Impact of Automobile Workshop Activities on Groundwater in Aule, Ondo State, Nigeria

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ORIGINAL RESEARCH

Abstract- In many parts of Nigeria, groundwater is one of the most essential sources of water. Pollution brought on by petroleum products (a complete mixture of hydrocarbons) has been acknowledged as a severe environmental issue. This research is aimed at examining the impact of automobile repair activities on well water quality in Aule, Ondo state, Nigeria. Physio-chemical parameters such as temperature, turbidity, pH, electrical conductivity, total dissolved solids, alkalinity, acidity, total hardness, chloride, nitrate, sulphate, phosphate, total suspended solids, magnesium, calcium and bacteriological parameters from 5 wells in different automobile workshops and control well in Aule were analyzed in this research. The results were compared with the WHO standards. The analysis revealed that the mean values of NO_3, SO_4, Mg, Ca, and pH were within the WHO permissible limit, while the mean value of the other water parameters exceeded the WHO permissible limit. Also, NO_3 negatively correlated with pH, and positively with Ca (r=0.873, p<0.05). PO_4 correlated positively with Ca (r=0.903, p<0.05). TDS correlated negatively with Temp, and pH and positively with TSS (r=0.879, p<0.05). pH correlated negatively with EC, pH, and TVBC. This study also revealed that poor waste disposal practices by automobile repairers, inadequate regulatory frameworks, and a lack of awareness among community members on the dangers of groundwater pollution are contributing factors to the problem.

Keywords- Automobile, Groundwater, Parameters, Pollution, WHO.

1 INTRODUCTION

One of the essential requirements for human survival, following air, is water (Nwankwoala and Omemu, 2018). Within a community setting, water supply primarily relies on groundwater, surface water, and rainwater. Safe drinking water should be devoid of harmful microorganisms, dangerous impurities, and excessive minerals and chemical substances (Ezeh, *et al*., 2017). Ensuring a dependable and accessible source of clean drinking water holds utmost importance in safeguarding human well-being and contributing to global efforts in poverty alleviation and improved living standards (Enukorah and Ozuah, 2018). Beyond its role in consumption, water also serves various purposes in industry, agriculture, recreation, and household tasks such as cleaning and cooking (Winifred *et al*., 2014).

Within a community context, water supply primarily relies on groundwater, surface water, and rainwater. To be suitable for consumption, water must be devoid of harmful pathogens, hazardous pollutants, and excessive levels of minerals and chemicals (Ezeh, *et al*., 2017). As stated by Ismaila et al. (2017), over fifty percent of the global population primarily relies on groundwater as their main source of drinking water. Anthropogenic pollution arises when substances originating from human activities, such as gasoline, oil, fertilizers, pesticides, and other chemicals, enter water bodies, rendering them hazardous and unsuitable for human consumption (Asonye *et al*., 2007).

Industrial operations play a significant role in pollution, with a rise in these activities resulting in what is known as "pollutional stress." This stress affects both surface water and groundwater due to pollution originating from industrial, agricultural, and household origins (Breida *et al*., 2019). Activities carried out within auto mechanic workshops encompass processes that entail the handling and accidental spilling of substances like oils, greases, petrol, diesel, battery electrolytes, paints, and other materials that can have adverse environmental impacts (Adelekan and Abegunde, 2011).

The predominant water supply for the inhabitants in this region is sourced from wells, as highlighted by Ojo in 2022. Research has indicated that waste produced as a result of auto repair procedures can also lead to environmental contamination, primarily due to inadequate waste management and disposal practices (Oniawa et al., 2002; Ipeaiyeda and Dawodu 2008; Olusoga and Osibanjo 2007). The pollution attributed to petroleum products, which consist of a complex blend of hydrocarbons, is recognized as a significant environmental concern, particularly due to the substantial volumes that are occasionally spilled (Horsfall, 2011).

While there have been investigations conducted on automotive mechanic settlements in Nigeria, there exists limited knowledge regarding the effects of these operations on the quality of groundwater utilized for household needs (Oloruntoba and Ogunbunmi, 2020). This study seeks to assess the influence of automobile repair tasks on the physical, chemical, and bacterial characteristics of groundwater samples in Aule, located in the Ondo state of Nigeria.

