WATER QUALITY ASSESSMENT ON PHYSICOCHEMICAL AND BIOLOGICAL PARAMETERS OF SELECTED LENTIC ECOSYSTEM IN ABOH MBAISE LOCAL GOVERNMENT AREA, IMO STATE

ABSTRACT

The aim of this study is to determine the suitability of the ponds in Aboh Mbaise Local Government Area, Imo State, Nigeria for domestic use. A cross-sectional study was carried out for the study. A composite sampling method was used, where three water samples were collected randomly from each station to ensure that the samples were representative of the entire station. Samples were collected during the rainy season, given that the ponds always dry up during the dry season. Physicochemical and microbial analyseswere carried out on water samples of selected lentic aquatic ecosystems in randomly identified ponds in five communities of Aboh Mbaise. These ponds are used by the residents of these villages for various domestic and anthropogenic activities. The five selected ponds are located in the following villages: Olakwo in Enyiogugu, Umuabazu in Okwuato, Ibeku in Okwuato, Ama-Ukwu inUmuelemand Umuanumain Nguru. Statistical analyses include: descriptive statistics, Analysis of Variance, Parallel coordinate plot, Pearson correlation, Agglomerative Hierarchical Clustering (AHC), and Water Quality Index (WQI)according to Brown et etal(1972) modelwere calculated.Results indicate that pond water within the study area did not fall within the bracket of good water quality, as per the WQI range of 0 to 50, thereby affirming the poor quality of water. The WQI for the five ponds ranges from 1338.71 - 3322.81. There is a direct correlation between the presence of Total Bacterial Counts from Shigella and Salmonella counts and the presence of fecal contamination from both human and animal wastes. Given the poor quality of the pond water, it is unhealthy to use pond water for food preparation and other household tasks, except if it is treated.

Keywords: pond water, physicochemical-microbial analyses, WQI, Pearson correlation, AHC, Aboh-Mbaise

1. INTRODUCTION

Among the most fundamental of all-natural resources, water is absolutely crucial to every aspect of human life [1]; [2]. As the world's population has grown rapidly in recent years, so has the amount of fresh water that is needed for agriculture and industry [3]. Population growth, industrialization, mechanization, and urbanization are rapidly increasing the demand for water, which has led to a widespread effort to collect fresh water for commercial, industrial, and domestic use. However, appropriate sources of water supply continue to diminish due to resource depletion and pollution, even as demand rises rapidly [4]. Extreme water scarcity and the accompanying rise in water pollution are major contributors to the spread of water-borne diseases, making the situation particularly dire in most of Nigeria's southeastern states [5]. Water is a valuable natural resource and national treasure, and an ecosystem's primary component. Rivers, lakes, glaciers, rainwater, groundwater, and other natural bodies of water including pond water are the most common water sources. In most rural communities in Nigeria, pond wateris a result of runoff water or overland flow that discharges into burrow pits or valleys. In effect, it is possible that the runoff water has picked up sediments, dissolved solids, toxins, etc., from the environment in the cause of its flow into the pond. Aside from the necessity of water for drinking, water resources are essential to many economic sectors, including agriculture, raising cattle, forestry, industrial operations, hydropower production, fishing, and other creative endeavors. Due to certain significant reasons like population growth, industrialization, urbanization, etc., the availability and quality of water, whether it be surface or groundwater, have decreased. Physical, chemical, and biological factors can be used to evaluate the water quality of any particular source. If these factors' values exceed prescribed values by WHO, it is detrimental to human health [6]. Aboh Mbaise Local Government Area (LGA) is an environmentally sensitive geolocation that is one of the most densely inhabited areas of Imo state with a population of about 286,000 people and lacks a natural aquatic system to drain the land area. To improve water utilization during the dry and semi-dry seasons, residents of the local government rely on artificially made ponds as a source of water storage, while rainwater is harvested and stored during the rainy season. It's true that few people in the area really have access to borehole water. The inference is that the local population primarily uses the artificial aquatic system for household, agricultural, and food processing purposes. They use the water that has been stored in the ponds for cooking (cassava, breadfruit), washing (motorcycles, animals, etc.), and other household needs.

