Nigerian Research Journal of Engineering and Environmental Sciences 7(1) 2022 pp. 40-48
p ISSN: 2635-3342; e ISSN: 2635-3350

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

Original Research Article

Statistical Analysis of the Physico-Chemical and Bacteriological Properties of Some Surface Water Samples in Akure, Ondo State, Nigeria

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http://doi.org/10.5281/zenodo.6720740

ARTICLE INFORMATION

Article history:
Received 09 Mar, 2022
Revised 19 Apr, 2022
Accepted 20 Apr, 2022
Available online 30 Jun, 2022

Keywords:
Physico-chemical
Bacteriological
Parameters
SPSS
Statistical analysis

ABSTRACT

In this study, four sampling points from the major river that flows through Akure, Ondo State, Nigeria was considered. A total of 16 samples were obtained from the sampling points and some physico-chemical and bacteriological tests were carried out on each sample. Statistical analysis of the water parameters was carried out using SPSS statistics 22 software, and a comparison between the mean value of the parameters in each location to the World Health Organization (WHO) standard was made for each water quality parameter. The results obtained from the statistical analysis showed that of all the physico-chemical and bacteriological parameters tested only two parameters (sulphate and zinc) had a P value that was > 0.05 which implies that they did not significantly affect surface water quality in the study area, while other parameters fell short of this criterion. It is recommended that water from these surface water sources undergo adequate treatment before potable use.

1. INTRODUCTION

Water is one of the most important compounds on earth, and its quality and usage is of paramount importance (Boyd and Tucker, 2012). Different sources of water including underground and surface water and its primary usage for example, domestic, industrial and agricultural are recognized (Cuo, 2016). The quality of surface water is important for various purposes such as domestic, industrial, agriculture uses (Nagaraju *et al.*, 2014). The quality of water resources is affected by natural and anthropogenic activities which may render it less valuable for human use, hence, water quality issues are of great concern to public decision and policy-makers (Matshakeni, 2016). Periodic assessment of water quality is recommended in order to monitor any deterioration in the quality of the water (Ojo, 2022).

Water pollution is one of the several critical issues facing the world in both developed and developing countries (Chaudhry and Malik, 2017). River water quality can be reflective of activities within its catchment as well as anthropogenic land uses and climate and geomorphic processes (Lespez *et al*., 2015). For instance, water turbidity can occur if there is a high volume of livestock grazing on steep slopes due to surface runoff, with this being reversible if grazing occurs on flatter areas. Likewise, high applications of fertilizer may result in eutrophic rivers, especially when applied to sandy soils with high drainage density over a period of time (Lange *et al*., 2011). Anthropogenic activities such as agriculture, deforestation and urbanization have been identified as the main drivers of land use and land cover change which affect the quality of water bodies (Khan *et al.,* 2015; Olusola *et al.,* 2018). Physico-chemical and bacteriological parameters are tested to assess the usability of the water samples. Assessing the water quality parameters is essential for evaluating and improving surface water quality (Islam *et al.,* 2019). Ojo *et al.* (2022) affirmed that there are seasonal variations in surface water quality but recommended that adequate water treatment should be carried out before usage irrespective of the season.

Various computer software programs for data analysis are available but the unique features and user-friendly interface of SPSS compels researchers to utilize it despite the availability of other options (Arkkelin, 2014). This study utilizes SPSS to analyze and evaluate the effect of the physico-chemical and bacteriological properties of surface water samples in Akure, Ondo state, Nigeria.