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Section E- CIVIL ENGINEERING & RELATED SCIENCES
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2 METHODOLOGY

2.1 DESCRIPTION OF STUDY

The study area is located within Akure metropolis, South-Western Nigeria and can be located between the UTM coordinate of Eastings 738600 to 739300 m and Northings 804100 to 804500 m and it can be accessed through several networks of roads. The study area is accessible through the popular Oyemekun road, Akure with other minor roads and footpaths interconnecting the area. The area is characterized by two distinct seasons which are the wet (May – October) and dry seasons (November – April). The location is recognized as one of the key locations for the sale, maintenance, and repair of various car parts and generators. Thus, the main activities performed in the area include panel beating, spray painting and polishing, welding, vulcanizing, battery recharge and repairs, among other mechanical activities.

2.2 STUDY DESIGN

This research used a simple random sampling method that included two components: on-site study and laboratory analysis.

2.3 STUDY POPULATION

The study group was comprised of all groups of personnel involved in the repair of automobiles. This includes auto mechanics, panel beaters, welders, painters, rewires, battery chargers, and vulcanizers.

2.4 SELECTION OF SAMPLE POINTS

Before the main survey, an initial assessment was carried out. This preliminary investigation took place in Agagu Road, Aule, with the intention of understanding the study location. The following criteria were utilized to pinpoint the specific workshops that align with the study's objectives:

1. the number of years of operation (a minimum of 5 years),
2. the absence of other industries within the area,
3. the presence of groundwater and
4. the type of activities carried out within the workshop.

Workshops was then selected based on the result obtained from the survey. The control point was also sited Agagu road, Aule and was characterized as a source of ready to use water for the residents.

2.5 RAW WATER SAMPLE COLLECTION

Samples of untreated water were gathered from excavated wells situated within a range of 0 to 50 meters around each workshop. These water samples were meticulously collected in sanitized and clearly labelled one-litre plastic containers, originating from different locations. To safeguard the integrity of the water quality during transportation to the laboratory for subsequent analysis, the samples were stored at a temperature lower than 4 degrees Celsius inside coolers. This precautionary measure aimed to prevent any alterations in the water quality during transit.

2.6 WATER QUALITY TESTS

2.6.1 Physical Parameters

A. Temperature

The temperature of the water samples for both wet and dry seasons was measured in degrees Celsius using a thermometer.

B. Turbidity

The turbidity of the water samples for both wet and dry seasons was determined using a turbidimeter.

2.6.2 Chemical Parameters

A. pH

The pH was measured using Technel USHA pH meters, model PHS 25. The pH meter was calibrated with buffers 4 and 6.7. Then Electrodes was placed in a 50 ml sample measured in a beaker, and the readings were taken.

B. Electrical Conductivity (EC) and Total Dissolved Solid (TDS)

Electrical conductivity and Total Dissolved Solid (TDS) were measured using Jenwey portable condition meter, model 470. The electrodes of the portable meter were dipped into the samples and the reading was taken after stabilization.

C. Total Alkalinity

A 50 ml sample was titrated with 0.02N of H2SO4 using 5 drops of Phenolphthalein indicator. Titration was continued while rotating the flask until a pink solution is obtained. The colour changed from pink to colourless. At this endpoint, bromocresol green methyl red Indicators was added to the titrated sample, vortexed and mixed. The titration continued until the pale pink colour faded out. Then the amount of H2SO4 used was recorded and calculated as alkalinity (APHA, 1998).

D. Hardness

A DR/890 Colorimeter was used to measure the Hardness of the water samples for both dry and wet seasons.

E. Chloride

Mohr's method (precipitation titration) was used for the determination of chloride ions in the water samples. This method determines the chloride ion concentration of a solution by titration with 0.02N silver nitrate and the indicator used is 5% potassium chromate solution (Bitar, 2016).

F. Nitrate

Nitrate was determined based on the reactions involving sulfanilic acid with methyl anthranilate as the coupling agents followed by reduction using Zn/NaCl and diazotization (Narayana and Sunil, 2009).

