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INVESTIGATION OF WATER QUALITIES OF OPEN WELLS LOCATED AT FUEL STATIONS WITHIN ILORIN METROPOLITAN COMMUNITIES, NIGERIA

***Adebayo K. R., Adesina I. K. and Adeniji F. A.**

Department of Food and Agricultural Engineering, Kwara State University, P.M.B 1530, Ilorin
***Corresponding Author:** *kehinde.adebayo@kwasu.edu.ng;* +234 0806 315 3027

ABSTRACT

This study evaluated the quality of water samples collected from twenty-seven open wells located at nine selected fuel stations situated within three Ilorin metropolitan areas. Three stations each, in the three local government areas were randomly selected. Physiochemical parameters of samples and total petroleum hydrocarbon (TPHC) were analysed for any possible petroleum product leaking from the station's underground storage tank into the nearby wells, using standard methods for the analysis. Physiochemical values of the samples analysed for Ilorin South fuel Stations (SFS), Ilorin East fuel stations (EFS) and Ilorin West fuel stations (WFS) were pH, colour, electrical conductivity, turbidity, total dissolved solids (TDS), total hardness (TH), total iron (TI), copper, manganese, nitrate, chloride, TPHC, chemical oxygen demand (COD) and biological oxygen demand (BOD).The best average pH was obtained for WFS at 7.01 and lowest TPHC. Data analysis showed that factor area and location accounted for 51.17% (BOD), 62.75% (COD) and 38.51% (TPHC) of open wells within Ilorin Metropolitan area.

Keywords: *Fuel Station, Open Wells, Petroleum Hydrocarbon, Physiochemical, Water.*

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INTRODUCTION

World Health Organization (WHO, 2003) stated that about 1 billion people in the world lack access to potable water with a greater percentage found in developing countries. This increasing deficiency of potable water has necessitated the use of water from other sources that are proned to contamination. Consequently, developing countries are particularly plagued with water-borne diseases (Aderibigbe *et al*., 2008). Therefore, it is essential to routinely examine the sources and quality of drinking water to safeguard public health. These contaminants have found their ways into supplies as a result of inadequate treatment and improper disposal of waste, industrial discharges, underground storage fuel tank leakage, open defecation and surface disposal of hydrocarbon fuels. The major aim of this research is to ascertain the physiochemical and bacteriological qualities of groundwater samples located at or near petrol and diesel filling stations within Ilorin Municipality, Kwara State, Nigeria.

Incidence of spills resulting from auto crash or pipeline vandalism involving trucks or pipes carrying refined petroleum products (petrol, kerosene, diesel etc. are common occurrence in Nigeria. The spilled products are not recovered but find their way into rivers, streams, open wells and sink into soils thereby polluting groundwater (Kayode *et al*., 2001). Water pollution is a major problem in the global context. It has been suggested that it is the leading cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily worldwide (WHO, 2009). An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrhoea sickness every day. Some 90% of China's cities suffer from some degree of water

pollution, and nearly 500 million people lack access to safe drinking water. In addition to the acute problems of water pollution in developing countries, industrialized countries continue to struggle with pollution problems as well. In the most recent national report on water quality in the United States, 45 percent of assessed stream miles, 47 percent of assessed lake acres, and 32 percent of assessed bay and estuarine square miles were classified as polluted (Franzluebbers,2002; EPA, 2003).
Site-specific characteristics such as soil type, depth of the aquifer, weather, season and the recharge rate of an aquifer all influenced the probability and severity of a particular pollution incident. The saturated zone is recharged through the percolation of water through the unsaturated zone. Any contamination that has percolated through the unsaturated zone has the potential to reach the saturated zone, thereby contaminating the groundwater held in the saturated zone. Areas that are replenished at a higher rate are generally more vulnerable to contamination by providing a pathway for the contaminants (EPA, 2003).

Storing liquid petroleum products, such as motor fuel and heating fuel, above ground or underground presents a potential threat to public health and the environment. Nearly one out of every four underground storage tanks in the United States may now be leaking. According to the U.S Environmental Protection Agency, if an underground petroleum tank is more than 20 years old and especially if it is not protected against corrosion, the potential for leaking increases naturally.