Water ponds are strategically placed in various areas of the local government. It is important to evaluate the water bodies and establish a quality index. This is crucial for determining whether or not the water is fit for human utilization. Therefore, the study is aimed at ascertaining the suitability of the ponds in Aboh Mbaise for anthropogenic activities and their domestic use. Thus, the study's objectives are to find out the physical characteristics of the lentic aquatic environment, learn the chemical properties of the ponds that have been left to stagnate, and to detect the microbiological quality of the water supply. The results of the evaluation will be used to establish a water quality index, and in addition, the pattern of water use will be identified, and appropriate recommendations will be made for improvement.

2. MATERIALS AND METHODS

2.1 Study Area

The study area of this research is made up of three communities in Aboh-Mbaise Local Government Area in Imo State where five water ponds are randomly selected (Figure 1). These ponds are located in five villages: Olakwo, Umuabaza, IbekuOkwuato, Ama-ukwuUmuelem, and UmuanumaNguru. The climate of the study area is characterized by two main seasons: the wet and dry seasons. Average yearly temperatures in the study area varies from 19.4°C to 30.5°C and is rarely below 15°C or above 32°C [7], and an average annual relative humidity of 75%, with humidity exceeding 90% during the rainy season [8]. The harmattan (wind) blows for two months during the dry season, from late December to late February. January and March experience the highest temperatures, while April is the onset of the rainy season that continues through October and brings an average of 1,500 to 2,200 millimeters of rain (60 to 50 inches) [7]. Due to excessive evaporation during the dry season, water levels drop, leading to an increase in the concentration of certain ionic species [9]. Anthropogenic activities, including agriculture and semi-urbanization, have had an impact on the lowland tropical rainforest in the study area. Tree crops including maize, yam, cassava, banana, plantain, vegetables, melons, and okra predominate in the vegetation, along with grasses like sidaacuta, chromoliar, etc. The majority of the land in these regions is farmed for food, but because of the lack of modern farming technology and the high population density, much of the farming done there is of the subsistence kind. Elevations ranging from (61 – 122) m above mean sea level characterize the Okigwe regional escarpment, which dominates the region's physiology [7]. There are no rivers, but the large spaces between these elevations are characterized by dry valleys that collect surface runoff after heavy rain. The uniformity of the rock structure and the lack of tectonic disturbances might explain the landscape's amazing monotone [10].

2.2 Data Collection

Sampling was an important tool for this research study because the population of interest consisted of many ponds for the research project to include as subjects. A good sample is a good representation of the population of interest and is enough for any examination required by the researcher [11]. A simple random sample technique was used in this study, where every pond at Aboh-Mbaise had an equal chance of being selected. Only specified equipment, including sample container bottles, and other sampling equipment was used. The sampling equipment was cleaned and maintained in good working order before use. The composite sampling method was used, where three water samples were collected randomly from each station to ensure that the samples were representative of the entire station. These individual samples were then combined to create a composite sample for each station, resulting in a total of four composite samples that were analyzed. The pond's water was sampled to analyze its chemical and biological composition. At each location where water was sampled, water was collected in designated 50 ml plastic containers for examination. The pond collected water samples were categorized as types A through E.

2.2.1 Description of Pond Location

Pond 1/Sample A located at **Olakwo, Enyiogugu Autonomous Community, AbohMabise LGA**., with coordinates 5°28’20.0” N 7°12’59.2” E - Pond 2/Sample B is located at **Umuabazu, OkwuatoAbohMbaise LGA**., with coordinates 5°28’22.2” N 7°13’0.9” E. Pond 3/Sample C is located at **Ibeku, OkwuatoAbohMbaiseLGA**., with GPS coordinates 5°2’30.4” N 7°15’6.7” E. Pond 4/Sample D located at **Ama-Ukwu, Umuelem, Autonomous Community Aboh Mbaise LGA**., having coordinates 5°28’33.9” N 7°14”23.3” E. POND 5/Sample E located at **Umuanuma, Nguru, AbohMbaise LGA,** with GPS coordinates 5°29’22.7” N 7°14’5.4” E.