2. MATERIALS AND METHODS

2.1. Description of Study Area

Akure, is one of the largest cities and capital of Ondo State, Nigeria with a current population of 3,441,024 according to National Population Commission of Nigeria and this has risen dramatically since then as a result of immigration, high birth and low mortality rate. It is a settlement located in the south western part of Nigeria, about 350 km away from Lagos. It lies in the southern part of the forested Yoruba Hills and at the intersection of roads from Ondo, Ilesha, Ado-Ekiti, and Owo. Akure is an agricultural trade centre for cassava, corn (maize), bananas, plantain, rice, palm oil and kernels, okra, rubber, coffee, and pumpkins. Although cocoa is by far the most important local commercial crop, cotton, teak, and palm produce are also cultivated for export. The town's industries include electronics manufacturing, carbonated drink bottling, weaving, and pottery making. Akure is the site of the Federal University of Technology, Akure (founded in 1981), and the Federal College of Agriculture (1957). The rate of urbanization in Akure has been on the increase because of the dual roles it plays as the State capital and local government headquarter, hence the population has been on the rise, with the concentration of government administrative activities at both the local and state levels, coupled with other commercial and few industrial activities in the city. Ala catchment cut across two local government areas in Ondo State, namely Akure South and Akure North. The coordinate of the catchment is latitude 7º 40` N and 7º 80`N and longitude 5º 10` E to 5º 10`E. The catchment area of Ala catchment is 15.6km², the catchment drains more than 60% of Akure Metropolis such as Oyemekun, Federal University of Technology Akure (FUTA), Alagbaka, Adesida, Shagari Village, Oba-Ile areas and so on. Ala-River traverses the city of Akure. The rainfall distribution in the region has two modes and these are the rainfall peaks in July and September. Also, it breaks for about two weeks in August.

2.2. Selection of Sampling Points

Ala-river is a large river that have many tributaries and travel along various places in Akure, Ondo State. The locations and the places used for sampling considered the influence of human impact and land use. The sampling sites were selected and tracked using the Google map and Google earth pro computer software.

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The site map as shown in Figure 1 was drawn using ArcGIS software and visitation was done to the river site where samples were collected for laboratory tests. Four sites were selected and each site consisting of four sample points at an interval of 1 km. These sites are; Araromi, Oba-Ile, Ala-Elefosan and Ifon. The selection was strategically based on the land use of the area.

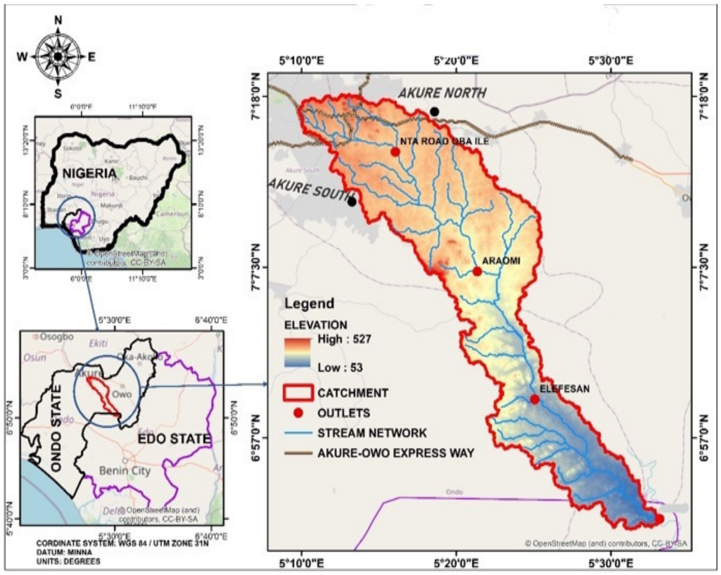

Figure 1: Study area showing sampling points (Ojo *et al.,* 2022)

2.3. Sample Collection

The sterile sampling bottles for biological test and the plastic bottles for chemical and physical tests were used for the collection of water samples in this research. The bottles were first rinsed with distilled water and the water samples were collected securely and sealed with proper labels. Four liters of water per visit was collected four times from each sample point, and the samples were labelled and protected with ice block in a cooler to prevent the micro-organism from multiplying so as to get the correct results from the analysis. The samples were then taken to the laboratory on the same day for analysis. Aeration during sampling was avoided as much as possible, so as not to affect the volume of water sample taken (Jannat *et al.,* 2019). The water samples were carefully transported to the laboratory and were preserved for analysis.

2.4. Physico-chemical and Bacteriological Tests

The USEPA (1979) and (1996) standard methods were used to carry out the laboratory tests on the water samples. The physico-chemical tests carried out includes total hardness (TH), magnesium (Mg), chlorine (Cl), nitrite (NO_2), nitrate (NO_3), sulphate (SO_3), phosphate (PO_4), dissolved oxygen (DO), turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), chromium (Cr), cadmium (Cd), iron (Fe), manganese (Mn), zinc (Zn) and pH, while the biochemical tests that were carried out were total faecal count (TFC) and total viable coliform count (TVCC).