MATERIALS AND METHODS

Study Area

The study was conducted within the cosmopolitan of Ilorin, Kwara State. Ilorin as the State capital comprises of three Local Government areas namely; Ilorin South, Ilorin East and Ilorin West. Ilorin is located on latitude 8°24'N and 83°6'N and longitude 4°10'E and 4°36'E and is situated at a strategic point between the densely populated South-Western and the sparsely populated middle belt of Nigeria. Ilorin is located in the transitional zone between the deciduous wood land of the South and dry Savannah of North Nigeria (Jimoh, 2003). The choice of Ilorin as the State capital has resulted in its rapid increase in population and urban development. The 2006 population census figure showed that the city had a population of 766,000 (Aderibigbe *et.al*. 2008). Ilorin has grown from what can be described as “Foot City” with residential houses located around the Emir’s palace to an “Automobile City” (Aderamo, 2003). The neighbouring States and borders by location are Niger State to the North, Kogi State to the East, Republic of Benin to the West, Oyo and Osun States to the South.

Surface Drainage and Geological Relief

The state is drained by several river systems. The dominant ones are River Moro, Asa, Niger, Weru, Adere, and Oshin. Ilorin consists of Precambrian basement complex rock. The soils of Ilorin are made up of loamy soil with medium and low fertility. Because of the high seasonal rainfall coupled with high temperature, there is tendency for lateritic soil to constitute the major soil types in Ilorin due to the leaching of minerals nutrients of the soil (Ajibade and Ojelola, 2004). The elevation of the area varies from 273 m - 333 m in the western side with isolated hill (Sobi Hill) of about 394 m above the sea level, while on the eastern side it varies from 273 m to 364 m. The lowest level is along the river valleys of Asa and Oyun while the highest point is Sobi Hill.

Ilorin is mainly drained by Asa River which flows in a South-North direction. The pattern of the drainage system of Ilorin is dendritic. Asa River occupies a fairly wide valley and goes a long way to divide Ilorin into two parts, namely the eastern and the western part. The eastern part covers those areas where the GRA is located while the core indigenous area of Ilorin falls under the western part. Other rivers in Ilorin that drains into Asa River are river Agba, river Alalubosa, river Okun, river Osere, river Aluko, river Yalu, river Odota and river Loma.

Climate

The climate of Ilorin is characterized by both wet and dry seasons. The rainy season begins towards the end of April and last till October while the dry season begins in November and end in April. The temperature of Ilorin ranges from 33°C to 35°C from November to January while from February to April; the value ranges between 34°C to 37°C. Days are very hot during the dry season. The total annual rainfall in the area ranges from 990.3 mm to 1318 mm. The rainfall in Ilorin city exhibits the double maximal pattern and greater variability both temporarily and spatially. The relative humidity at Ilorin city ranges from 75% to 88% from May to October while in the dry season; it ranges from 35% to 80% (Ajibade & Ojelola, 2004).

Vegetation

The derived guinea savanna grasslands dominate the Northern parts of the state while some parts of Southern Ilorin falls within the rain forest agro-ecological zone of Nigeria. Parts of the state especially those surrounding Asa local government is low lying Nigerian basement complex of between 300-400 m above sea level. In some of the forested savanna areas of the state, a native African savanna tree can be found. The tree is heavily used for the following purposes such as handles for hoes, chewing stick to protect gum decay, etc.

Field Investigation

Three samples each, were taken from three randomly wells in each area making 9 samples from each Local Government area. Properly labelled plastic sample bottles were rinsed with distilled water and later with a little quantity of the sample. These bottles were then securely taped up leaving no space for air. They were packed in a cooler provided with ice pack and taken to the laboratory for the analysis. Recommended physiochemical and bacteriological analyses were conducted at a competent laboratory that is authorized by WHO. All necessary precautions were duly followed. A geographical positioning system (GPS), German 76 model was used for recording the geographical coordinates of the sampling points of each filling station. Tables 1 and 2 show the location of randomly selected control wells and samples location of selected fuel stations within Ilorin metropolitan areas.