Include these data into a Table

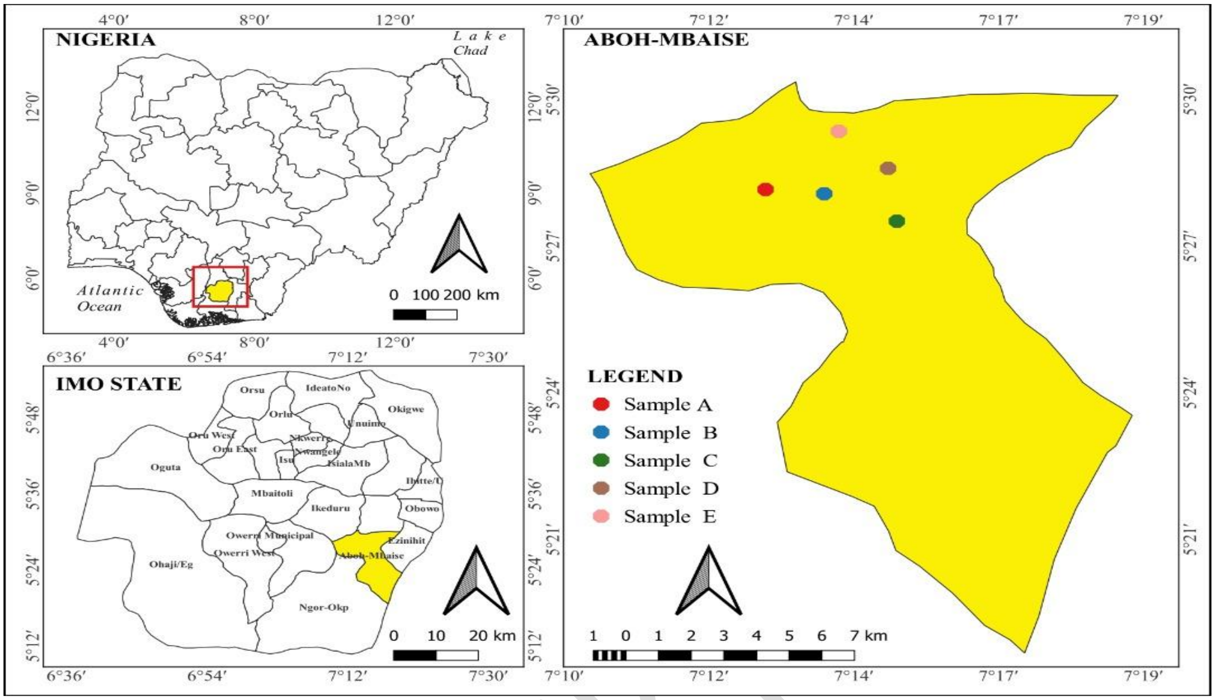

Figure 1: Map of the study area, showing five sampling locations

2.3 Water Quality Index (WQI)

The Weighted arithmetic Water Quality Index was employed to calculate WQI (Brown et al., 1970) [12] and implemented in Microsoft Excel. Horton et al (1965) [13] introduced the use of a weighted arithmetic water quality measure, which was further refined by Brown et al., [12]. The formula for the water quality index using weighted arithmetic (WQI) is presented as Equation (1):

$$WQI = \sum_{i=1}^{n} \frac{W_i Q_i}{\sum_{i=1}^{n} W_i} \qquad 1$$

Where: Q_i = Sub-Index of the i*th* parameter,

W_i = the unit weightage of the i*th* parameters

n = number of parameters

The ideal value for pH = 7, dissolved oxygen = 14.6 mg/l, and for other parameters, it is equal to zero (Tripathy &Sahu[14];Chowdhury et al. [15].

AccordingtoBrown et al.,[12] thevalueofQiiscalculatedusingEquation (2):

$$Q_i = \frac{(M_i - L_i)}{(S_i - L_i)} \times 100 \qquad 2$$

Where:

M_i = Observed value for physiochemical parameters,

Li = ideal value

S_i = standard value of the i*th* parameter.