G. Sulphate

Sulphate was determined using Turbidimetry. Barium Chloride was used as precipitating agent and glycerol with conc. HCl distilled water 95% ethyl alcohol and 75 g sodium chloride was used as conditioning agent. Concentration of sulphate was calculated from calibration curve (Yogita and Kamalpreet, 2016).

H. Phosphate

To 4ml of the water samples, 1ml of ammonium molybdate and 0.4 ml of hydrazine sulphate were added and was made up to the mark with double distilled water in a 10ml standard flask. This was kept for 30 minutes in a water bath for heating at 60°C. On heating, a blue colour was developed due to the formation of phosphomolybdate complex and was cooled and the absorbance was measured using CECIL CE 7200, 7000 series at 860nm (Oladeji et al., 2016).

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I. Total Suspended Solid

Total suspended solids were measured using the Gravimetric method. A known amount of the water sample was filtered through a pre-weighed filter paper. The filter paper was dried between 103°C and 105°C (APHA, 1995). TSS was determined using the following formula:

$$\text{Total Suspended Solids (TSS) mg/l} = \frac{(A-B) \times 10^3}{C} \quad (1)$$

Where:
A is the weight of the filter paper plus solids (g);
B is weight of filter paper (g);
C is the volume of the filtered sample (ml).
Bacteriological Parameter
Total Bacterial Count

The pour plate method was adopted for the enumeration of the total bacterial count of the water samples.

2.6.3 Coli Form Count

The most probable number (MPN) technique as suggested by APHA (1995) and modified by Olutiola et al. (2000) was adopted.

2.6.4 Analysis of Physico-Chemical Properties

The statistical analysis of the water parameters was carried out using SPSS statistics 22 software. The pairwise comparison, which is a comparison between the mean value of the parameters in each location to the WHO standard, was also made for each water quality parameter. The significant level (P) was set to 0.05; i.e., if P > 0.05, it is not significant (the parameter is within the WHO permissible limit) while P < 0.05 means it is significant (the parameter exceeds the standard) (Ojo et al., 2022).

3 Results

Table 1. Physicochemical Test Result for Wet Season

Water parameter	Control point	Well A	Well B	Well C	Well D	Well E	WHO
Alkalinity	62.17	103.33	83.33	123.05	80	143.33	-
Acidity	11.90	120.83	70.83	91.67	79.17	75.00	-
TH	56.37	150.00	163.33	123.33	146.66	263.33	500
Cl	180.00	650.83	840.16	556.17	639.00	1147.83	200
NO3	23.55	76.00	74.00	71.60	64.80	44.60	50
SO4	70.14	95.60	82.20	113.20	79.60	124.00	100
PO4	51.70	122.00	107.60	145.20	152.00	162.80	1
TDS	100.00	210.00	200.00	190.00	210.00	200.00	500
TSS	100.00	160.00	500.00	152.00	170.00	142.00	500
Mg	20.09	33.34	39.99	10.00	26.66	110.00	50
Ca	29.50	116.66	123.34	113.30	120.00	163.33	75-200
Temp.	27	28	24	27	30	29	25
Turb	11	11	10	10	12	11	5
pH	8.09	6.1	5.7	8.7	8.5	8.8	6.5-8.5
EC	240.16	1100.00	1000.00	1200.00	1000.00	1200.00	400

Table 2. Physicochemical Test Result for Dry Season

Water parameter	Control point	Well A	Well B	Well C	Well D	Well E	WHO
Alkalinity	51.70	79.16	54.16	70.83	54.16	95.83	-
Acidity	10.50	100.00	25.00	50.00	41.60	41.60	-
TH	50.11	136.60	140.00	83.33	116.60	200.00	500
Cl	196.50	473.30	745.50	449.60	579.80	982.10	200
NO3	20.05	35.00	34.00	31.60	24.80	44.60	50
SO4	65.00	55.60	70.00	73.20	62.00	79.60	100
PO4	49.16	57.60	67.60	65.20	72.00	94.00	1
TDS	10.00	20.00	21.00	14.00	17.00	20.00	500
TSS	10.00	15.000	17.000	14.000	14.000	14.000	500
Mg	22.90	53.27	50.00	13.33	29.94	73.40	50
Ca	26.90	83.33	90.00	70.00	86.66	126.60	75-200
Temp.	28	26.00	25.00	28.00	29.00	31.00	25
Turb.	10	10.00	10.00	10.00	9.00	10.00	5
pH	8.06	6.40	6.30	8.50	8.90	7.80	6.5-8.5
EC	209.50	1000.00	900.00	1000.00	900.00	1000.00	400