Table 1. Location of some selected control wells within Ilorin Metropolis

Area	Location	Latitude	Longitude	Altitude
Ilorin South	Maraba Sabo-Oke, beside CAC Church	8°48'99"	4°57'10"	268m
Ilorin West	Gari Alimi, behind Total fuel station	8°46'04"	4°50'33"	233m
Ilorin East	Oloje	8°52'31"	4°49'12"	315m

Table 2. Samples location of selected fuel stations within Ilorin Metropolis

Area	Locations	Latitude	Longitude	Altitude
Ilorin South	1. Okin Oloja fuel station (SFS_1)	8°50'37"	4°57'92"	223m
	2. M.D Ayoka fuel station (SFS_2)	8°50'35"	4°57'86"	274m
	3. Total fuel station faite (SFS_3)	8°49'98"	4°58'02"	276m
Ilorin West	1. Oando fuel station Gari Alimi overhead	8°46'11"	4°52'02"	322m
	bridge (WFS_1)	8°46'08"	4°51'93"	324m
	2. A. Tapita fuel station after Gari Alimi	8°48'18"	4°53'62"	279m
	overhead bridge (WFS_2)			
	3. Total fuel station Surulere Rd. (WFS_3)			
Ilorin East	1.Yuslat oil & gas Nig, Oloje (EFS_1)	8°52'61"	4°49'37"	304m
	2. Olumo oil Okolowo (EFS_2)	8°53'12"	4°48'67"	293m
	3. Bovas petrol station Okolowo (EFS_3)	8°53'27"	4°48'83"	219m

Laboratory Analysis of Physiochemical Properties of Water Samples

Physiochemical analysis involved the studies of both physical and chemical properties of the samples. Chemical characteristics tend to be specific in nature than the physical parameters and are useful in assessing the properties of water samples. The physiochemical parameters studied in this study according to Simpi *et al*., (2011) include EC, Colour, pH, Taste/Odour, Turbidity, TDS, TH (Ca, Mg), TI, Cu, Mn, Nitrate, Chloride, TPHC, COD and BOD.

Electrical Conductivity

HANA Instrument pH/Conductivity meter mode of H198129 (ELE PAQUAQ LAB SYSTEM) was used. The meter was calibrated for EC (Electrical conductivity) using calibration code or solution H2703 (1413 µS/cm) for H198129.25 ml of the sample was measured into a beaker. After selecting the mode, the measurement was taken when the stability symbol on the screen was displayed.

Turbidity
When a sample of water is clear but contains suspended matter such as clay silt, finely divided organic matter which gives it a cloudy appearance the water is said to be turbid.

Colour
Pure water is generally colourless. The presence of organic matter modifies this colour to green, straw, yellow or brown.

Nitrate
This was done with an instrument known as digital spectrophotometer. 25 ml of water sample was filled into the sample cell and nitrate reagent which is in powder form (pillow reagent of nitriver 5 was poured into the 25 ml sample). Shake for one (1) min and was allowed for reaction for five (5) min (reaction between chemical and water), after that the sample will change to light orange colour which show that reaction has taken place. Then the spectrophotometer was programmed to 355 and wavelength of 500 Nm. Then press clear zero and sample was put into the cell holder box press read/enter, the reading was displayed on the screen.

Total Hardness (TH)
This was done with an instrument known as DR/890 data logging colorimeter. The colorimeter was programmed by pressing 30 on the button and enter which displayed mg/L $CaCO_3$ and zero, 25 ml water sample was poured into a sample cell and 1.0 ml of Ca and Mg indicator solution using a 1.0 ml measuring dropper and shake for one (1) min. Then, allowed for five (5) min for chemical reaction to take place. 1.0 ml of Alkali solution of Ca and Mg was added into the sample using dropper and shook vigorously. One (1) drop of 1MEDTE solution added into another sample cell containing distill water (blank) and swirl to mix, so also 1.0 ml of Ca and Mg indicator was added to the sample prepared and shake several times to mixed. The blank sample was place into the colorimeter holder and covered, zero was press and 0.00 mg/L $CaCO_3$ was displayed then the prepared sample was placed into the cell holder and covered, then the result was displayed on the screen in mg/L Mg hardness (as $CaCO_3$). Without removing the cell, program was press and 29 were entered then press zero and reading was entered.

Total Iron (TI)
TI was determined using DR/890 data logging colorimeter, 25 ml of the water sample was filled into the sample cell and power pillow reagent of phenanthroline was poured into the sample and was shook vigorously which was allowed to react for three (3) min and was placed inside colorimeter cell holder and the result was displayed on the screen.

Manganese (Mn)
Mn was determined using DR/890 data logging colorimeter. 25 ml of the water sample was filled into the sample cell and buffer powder pillow and sodium periodate was poured into the sample with vigorous shaking, and was allowed for three min to react and placed into the colorimeter hold and reading was taken.