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3. RESULTS AND DISCUSSION

3.1. Results of Physico-chemical Tests

The results of the physico-chemical tests for the four batches and sample points are represented in Figures 2 to 18. In all the locations, TH, Cl, PO_4, Turbidity, COD, Fe and Mn values in the samples were below the WHO standard for the four weeks. The third week sample for Oba-Ile had a Mg value that was less than the WHO standard value, while other samples were above the standard. Cd and Zn values in the 16 samples were above the WHO standard. The Cr and NO_3 values were high in the samples with the exception of Ifon on the first and second week respectively. The SO_3 values for Ala (week 1, 3 and 4), Ifon (week 3) and Oba-Ile (week 1) were low, while other samples had values that was higher than the acceptable limit by WHO. Likewise, the BOD values for Ala & Araromi (week 1) and Ifon (week 1 &2) were low, while other samples had values that were higher than the standard. In the same vein, the pH values were within the acceptable limit all samples except Ala (week 2), Araromi (week 4) and Oba-Ile (week 2, 3 and 4). The results obtained from the tests can be likened to the result obtained by Al-Ghamdi *et al.* (2014) in their research.

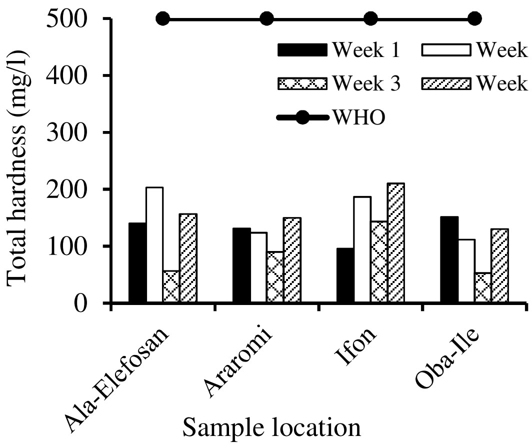

Figure 2: Results of total hardness of the samples

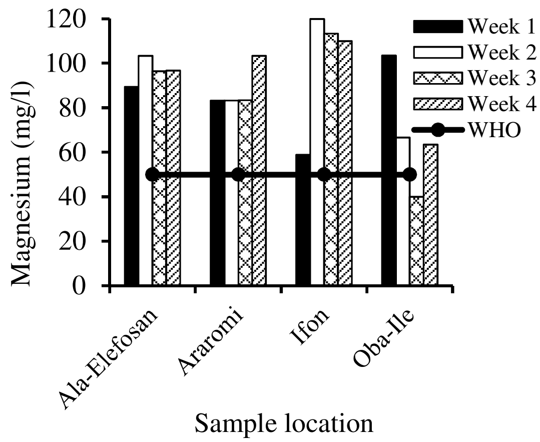

Figure 3: Results of Mg of the samples

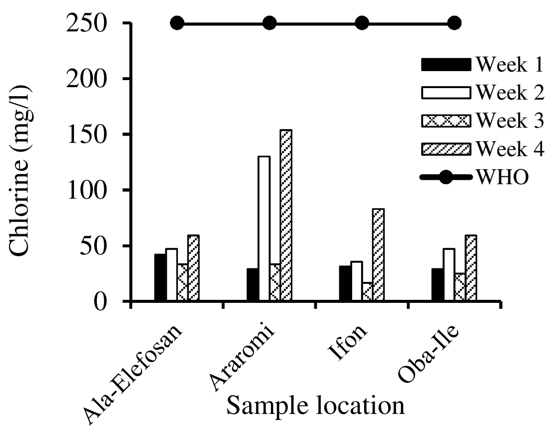

