those reported by Adewoyin *et al.*, (2013) in an investigation to evaluate the impacts of auto-mechanic workshops on groundwater in Ibadan metropolis, in which the level of conductivity recorded ranged from 192.33±5.51µS/cm to 263.67±1.53µS/cm and the control recorded the highest value of 263.67±1.53µS/cm. Since the level of conductivity reflects the concentration of ions in solution and high conductivity in most cases affects the taste of drinking water, the low conductivity observed in this study indicates the absence of an abhorrent taste in the water (Sokpuwu, 2016).

The findings of this research investigation revealed that the concentration of lead (Pb) and cadmium (Cd) in the groundwater within the vicinity of the auto-mechanic workshop cluster in Mile 2 was below the detection limit of the equipment (<0.001mg/L). Nebo *et al.*, (2018) also reported cadmium concentration in groundwater within the Elekahia mechanic village that was below detection limit but reported concentrations of lead that were a little different as one of the boreholes recorded a lead content of 0.001mg/L. Lead is the most venomous metal of all the heavy metals and has no known benefit in biological systems (Njar *at al.*, 2012). The deleterious health effects of excessive levels of lead in drinking water varies depending on the amount and duration of exposure. Prolonged exposure can result in a hindrance of haem production, high blood pressure, liver and kidney damage, impaired fertility, central nervous system disorder, gastrointestinal disease and plumbism (Edori and Edori, 2012). Lead absorbed by pregnant women can result in spontaneous abortion, preterm birth, and reduced birth weight as well as stillbirth. It can also cause mental retardation in children (Duru*et al.*, 2019). The possible sources of lead in groundwater could be as a result of improper disposal of lead-acid batteries, lead-based paints (for example spray paints containing lead arsenate) and lead-based solder within a mechanic workshop (Adewoyin*et al.,* 2013). Cadmium is an element of major public health concern due to its carcinogenic properties. Other adverse health effects of cadmium include bone defects, kidney, liver and stomach cancers, reproductive defects and even infertility (Tchounwou*et al.,* 2012). The possible sources of cadmium in groundwater within the vicinity of an auto-mechanic workshop could be due leachates of cadmium compounds from batteries, electronic components and steel, as cadmium is oftentimes used to coat steel materials as an anticorrosive (Duru*et al.*, 2019).

In this study, iron was below detection limit in all the groundwater samples analyzed except in BHWS1, in which its concentration was close to the maximum tolerable limit of iron in drinking water stipulated by WHO (2011) (Table 3). The values of iron obtained in this study are different from those reported for groundwater in auto-mechanic workshop in Ibadan Metropolis Nigeria by Adewoyin*et al.,* (2013) in which the concentration of iron ranged from 0.23±0.41mg/L – 10.90±10.31mg/L. The high iron content in BHWS1 may be linked leachates from corroded metal scraps or body parts of vehicles left outside the mechanic workshop for a long time, in which iron is the main component (Edori and Edori, 2012). Although iron has no deleterious health effect at a high concentration, it may give water an objectionable taste, color and odour, enhance the growth of iron bacteria and cause stains on laundry and faucets (Njar*et al.,* 2012; Winifred *et al.*, 2014).

The concentration of chromium in all the borehole water samples analyzed were far below the maximum tolerable limit set by WHO (2011). Duru*et al.,* (2019) reported chromium levels that ranged from 0.001mg/L – 0.05mg/L in borehole water samples within a reclaimed section of Nekede mechanic village in Imo State, Nigeria. Chromium is a naturally occurring element but its concentration in the environment could be increased by careless dumping of chromium bearing liquids and solids such as paints and alloys. Chromium in its trivalent form is an essential nutrient required in trace amounts in living systems. However, human exposure to the hexavalent form can be venomous as Cr(vi) compounds have been reported to be associated with deleterious health effects such as respiratory cancer, dermatitis, ulcer, renal injury and asthma (Tchounwou*et al.,* 2012). The chromium content of the groundwater observed in this study may not be harmful to its users since it still within the acceptable limit set by WHO.