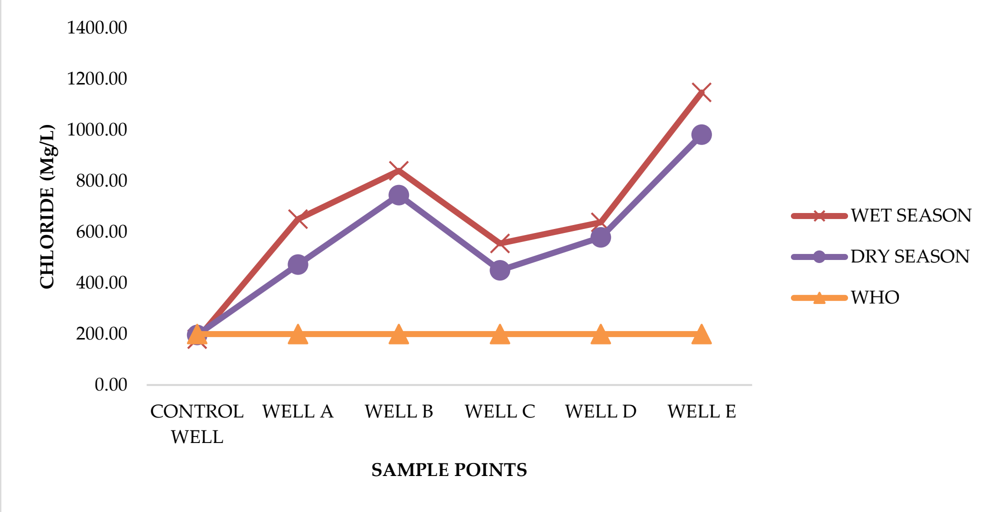

Fig. 1: Chloride value of the Sample wells

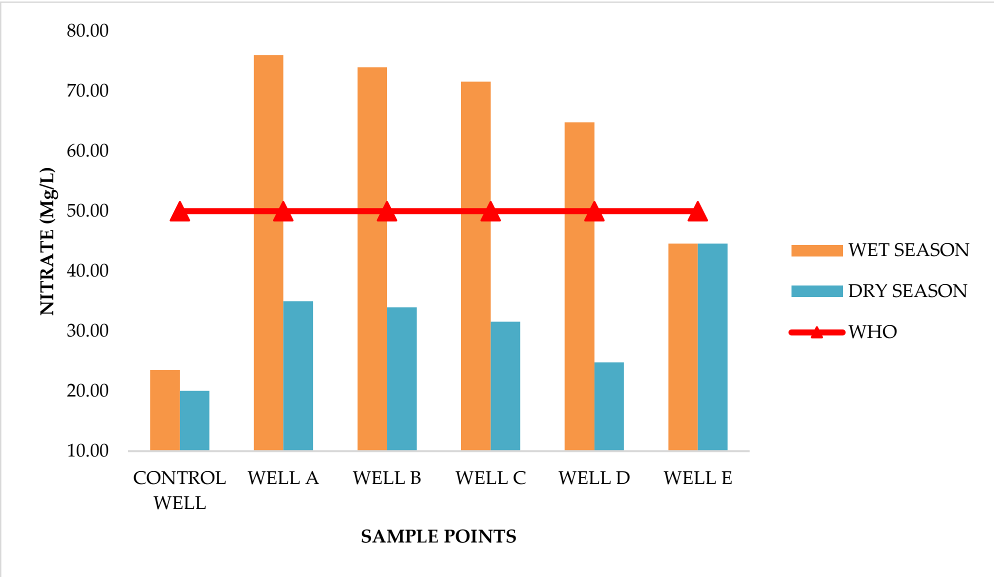

Fig. 2: Nitrate value of the Sample wells

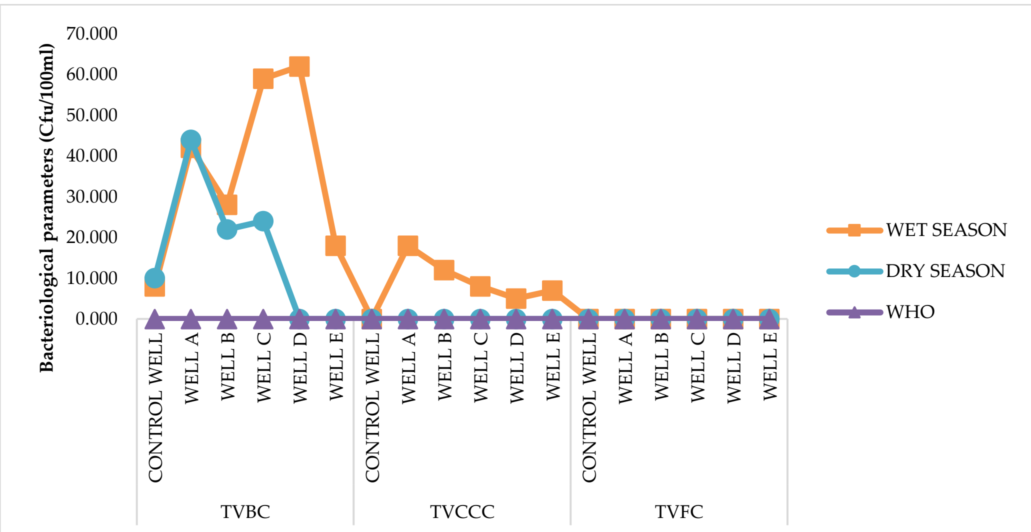

Fig. 3: Bacteriological parameter value of the Sample wells

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Table 3. Correlation Matrix between the Physicochemical and Bacteriological parameters of the Water Samples for Wet season

	Alkalinity	Acidity	TH	Cl	NO3	SO4	PO4	TDS	TSS	Mg	Ca	Temp.	Turb	pH	EC	TVBC	TVCC	TVFC
Alkalinity	1																	
Acidity	.541	1																
TH	.761	.450	1															
Cl	.714	.477	**.983****	1														
NO3	.223	.856*	.219	.333	1													
SO4	**.997****	.505	.714	.665	.194	1												
PO4	.755	.690	.756	.738	.509	.726	1											
TDS	.521	**.877***	.679	.732	**.829***	.469	**.843***	1										
TSS	-.197	.088	.165	.338	.484	-.224	-.057	.326	1									
Mg	.620	.062	**.885***	**.823***	-.233	.582	.434	.276	.001	1								
Ca	.762	.691	**.925****	**.945****	.546	.717	**.898***	**.890***	.254	.643	1							