3. RESULTS & DISCUSSION

3.1 Results

3.1.1 Descriptive Statistics of Water Quality Parameters

A comprehensive result of descriptive statistics on physiochemical and microbial parameters are presented in Tables 1 & 2.

Table 1: Descriptive Statistic of Physiochemical Parameters

Physiochemical Parameters	Statistic	Ama-UkwuUmuelem, AU	IbekuOkwuato, IO	UmuabazuOkwuato, UO	Umuanuma UN

pH	mean	6.40	6.35	6.00	6.45
	std	0.00	0.07	0.00	0.07
Temperature	mean	25.80	27.30	27.25	26.3
	std	0.99	0.57	0.49	0.35
Colour, PCU	mean	936.00	606.00	2570.00	980.0
	std	0.00	0.00	14.14	0.00
Electrical Conductivity	mean	132.50	88.00	107.50	138.5
	std	0.71	1.41	0.71	0.71
DO	mean	8.55	7.70	7.80	8.20
	std	0.07	0.00	0.00	0.00
BOD	mean	1.15	0.40	0.50	0.65
	std	0.07	0.00	0.00	0.07
COD	mean	148.00	292.00	196.00	104.0
	std	5.66	5.66	5.66	0.00
Turbidity	mean	700.20	410.75	891.50	640.5
	std	0.28	0.35	0.71	0.71
Total Solid	mean	356.00	198.00	552.50	271.0
	std	7.07	39.60	12.02	25.4
Total Alkalinity	mean	12.00	6.00	8.00	20.0
	std	0.00	2.83	0.00	5.66
TDS	mean	86.12	57.20	69.88	90.0
	std	0.46	0.92	0.46	0.46
TSS	mean	269.88	140.15	482.73	180.9
	std	7.53	39.60	12.34	25.0
Nitrate	mean	47.64	29.19	53.11	37.5
	std	0.09	0.00	0.00	0.10
Phosphate	mean	23.00	4.00	31.00	21.0
	std	1.41	0.00	0.00	4.24
Total Hardness	mean	119.14	88.06	119.14	98.4
	std	0.00	0.00	0.00	0.00
Sulphate	mean	100.00	0.00	100.00	50.0
	std	0.00	0.00	0.00	0.00
Iron	mean	1.80	1.87	1.89	1.80
	std	0.00	0.00	0.00	0.00
Copper	mean	0.00	0.02	0.01	0.01
	std	0.00	0.00	0.00	0.00

Table 2: Descriptive Statistic of Microbial Parameters

Microbial Parameters	**Statistic**	**Ama-UkwuUmuelem, AU**	**IbekuOkwuato IO**	**UmuabazuOkwuato UO**	**UmuanumaN UN**
Total Bacteria count	mean	1.04E+08	2.74E+08	2.70E+08	1.91E+0
	std	5.66E+06	8.49E+06	1.41E+07	1.27E+0
Total Coliform count	mean	3.75E+05	1.25E+05	4.25E+05	3.00E+0
	std	2.12E+04	3.54E+04	2.12E+04	4.24E+0
Total Shigella Count	mean	5.00E+03	2.50E+04	4.50E+04	0.00E+0

	std	7.07E+03	7.07E+03	7.07E+03	0.00E+0
Total Salmonella	mean	0.00E+00	0.00E+00	0.00E+00	0.00E+0
	std	0.00E+00	0.00E+00	0.00E+00	0.00E+0

3.1.2 Comparative Analysis of Selected Physiochemical Parameter for the five Sampling Locations

Comparative analysis in the form of plotting the distribution of various physiochemical parameters is presented in Figure 2. Similarly, an Analysis of Variance (ANOVA) was carried out for the physiochemical parameters for the five ponds (Table 3).