Figure 4: Results of Cl of the samples

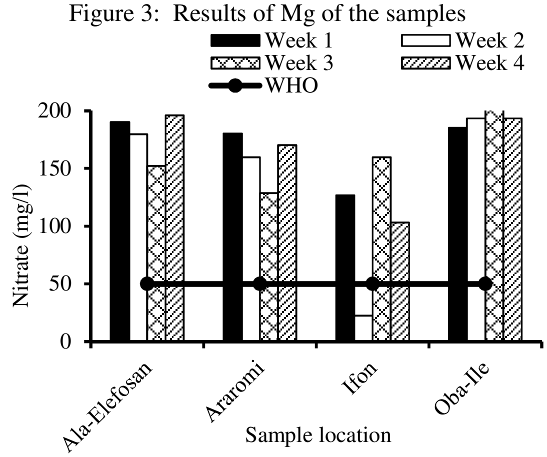

Figure 5: Results of NO_3 of the samples

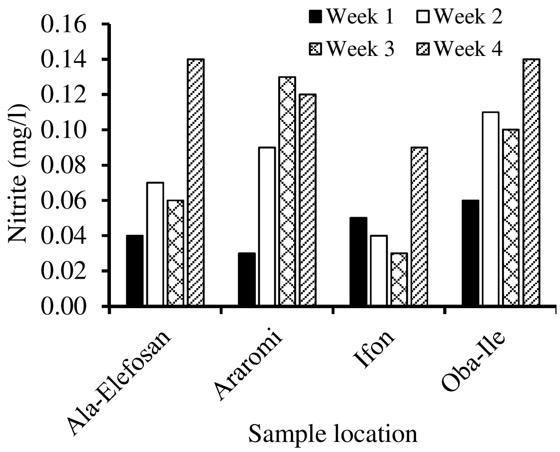

Figure 6: Results of NO_2 of the samples

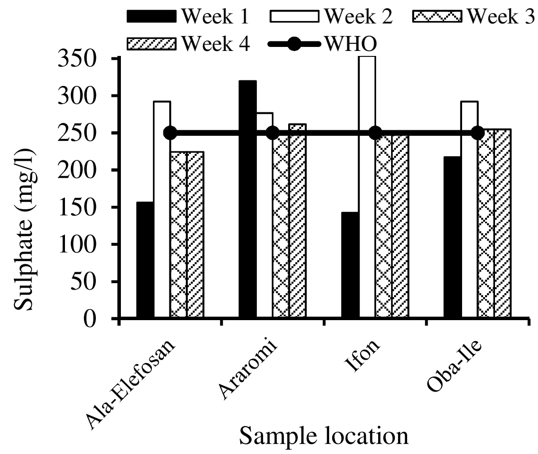

Figure 7: Results of SO_4 of the samples

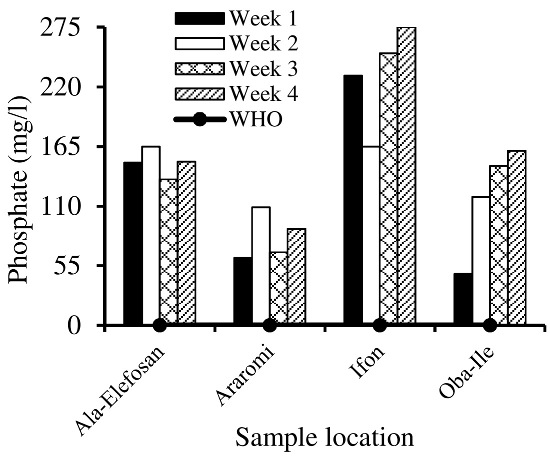

Figure 8: Results of PO_4 of the samples

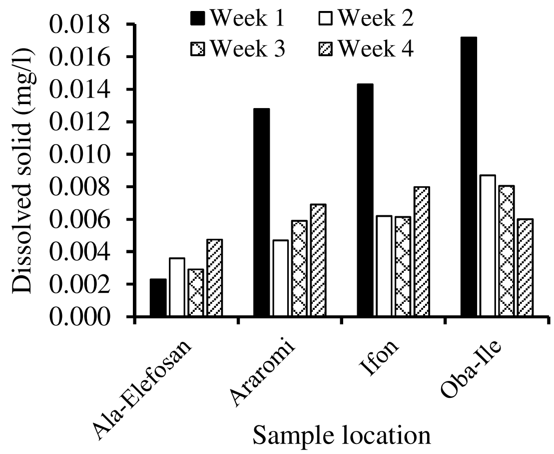

Figure 9: Results of DO of the samples

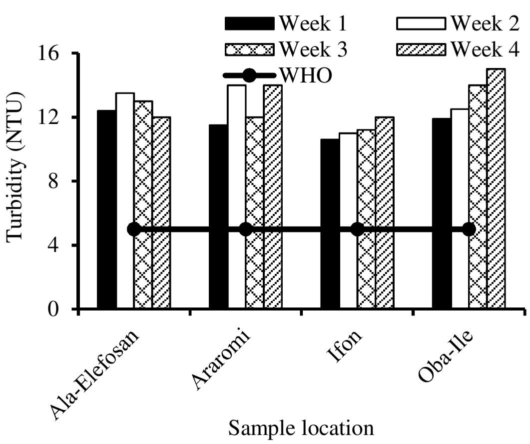

Figure 10: Results of turbidity of the samples

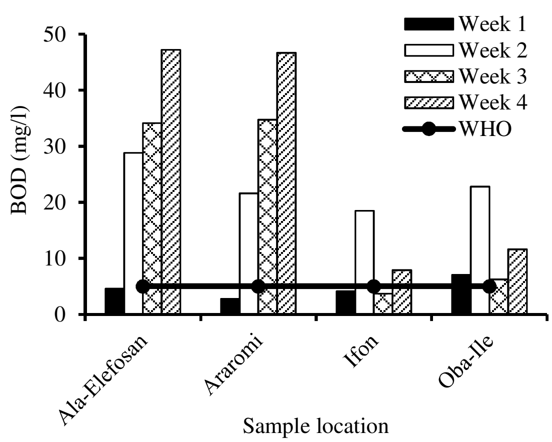

Figure 11: Results of BOD of the samples

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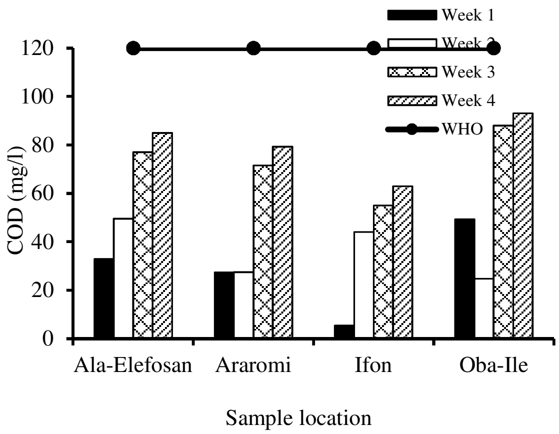