Temp.	.264	.192	.252	.101	-.184	246	.499	.194	-.706	.251	.220	1						
Turb	-.240	-.063	.042	-.073	-.277	-.275	.149	.031	-.502	.124	-.034	**.833***	1					
pH	.326	-.282	.070	-.052	-.484	.363	.335	-.211	-.699	.159	.005	.639	.336	1				
EC	.774	**.862***	.729	.764	.750	.743	**.906***	**.928****	.195	.346	**.923****	.168	-.178	-.020	1			
TVBC	.134	.654	-.031	.006	.732	.130	.597	.625	-.042	-.452	.324	.314	.135	.129	.576	1		
TVCC	-.150	.731	-.217	-.177	.588	.169	-.747	.290	.220	-.172	-.324	-.401	-.290	-.831	-.097	-.229	1	
TVFC	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

b Cannot be computed because at least one of the variables is constant

Table 4. One-Sample T Test for the Physicochemical and Bacteriological parameters of the water samples for wet season

Water Parameters	Test Value (WHO Standard)	Df	Sig. (2-tailed)
TH	300	5	*0.003
Cl	200	5	*0.016
NO3	50	5	0.334
SO4	100	5	0.522
PO4	1	5	*0.001
TDS	500	5	*0.000
TSS	500	5	*0.004
Mg	50	5	0.525
Ca	138	5	0.193
Temp.	25	5	*0.032
Turb	5	5	*0.000
pH	7.5	5	0.803
EC	400	5	*0.013
TVBC	0.000	5	*0.010
TVCC	0.000	4	*0.012