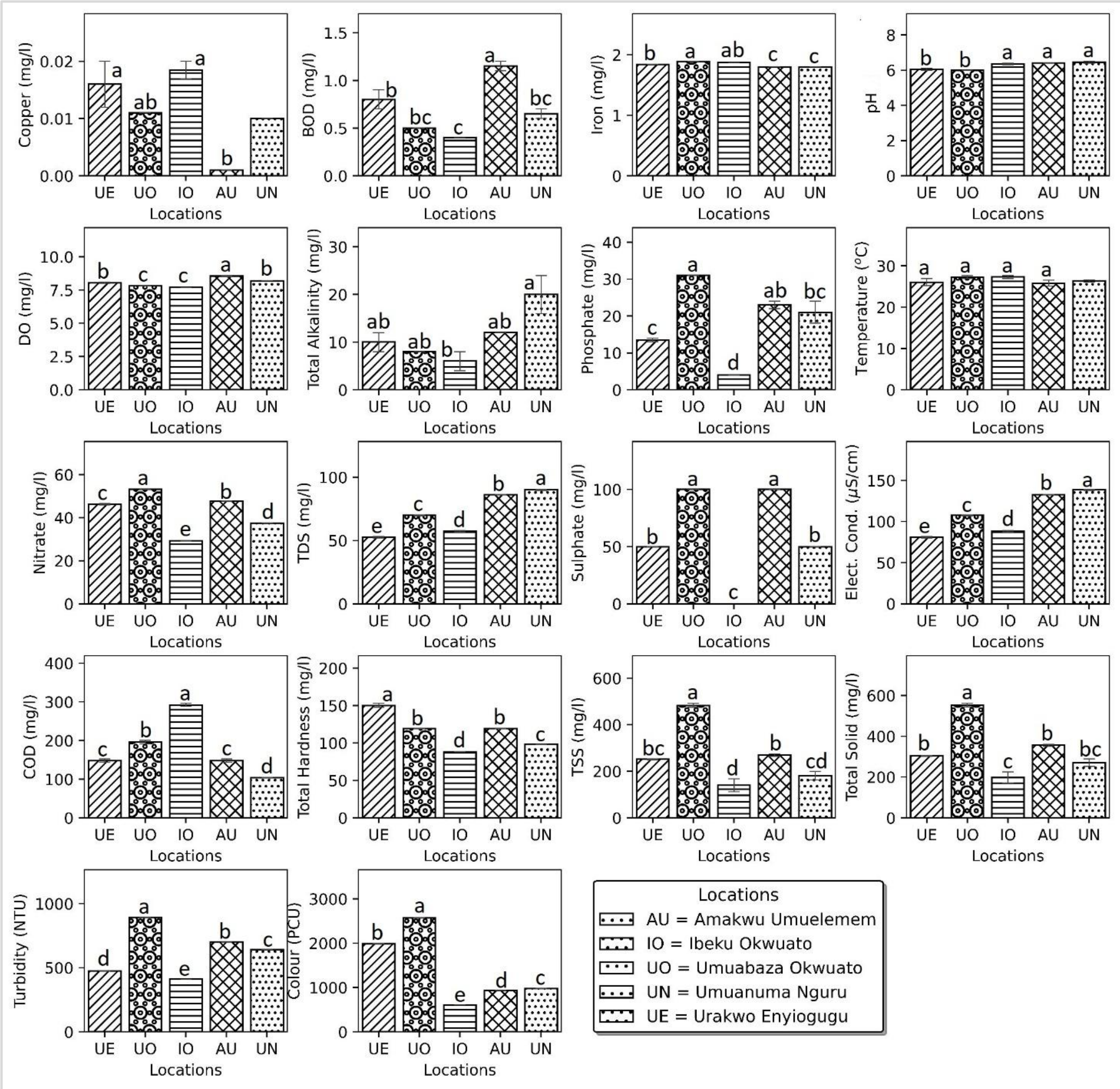

Figure 2: Barplots showing a test of the significance of the various physiochemical parameters

Table 3: Summary Table for Analysis of Variance of physiochemical parameters among the five sampling locations

Physiochemical Parameters	df	F-Statistic	P-value	Remark
Copper	9	12.452	0.008	Significant Difference
BOD	9	28.750	0.001	Significant Difference