The concentration of zinc in the groundwater samples investigated were all far below the WHO maximum allowable limit of 3mg/L. The level of zinc in the control groundwater sample exceeded that in BHWS1 and BHWS3 but was lower than that of BHWS2 from the study area. The zinc content in the control might be due to weathering of bedrocks. Zinc has been reported to be a vital element required in biological systems in trace amounts (Njar*et al.,* 2012). Zinc can enter groundwater within the vicinity of an auto-mechanic workshop from the breakdown of zinc used to galvanize iron or steel that are used to make various car body parts which are susceptible to corrosion. When car parts made from galvanize materials deteriorate, the external layer made of zinc corrodes first and leachates from such site infiltrates and eventually contaminate groundwater (Usman *et al.,* 2013; Owoso*et al.*, 2017). Other sources from which zinc can enter the environment include brake linings, car tyres and burning of engine oil (Nebo *et al.*, 2018). The outcome of this research findings are different from that reported by Duru*et al.,* (2017) in which the concentration of zinc in groundwater samples from boreholes within Orji mechanic Village in Imo State were all <0.001mg/L (below detection limit).

The contamination factors and PLI of the heavy metals analyzed were computed so as to provide a clear picture of the level of pollution of the borehole water samples analyzed. All the heavy metals analyzed had a contamination factor of less than 1 indicating a low contamination although the contamination factor of Fe for BHWS1 was 0.967 which is very close to 1. The PLI values for all the borehole water samples analyzed were zero, indicating no pollution.

Table 3: Result of analyzed groundwater samples

Parameter	Groundwater sample				WHO (2011)
	BHWS1	BHWS2	BHWS3	Control	
Temp (˚C)	25.1	24.7	25.4	24.8	-
pH	6.1	6.2	6.0	6.0	6.5 – 8.5
EC (µS/cm)	62	26	24	20	500
Pb (mg/L)	<0.001	<0.001	<0.001	<0.001	0.01
Cd (mg/L)	<0.001	<0.001	<0.001	<0.001	0.003
Fe (mg/L)	0.290	<0.001	<0.001	<0.001	0.3
Cr(mg/L)	<0.001	0.004	<0.001	<0.001	0.005
Zn (mg/L)	<0.001	0.184	<0.001	0.143	3

Temp = temperature, EC = electrical conductivity

Table 4: Descriptive statistics of parameters evaluated in the groundwater samples analyzed.

Parameter	Minimum	Maximum	Mean	Standard deviation	Variance
Temp (˚C)	24.7	25.4	25.1	0.351	0.12
pH	6.0	6.2	6.1	0.11	0.01
EC (μS/cm)	24	62	37.33	21.853	457.333
Pb (mg/L)	0	0	0	0	0
Cd (mg/L)	0	0	0	0	0
Fe (mg/L)	0	0.290	0.1	0.167	0.028
Cr (mg/L)	0	0.004	0.001	0.002	0.00001
Zn (mg/L)	0	0.184	0.061	0.106	0.011

Table 5: Contamination factors (CF) and pollution load index (PLI) of groundwater within the auto-mechanic workshops in the area of study.

Sampling location	**Contamination factor (CF)**					**PLI**
	Pb	Cd	Fe	Cr	Zn	
BHWS1	0	0	0.967	0	0	0
BHWS2	0	0	0	0.08	0.061	0
BHWS3	0	0	0	0	0	0

V. CONCLUSION

An assessment on the impact of auto-mechanic activities on groundwater in Mile 2 Diobu was carried out. The outcome of the research proved that the groundwater within the auto-mechanic workshops was slightly acidic as the pH of the water samples investigated ranged from 6.0 – 6.2. The results also proved that the concentration of iron in one of the boreholes was approximately up to the maximum tolerable limit for drinking water as stipulated by WHO. All the other parameters analyzed were within the WHO permissible limit. Therefore, divergent from the popularly perceived notion, the result of the finding indicated that the groundwater from the auto-mechanic village in Mile 2 has not been greatly impacted on as the pollution load index (PLI) for all the analyzed groundwater samples was zero.

However, the low pH indicates that the water requires minor treatment before human consumption. It is also therefore recommended that there should be continuous monitoring of the concentration of iron by the appropriate regulatory agencies as there is a likelihood of that its concentration may increase over time. In addition, there is a high possibility that there might be a rise in the level of other contaminants in the groundwater sample and eventually bioaccumulation with the passage of time and as a result, routine assessment of the groundwater within the area should be carried out to ascertain its pollution status and thus adverse effects on biological systems. Also, concerted efforts should be made by the Rivers State government, in collaboration with the ministries of health and environment to put in place legislature to manage, regulate and control waste disposal within the area as well as educate workshop owners on the dangers of their indiscriminate waste disposal.

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