* Significant at p<0.05

Table 5. Correlation Matrix between the Physicochemical and Bacteriological parameters of the Water Samples for Dry season

	Alkalinity	Acidity	TH	Cl	NO3	SO4	PO4	TDS	TSS	Mg	Ca	Temp.	Turb	pH	EC	TVBC	TVCC	TVFC
Alkalinity	1																	
Acidity	.527	1																
TH	.708	.315	1															
Cl	.571	.049	**.939****	1														
NO3	**.860***	.395	**.895***	**.840***	1													
SO4	.402	-.470	.366	.589	.519	1												
PO4	.637	-.013	**.841***	**.927****	.755	.687	1											
TDS	.442	.460	**.876***	.799	.761	.060	.567	1										
TSS	.173	.382	.605	.625	.582	.058	.367	**.879***	1									
Mg	.651	.266	**.919****	.787	.805	.228	.637	.793	.438	1								
Ca	.680	.320	**.962****	**.955****	**.873***	.426	**.903***	**.520***	.665	.776	1							
Temp.	.470	-.196	.262	.317	.200	518	.636	-.196	-.451	.143	.319	1						
Turb	.374	.051	.043	-.016	.394	.320	.142	.000	-.000	.231	-.092	-.267	1					
pH	-.132	-.341	-.358	-.204	-.406	.222	.150	-.608	-.562	-.557	-.186	.714	-.561	1				
EC	.559	.620	.683	.664	.727	.177	.597	.771	.809	.404	**.814***	.011	-.103	-.181	1			
TVBC	.886	**.973***	.728	.354	.792	-.621	.253	.697	.562	.604	.700	-.457	b	-.559	.754	1		
TVCC	b	b	B	B	B	b	b	b	b	b	B	b	b	b	b	b	b	
TVFC	b	b	B	B	B	b	b	b	b	b	B	b	b	b	b	b	b	b

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

b Cannot be computed because at least one of the variables is constant

Table 6. One-Sample T Test for the Physicochemical and Bacteriological parameters of the water samples for dry season

Water Parameters	Test Value (WHO Standard)	df	Sig. (2-tailed)
TH	300	5	*0.000
Cl	200	5	*0.020
NO3	50	5	*0.003
SO4	100	5	*0.000
PO4	1	5	*0.000
TDS	500	5	*0.000
TSS	500	5	*0.000
Mg	50	5	0.344
Ca	138	5	*0.007
Temp.	25	5	*0.023
Turb	5	5	*0.000
pH	7.5	5	0.732
EC	400	5	*0.019

* Significant at p<0.05

4 Discussion Of Results

4.1 Physico-Chemical Parameters of the Groundwater Samples

The physical and chemical parameters of the water samples in the locations were measured during the wet and dry seasons and the results are presented in Table 1 and Table 2 respectively. The control well has a relatively low alkalinity level during the wet season, and a slightly higher value of 51.70 mg/L during the dry season. Wells A, B, C, D, and E all have higher alkalinity values than the control well during both seasons. The highest alkalinity value is observed in well E during the wet season, which is 143.33 mg/L. These levels may indicate that the water is harder, meaning it has a higher concentration of dissolved minerals like calcium and magnesium. Hard water can have negative effects on plumbing systems, and may also affect the taste, odour and appearance of water.

Based on the WHO standards provided, all wells in the study area fell within the recommended range for total hardness in water, which is between 100 and 500 mg/L. However, Wells A, B, and E have hardness levels at or near the upper limit, indicating that the water in these wells may be more challenging to use for domestic or industrial purposes, as hard water can cause scaling and buildup in pipes and appliances. Additionally, high levels of hardness in drinking water have been associated with increased risk of kidney stones and cardiovascular disease. Based on Figure 1, all wells have higher levels of chloride than the WHO standard during both wet and dry seasons, with Well E having the highest levels throughout. The presence of high levels of chloride in the water supply can have negative effects on both the environment and human health. Chloride can impact the taste and odour of drinking water, and excessive chloride consumption can lead to gastrointestinal problems such as diarrhoea and stomach cramps, and may cause hypertension in some individuals.