Iron	9	43.875	0.000	Significant Difference
pH	9	29.167	0.001	Significant Difference
DO	9	114.250	<0.0001	Significant Difference
Total Alkalinity	9	6.083	0.037	Significant Difference
Phosphate	9	50.976	0.000	Significant Difference
Temperature	9	1.529	0.322	Not Significant
Nitrate	9	3549.644	<0.0001	Significant Difference
TDS	9	1203.864	<0.0001	Significant Difference
Sulphate	9	92227.269	<0.0001	Significant Difference
Electrical Conductivity	9	1203.864	<0.0001	Significant Difference
COD	9	402.250	<0.0001	Significant Difference
Total Hardness	9	424.00	<0.0001	Significant Difference
TSS	9	72.710	0.000	Significant Difference
Total Solid	9	73.976	0.000	Significant Difference
Turbidity	9	291127.686	<0.0001	Significant Difference
Colour	9	34193.700	<0.0001	Significant Difference

3.1.3 Relationship between the physiochemical parameters found in the ponds

The result of the Pearson correlation is shown in Table 4.

Table 4: Pearson Correlation showing the relationship between the physiochemicalparameters

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Copper (1)	**1.00**																				
BOD (2)	**-0.68**	**1.00**																			
Iron (3)	0.58	**-0.72**	**1.00**																		
pH (4)	-0.34	0.20	**-0.68**	**1.00**																	
DO (5)	**-0.79**	**0.93**	**-0.89**	0.45	**1.00**																
Total Alkalinity (6)	-0.34	0.28	**-0.73**	0.47	0.55	**1.00**															
Phosphate (7)	-0.63	0.27	-0.05	-0.29	0.33	0.22	**1.00**														
Temperature (8)	0.52	-0.55	0.63	-0.29	-0.60	-0.29	-0.06	**1.00**													
Nitrate (9)	-0.48	0.43	0.08	-0.62	0.30	-0.04	**0.82**	-0.20	**1.00**												
TDS (10)	**-0.77**	0.42	**-0.68**	0.60	**0.68**	**0.70**	0.57	-0.26	0.14	**1.00**											
Sulphate (11)	**-0.75**	0.55	-0.15	-0.28	0.52	0.14	**0.91**	-0.26	**0.92**	0.49	**1.00**										
Electrical Conductivity (12)	**-0.77**	0.42	**-0.68**	0.60	**0.68**	**0.70**	0.57	-0.26	0.14	**1.00**	0.49	**1.00**									
COD (13)	0.52	-0.59	**0.73**	-0.10	**-0.72**	**-0.76**	-0.54	0.57	-0.45	-0.60	-0.52	-0.60	**1.00**								
Total Hardness (14)	-0.09	0.46	-0.03	**-0.65**	0.24	-0.11	0.25	-0.42	**0.71**	-0.33	0.44	-0.33	-0.43	**1.00**							
TSS (15)	-0.25	0.00	0.47	**-0.70**	-0.12	-0.28	**0.81**	0.14	**0.87**	0.02	**0.78**	0.02	-0.10	0.41	**1.00**						
Total Solid (16)	-0.34	0.05	0.39	-0.62	-0.03	-0.20	**0.87**	0.11	**0.88**	0.14	**0.83**	0.14	-0.17	0.36	**0.99**	**1.00**					
Turbidity (17)	-0.58	0.13	0.11	-0.27	0.19	0.14	**0.96**	0.06	**0.76**	0.54	**0.87**	0.54	-0.34	0.09	**0.84**	**0.90**	**1.00**				
Colour, PCU (18)	0.09	-0.13	0.52	**-0.91**	-0.28	-0.22	0.59	0.12	**0.80**	-0.29	0.54	-0.29	-0.18	**0.66**	**0.86**	**0.81**	0.56	**1.00**			
Total Bacteria count (19)	**0.85**	**-0.78**	**0.79**	**-0.64**	**-0.90**	-0.46	-0.34	0.48	-0.15	**-0.82**	-0.48	**-0.82**	0.50	0.13	0.12	0.02	-0.28	0.46	**1.00**		
Total Coliform count (20)	**-0.69**	0.39	-0.10	-0.26	0.41	0.22	**0.97**	-0.10	**0.83**	0.58	**0.95**	0.58	-0.52	0.26	**0.77**	**0.84**	**0.94**	0.52	-0.44	**1.00**	
Total Shigella Count (21)	0.40	0.05	0.18	**-0.64**	-0.17	-0.26	-0.23	-0.26	0.26	**-0.71**	-0.11	**-0.71**	-0.11	**0.83**	0.07	-0.02	-0.37	0.50	0.54	-0.25	**1.00**