Biological Oxygen Demand (BOD)
BOD is the measures the dissolved oxygen of the water sample both after it is obtained (initial DO) and after a period of five days (final DO). The amount of oxygen depleted by micro-organisms during the 5-day incubation period is used to calculate the BOD of the various water samples. Equation 1 gives the parameters to calculate BOD;

$$X_o + S + O_2 \xrightarrow{N;\,P;\,MN} X_f + T_n + CO_2 + H_2O \quad \ldots\ldots\ldots\ldots (1)$$

X_o: Initial biomass
S: Organic carbon sources
O_2: Oxygen
N: Nitrogen source
P: Phosphorus source
MN: mineral nutrients
X_f : Final biomass
Tp: Transformation products of biodegradation
CO2: Carbon (IV) oxide
H_2O: Water

Chemical Oxygen Demand (COD)
COD measures the oxygen-depletion capacity of the sample's contaminants with the hydrocarbon fuels. COD specifically measures the chemically oxidize organic compounds in the samples.

Data analysis

Analysis of variance (ANOVA) was carried out on the effect of area and location on physicochemical characteristics (BOD, COD and TPHC) of open well water in Ilorin Metropolitan areas comprised of SFS, EFS and WFS.

RESULTS

Influence of spilled petroleum products on the physicochemical properties of the open-wells water

Table 3 showed the laboratory analysis of average results obtained on the physiochemical properties of three open wells each, from the three local government areas of Ilorin; South (SFS), East (EFS) and West (WFS) which their properties such as (pH, colour, turbidity, electrical conductivity, total dissolved solid, total hardness, TPHC,BOD,COD etc.) are enumerated below. The graphs (Figures 1-3) were the plots of TPHC, COD and BOD values of water samples based on the locations of the fuel stations.

Table 3. Mean values of physiochemical characteristics of open wells water at fuel stations

S/No	Parameters	Ilorin South	Ilorin East	Ilorin West	WHO
1	pH	6.57	6.97	6.93	6.5-8.5
2	Colour	1.99	2.21	1.52	15 Mg/L
3	Turbidity	3.24	2.16	2.27	5.0 NTU
4	Electrical conductivity	442.5	573.3	433.3	1000µS/cm
5	Total dissolved solid	1466.7	1394.5	1413.2	1500Mg/L
6	Total hardness	356.5	260	360	500 Mg/L
7	Iron	0.25	0.36	0.34	1.0 Mg/L
8	Nitrate	20.99	19.77	20.31	50 Mg/L
9	Copper	0.44	0.23	0.57	1.5 Mg/L
10	Chloride	45.2	42.3	81.0	344 Mg/L
11	Manganese	0.11	0.15	0.23	0.05 Mg/L
12	Total petroleum hydrocarbon	0.026	0.007	0.005	0.007 Mg/L
13	Chemical oxygen demand (COD)	15.93	10.98	14.75	10 Mg/L
14	Biochemical oxygen demand (BOD)	10.97	11.54	10.92	5.0 Mg/L