Figure 2 shows that all wells have lower levels of nitrate than the WHO standard during the dry season, with Wells A, B, C, and D having values greater than the WHO standard during the wet season. While nitrate is an essential nutrient for plant growth, high levels of nitrate in drinking water can have negative impacts on human health. Excessive consumption of nitrate can lead to a condition called methemoglobinemia, also known as "blue baby syndrome," which reduces the ability of the blood to carry oxygen and can be fatal in infants. The lower levels of nitrate in these wells during the dry season are generally positive, as they reduce the risk of negative impacts on both human health and the environment. However, it is still important to monitor nitrate levels to ensure that they do not rise to levels that could be harmful. Excessive sulfate consumption can lead to gastrointestinal problems such as diarrhea and dehydration. It can also contribute to acid rain and can cause changes in the chemical composition of soils and surface water, affecting aquatic life. The high levels of phosphate in the wells A, B, C, D, and E during both seasons suggest that activities like washing and degreasing car parts using detergents and solvents may be responsible for the high phosphate levels. Materials such as motor oil, transmission fluid, and brake fluid can also contain phosphate that can leach into the groundwater. The high phosphate levels in the wells can have adverse effects on the environment and human health. Eutrophication caused by high phosphate levels can lead to the growth of harmful algal blooms that can produce toxins that can be harmful to aquatic life and humans who consume contaminated fish or shellfish. According to the World Health Organization (WHO), the recommended maximum level of TDS in drinking water is 500 milligrams per liter (mg/L). From Tables 1 and 2, all of the wells do not exceed this limit during both the wet and dry seasons, with concentrations ranging from 190 mg/L to 210 mg/L. The presence of TDS in water can have various effects on human health and the environment. High levels of TDS can lead to an unpleasant taste, odor, or color in the water, which can make it less appealing to drink. Additionally, some of the dissolved solids can have adverse health effects, such as causing gastrointestinal problems or contributing to the development of certain diseases. The use of cleaning chemicals, oil, and grease can all lead to elevated TDS levels in the wastewater generated by the workshop.

4.2 Bacteriological Parameters of the Groundwater Samples

The results (Figure 3) suggest that the groundwater in the sample areas is contaminated with bacteria, possibly due to activities and materials used in the nearby automobile mechanic workshop. The use of oil and grease in automobile repair can lead to bacterial contamination of the water. The higher concentrations of TVBC and TVCC in some wells during the wet season may be due to increased runoff and infiltration of contaminated water into the groundwater. In contrast, the lower concentrations during the dry season may be due to decreased water flow and dilution. The effect of bacterial contamination on the environment and human health can be significant. Pathogenic bacteria can cause waterborne diseases such as cholera, typhoid fever, and dysentery, which can be serious or even fatal.

4.3 Statistical Analysis

The statistical analysis of the water parameters was carried out using SPSS statistics 22 software. From the automobile workshop, there are several activities that can affect soil and water quality. For example, oil spills, leaks, and improper disposal of hazardous materials such as batteries and solvents can all contribute to soil and water pollution.

4.4 Correlation Matrix Between the Physicochemical and Bacteriological Parameters of the Water Samples for Wet Season

The following are the interpretations of the correlation matrix in Table 3 with respect to these activities: Alkalinity and SO4 (sulfate) are strongly positively correlated (0.997**). This suggests that the presence of sulfate in water may increase its alkalinity. Sulfate can come from a variety of sources, including automotive fluids and detergents used for washing vehicles. Acidity and NO3 (nitrate) are weakly positively correlated (0.856*). Nitrate is a common pollutant in areas with high agricultural activity, but it can also come from sources such as fertilizers and animal waste. In an automobile

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workshop, nitrate may be present in coolant and other fluids. TDS (total dissolved solids) and EC (electrical conductivity) are strongly positively correlated (0.928**). This indicates that water with a high TDS concentration is likely to have a high EC as well. TDS can come from a variety of sources, including dissolved minerals and salts in the soil, as well as chemicals from automotive fluids and cleaning products.