Figure 12: Results of COD of the samples

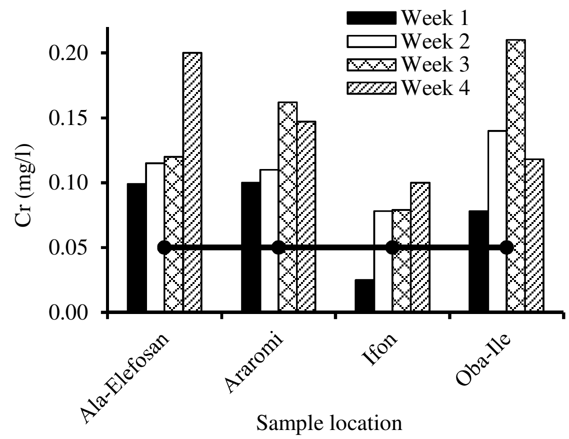

Figure 13: Results of Cr of the samples

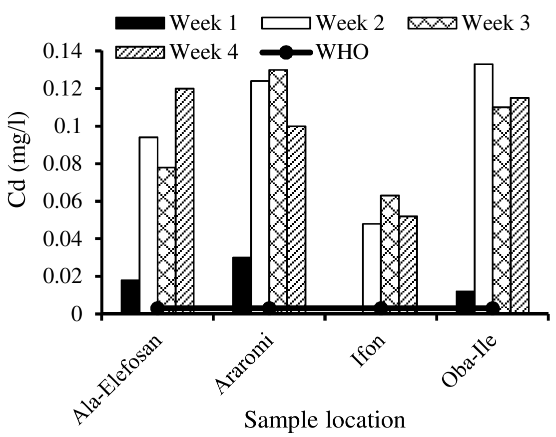

Figure 14: Results of Cd of the samples

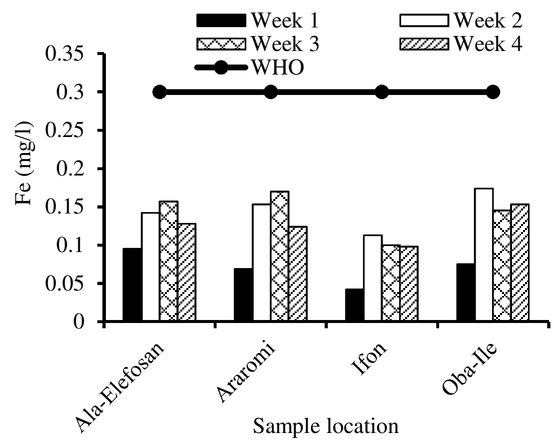

Figure 15: Results of Fe of the samples

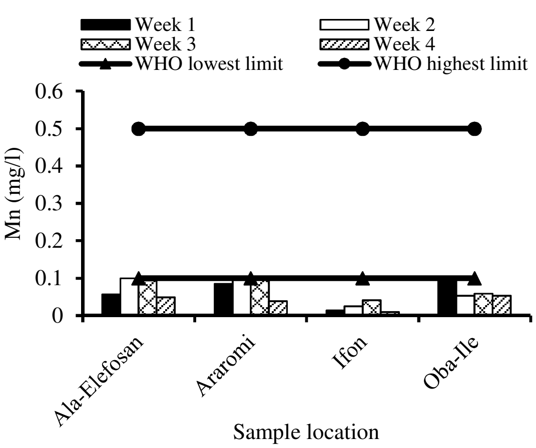

Figure 16: Results of Mn of the samples

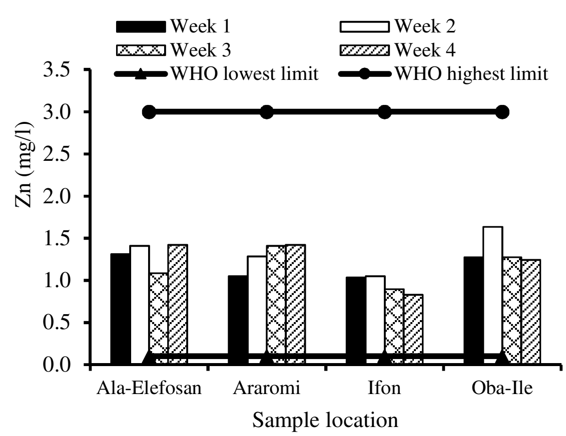

Figure 17: Results of Zn of the samples

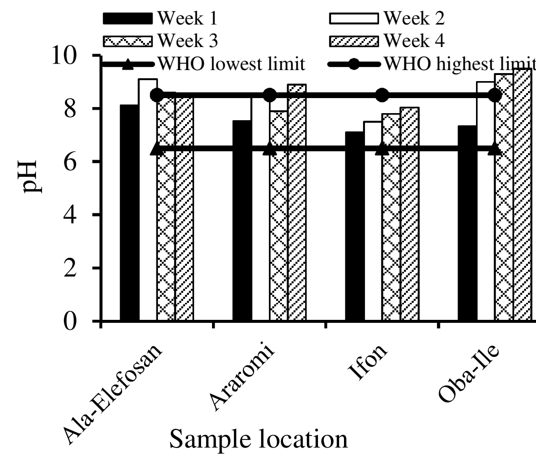

Figure 18: Results of pH of the samples

3.2. 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 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). The results obtained from the statistical analysis of the physico-chemical properties is shown in Table 1.