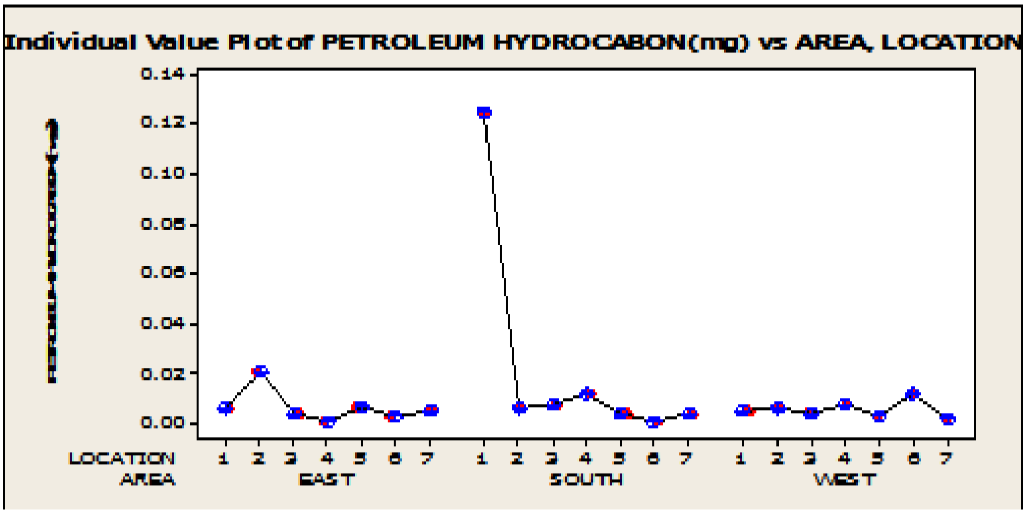

Figure 1: TPHC based on area and location of fuel stations

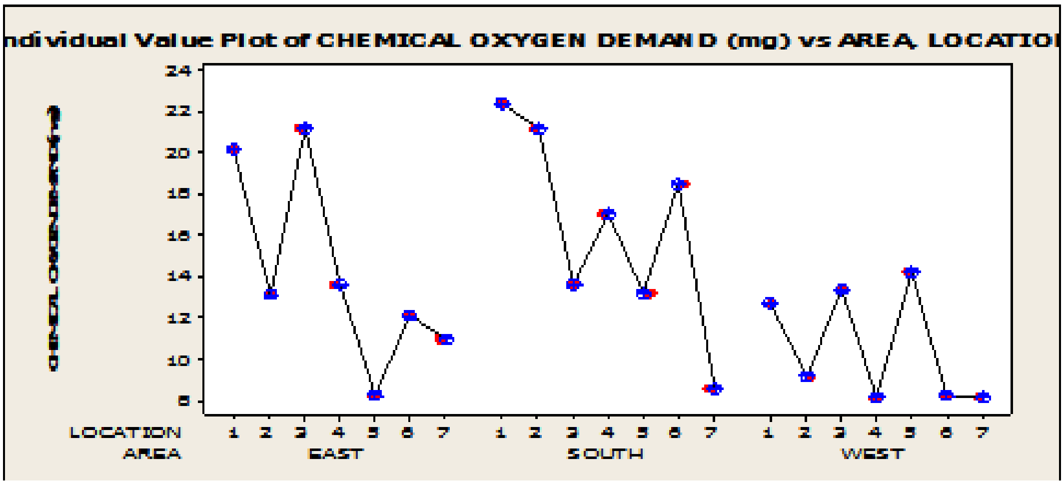

Figure 2: COD based on area and location of fuel stations

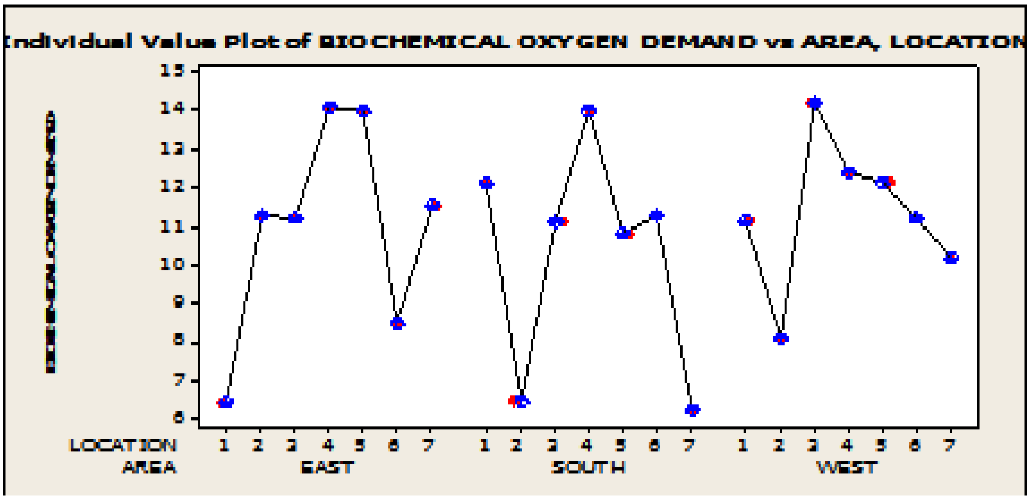

Figure 3: BOD based on area and location of fuel stations

DISCUSSION

The pH values of water samples were 6.57, 6.93 and 6.97 for South, West and East respectively which were in compliance with the pH recommendation of (6.5 - 8.5) by WHO. These pH values may be as a result of type of soil and free carbon (IV) oxide level in the samples. The fluctuations in optimum pH ranges may result in increase or decrease in the toxicity of poisons in water bodies (Okonkwo *et al*., 2008; Chikezie *et al*., 2018).Colour values of water samples were 1.52, 1.99 and 2.21 Mg/L for West, South and East respectively. The value for EFS was more than SFS as SFS was more than WFS respectively, that showed that the colour of the water samples in these locations complied with the values (15 pt-Co) recommended by WHO. Turbidity for SFS, WFS and EFS varied between 3.24, 2.27 and 2.16 NTU respectively. The turbidity level of the water samples was conformed to standard requirements of 5.0 NTU (WHO, 2006).

The EC of SFS, EFS and WFS were 442.5 µS /cm, 573.3 µS /cm and 433.3 µS /cm with EFS and WFS having the highest and lowest values respectively. The mean EC values obtained for the water samples were in compliance with the WHO standards of 1000 µS /cm. The average TDS for SFS was 1466.7 Mg/L, 1394.5 Mg/L for EFS and 1413.2 Mg/L for WFS respectively. TDS represents the percentage of inorganic substances available in water which reveals the nature of water quality. High TDS gives objectionable odour or offensive taste in water (Kayode *et al*., 2001).

Highest TH of 360 Mg/L was found in WFS while EFS recorded the lowest TH of 260 Mg/L and for SFS it was 356.5 Mg /L. Average TH for the three zones were not greater than 500

Mg/L which was the permissible limit for drinking water by World Health Organisation (WHO, 2009).TPHC content in the water samples recorded for SFS, EFS and WFS were 0.026 Mg/L, 0.007Mg/L and 0.005 Mg/ L respectively. TPHC values recorded in SFS water samples does not complied with the values (0.007 Mg/L) recommended by WHO.