4.5 One-sample T Test for the Physicochemical and Bacteriological Parameters of the Water Samples for Wet Season

Table 4 provides water quality parameters and their respective values, the degrees of freedom (df), and the significance levels (Sig.) based on a two-tailed test. The WHO standards serve as a benchmark for water quality. This is a comparison between the mean value of the parameters in each location to the WHO standard, was made for each water quality parameter. The significant level (P) was set to 0.05; i.e., if $P > 0.05$, it is not significant (the parameter is within the WHO permissible limit) while $P < 0.05$ means it is significant (the parameter exceeds the standard). From the result, NO3, SO4, Mg, Ca, and pH had the value $p>0.05$, while the other parameters had $p<0.05$. This means that the mean values of NO3, SO4, Mg, Ca, and pH is within the WHO permissible limit, while the mean value of the other water parameters exceeds the WHO permissible limit.

4.6 Correlation Matrix Between the Physicochemical and Bacteriological Parameters of the Water Samples for Dry Season

The statistical analysis of the water parameters was carried out using SPSS statistics 22 software and the result is shown in Table 5. Acidity correlated negatively with SO4, PO4, Temp and pH. Whereas it correlated positively with TVBC ($r=0.973$, $p<0.05$). TH had a negative correlation with pH, and a positive correlation with Cl ($r=0.939$, $p<0.01$), NO3 ($r=0.895$, $p<0.05$), PO4 ($r=0.841$, $p<0.05$), TDS ($r=0.876$, $p<0.05$), Mg ($r=0.919$, $p<0.01$), and Ca ($r=0.962$, $p<0.01$). A negative correlation exists between Cl, Turb, and pH, while Cl had a positive correlation with NO3 ($r=0.840$, $p<0.05$), PO4 ($r=0.927$, $p<0.01$), and Ca ($r=0.955$, $p<0.01$). NO3 negatively correlated pH, and positively with Ca ($r=0.873$, $p<0.05$). PO4 correlated positively with Ca ($r=0.903$, $p<0.05$). TDS correlated negatively with Temp, and pH and positively with TSS ($r=0.879$, $p<0.05$). pH correlated negatively with EC, pH, and TVBC.

4.7 One-sample T Test for the Physicochemical and Bacteriological Parameters of the Water Samples for Dry Season

From Table 6, it is observed that some parameters such as TH, Cl, NO3, SO4, PO4, TDS, TSS, Temp, Turb, and EC have a significance level less than 0.05, which indicates that they are significantly different from their respective WHO standards. On the other hand, Mg, Ca, and pH do not show a significant difference from their WHO standards. These metals can originate from the use of engine oil and other automotive fluids. Similarly, high levels of chloride (Cl), nitrate (NO3), and sulfate (SO4) in water can indicate the presence of chemicals such as brake fluid, coolants, and battery acids. This contamination may be from sources such as runoff from the workshop and nearby areas where cars are repaired.

5 Conclusion

Based on the results obtained from the analysis of the physicochemical parameters, the nitrate content for Wells A,B,C and D exceeded the WHO standard (Figure 2), while the chloride contents for all the sample wells excluding the control well exceeded the WHO standard (Figure 1), also this study revealed that automobile repair activities had impacts on some physicochemical parameters such as phosphate, chloride, lead, and EC which were found to be above the recommended limits set by WHO. Poor waste disposal practices by automobile repairers, inadequate regulatory frameworks, and a lack of awareness among community members on the dangers of groundwater pollution are highlighted as contributing factors to the problem.

6 Recommendation

The following recommendations were drawn from the study:

(a) It is essential to implement appropriate strategies for the management of waste. This includes the introduction of recycling mechanisms and the proper disposal of hazardous materials within the study area.

(b) Initiating awareness campaigns is recommended to educate the general public, automobile repair workers, and policy-makers about the significance of safeguarding groundwater resources and the potential hazards associated with soil and groundwater contamination.

(c) To ensure consistent adherence to environmental regulations and to continually assess the groundwater quality in the study region, the government should establish monitoring programs. This will contribute to maintaining the integrity of the environment and groundwater resources over time.

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