Table 1: Statistical analysis of the physico-chemical properties

Parameters	P-value			
	Point 1	Point 2	Point 3	Point 4
pH	0.217	0.034	0.068	0.844
TH	0.000	0.000	0.000	0.000
Mg^{2+}	0.009	0.169	0.002	0.001
Cl^{-1}	0.000	0.000	0.000	0.000
NO_2	0.000	0.000	0.000	0.000
NO_3^-	0.000	0.000	0.000	0.023
SO_4^-	0.459	0.894	0.474	0.954
PO_4^-	0.003	0.000	0.000	0.000
DS	0.000	0.000	0.000	0.000
Turbidity	0.000	0.000	0.000	0.000
BOD	0.028	0.446	0.017	0.692
COD	0.001	0.006	0.004	0.000
Cr	0.009	0.005	0.007	0.450
Cd	0.004	0.006	0.017	0.195
Fe	0.000	0.000	0.000	0.000
Mn	0.010	0.007	0.009	0.002
Zn	0.705	0.792	0.725	0.334

From the result obtained it was revealed that, sulphate and zinc with $P > 0.05$ were the two parameters that did not significantly affect the water sample from the four sample locations. The P-value of 0.000 was obtained for total hardness (TH), chlorine (Cl), dissolved solid (DS), total dissolved solid (TDS), turbidity, nitrate (NO_2) and iron (Fe) in all the water samples as shown in Table 1. This means that the effect of these parameters is felt on the water samples because they significantly affect the water samples and are beyond the permissible limit (i.e., $P < 0.05$). Also, as shown in Table 1, the sample from point 2 was not significantly affected by magnesium (Mg) because it had a P-value of 0.169 which means that it met the WHO requirement, unlike other sample locations with P-values < 0.05 i.e., Mg had a significant effect on the water samples, which would have been as a result of factors such as land relief, variation in precipitation and evaporation, and anthropogenic activities such as heavy use of fertilizers, improper discharge of wastewater amongst other activities (Potasznik and Szymczyk, 2015). The analysis showed that the effect of manganese (Mn), chemical oxygen demand (COD), phosphate and nitrate were significant in all the water samples, because the P value was less than (<) 0.05. From the statistical analysis, the results showed that the effects of Chromium (Cr), and Cadmium (Cd) were not significant on the water sample from point 4 ($P > 0.05$), but were significant on the samples from point 1, 2 and 3 i.e., $P > 0.05$. Cr pollution occurs due to a lack of waste management monitoring, while Cd is more typically found in basic sediments and suspended particles in natural waterways. Also agricultural activities (such as uncontrolled use of pesticides and fertilizers), landfills, sewage sludge, and a variety of activities in urban areas such as high emissions, industry, and mining are all anthropogenic sources of Cd (Sholehhudin *et al.*, 2021). BOD and pH were somewhat similar in that they were significant at two locations and were not significant at the other locations. BOD was not significant at point 2 and 4, while pH was not significant at point 1 and 4 ($P > 0.05$). Decayed leaves and wood, dead organisms, animal dung, broken septic systems, and discharge of wastewater are causes of BOD, while dissolved soil particles, chemicals and minerals increase the pH level of surface water.

3.3. Analysis of Bacteriological Properties

Table 2 shows the effect of total faecal count (TFC) and total viable coliform count (TVCC) of the water samples. The average value from each sample location was compared with the WHO standard using the pairwise comparison, the result showed that the TFC value for Ifon was significant because the P value was < 0.05, while the TFC value for other sample points were not significant. The TVCC value for all the sample locations were not significant because the P values were > 0.05, although Araromi had a close value of 0.064.

Table 2: Statistical analysis of the bacteriological properties

Parameters	P-value			
	Point 1	Point 2	Point 3	Point 4
TFC	0.217	0.034	0.068	0.844
TVCC	0.000	0.001	0.092	0.001

4. CONCLUSION

The statistical analysis showed that of all the physico-chemical properties of the water sample from Araromi, only pH, SO_4, Zn and TFC were not significant. In the water sample from Oba-Ile, the parameters that were not significant were pH, Mg, SO_4, BOD and Zn. The third sample points had pH, SO_4, Zn, TFC and TVCC to be not significant, while the last sample point had pH, SO, Cr, Cd, BOD, Zn and TFC to be not significant. Therefore, it is recommended that the water from these sources undergo adequate treatment before usage. Also, the government should enforce stringent laws and employ law enforcement agencies to ensure proper land usage and waste disposal methods so as to reduce water pollution.

5. ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of the staff of Chemistry Department, Federal University of Technology, Akure for carrying out the water analysis discussed in this study.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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