The COD for SFS ranged from 22.40 Mg/L to 13.61 Mg/L with sample SFS_1 had the highest value and SFS_3 had the lowest value with an average value of 15.93 Mg/L as shown in Table 3. While the values recorded for EFS ranges from 21.20 mg/L to 13.12 Mg/L with sample EFS_3 had the highest value and EFS_2 has the lowest value with an average value of 10.98 Mg/L. The COD recorded for WFS ranged from 13.39 Mg/L to 9.15 Mg/L with sample WFS_3 having the highest value and WFS_2 had the lowest value with an average value of 14.75 Mg/L. Chemical Oxygen Demand of the samples exceeded the maximum permissible limit for drinking water of 10 Mg/L by the WHO (Lv *et al*., 2002); this could be as a result of the heavy contaminants that infiltrated into wells.

The BOD for SFS generally ranged from 12.12 Mg/L to 6.48 Mg/L with sample SFS_1 had the highest value and SFS_2 had the lowest value. EFS ranged from 11.28 Mg/L to 6.45 Mg/L with sample EFS_2 had the highest value and EFS_1 had the lowest value. WFS ranged from 14.21 mg/L to 8.11 mg/L with sample WFS_3 possessed the highest value and WFS_2 has the lowest value. BOD values did not comply with the recommended standard value (< 5 Mg/L) for drinking water according to Clarke *et al*., (2012). The averages values of BOD for SFS, EFS and the WFS were 10.97, 11.54 and 10.92 Mg/L respectively which were not in compliance with WHO standard for potable water.

CONCLUSIONS

BOD and COD are used to measure oxygen used and equate it to the amount of organic matter available in the water sample. BOD measures the amount of oxygen utilized by microorganisms, in this case, bacterium, to oxidize organic matter available within the water sample. The analysis of the water samples from open wells located at fuel stations within Ilorin metropolis revealed that some of the samples contained one form of contaminant or the other which exceeded the WHO recommendations which makes the water unsuitable for drinking. The sample collected from Ep_2 and Sp_1 were polluted with TPHC which their levels were above the values stipulated by WHO. However, continuous drinking from these open wells can lead to accumulation of petroleum hydrocarbon in the body tissue which may cause adverse effect to human health and petroleum hydrocarbon are known to be carcinogenic in nature.

RECOMMENDATION

Open well within the fuel stations was recommended to be cited at a very long range to the fuel stations so as to curb over-accumulation of petroleum hydrocarbons that damage human health.

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