Values in bold are different from 0 with a significance level alpha=0.05

3.1.4 Water Quality Index (WQI)

The computation of water quality index is carried out for OlakwoEnyiogugu, OE using physiochemical data from Table 1 and metallic ions, the results is as given in Table 5. similar computation of the procedure for the WQI calculation is repeated for the remaining four sample locations (UO, IO, AU & UN) as shown in Table 6. The computational procedure for WQI computation is similar to that of Babatunde et al., [16].

Table 5: Water Quality Index for OlakwoEnyiogugu (OE)

Physiochemical Parameters	Observed Value	Standard Value (S_n)	Ideal Value	$1/S_n$	K	Q	W	WQ
pH	6.05	7.50	7.00	0.13	0.77	-190.00	0.10	-19.41
E.C (µS/cm)	81	400.00	0.00	0.00	0.77	20.25	0.00	0.04
TDS (mg/l)	52.65	1000.00	0.00	0.00	0.77	5.27	0.00	0.00
COD (mg/l)	148	250.00	0.00	0.00	0.77	59.20	0.00	0.18
Sulphate (mg/l)	50	250.00	0.00	0.00	0.77	20.00	0.00	0.06
Temp (^{0}C)	26.05	26.00	0.00	0.04	0.77	100.19	0.03	2.95
T.Hardness (mg/l)	150.22	500.00	0.00	0.00	0.77	30.04	0.00	0.05
Phosphate (mg/l)	13.5	2.00	0.00	0.50	0.77	675.00	0.38	258.56
Turbidity (NTU)	474.15	5.00	0.00	0.20	0.77	9483.00	0.15	1453.01
Nitrate (mg/l)	46.15	50.00	0.00	0.02	0.77	92.30	0.02	1.41
DO (mg/l)	8.05	5.00	14.60	0.20	0.77	68.23	0.15	10.45
BOD_5 (mg/l)	0.8	5.00	0.00	0.20	0.77	16.00	0.15	2.45
Copper (mg/l)	0.016	2.00	0.00	0.50	0.77	0.80	0.38	0.31
Iron (mg/l)	1.84	0.30	0.00	3.33	0.77	613.33	2.55	1566.27
Total Alkalinity (mg/l)	10	200.00	0.00	0.01	0.77	5.00	0.00	0.02
TSS (mg/l)	251.35	50.00	0.00	0.02	0.77	502.70	0.02	7.70
Total Solid (mg/l)	304	500.00	0.00	0.00	0.77	60.80	0.00	0.09
				1.31			1	1709.76

Table 6: Water quality index summary for the five ponds

Water Brands	WQI	Quality
OE	1709.76	Unfit for Consumption
UO	3322.813	Unfit for Consumption

IO	1338.71	Unfit for Consumption
AU	2591.95	Unfit for Consumption
UN	2370.381	Unfit for Consumption

WQI rating: 0-25=Excellent water quality, 26-50=Good water quality, 51-75=Poor water quality, 76-100=Very poor water quality, >100 unfit for consumption. Source: Brown *et al*. [12]

3.1.5 Analytical Hierarchical Clustering (AHC) of Physiochemical and Microbial Parameters

Agglomerative Hierarchy clustering was employed in the clustering of physiochemical and microbial parameters of the pond water obtained at the five different sampling locations (Figure 3). Similarly, the Parallel Coordinate Plot (Figure 4) of physiochemical parameters for cluster 1 and 2 was carried out.

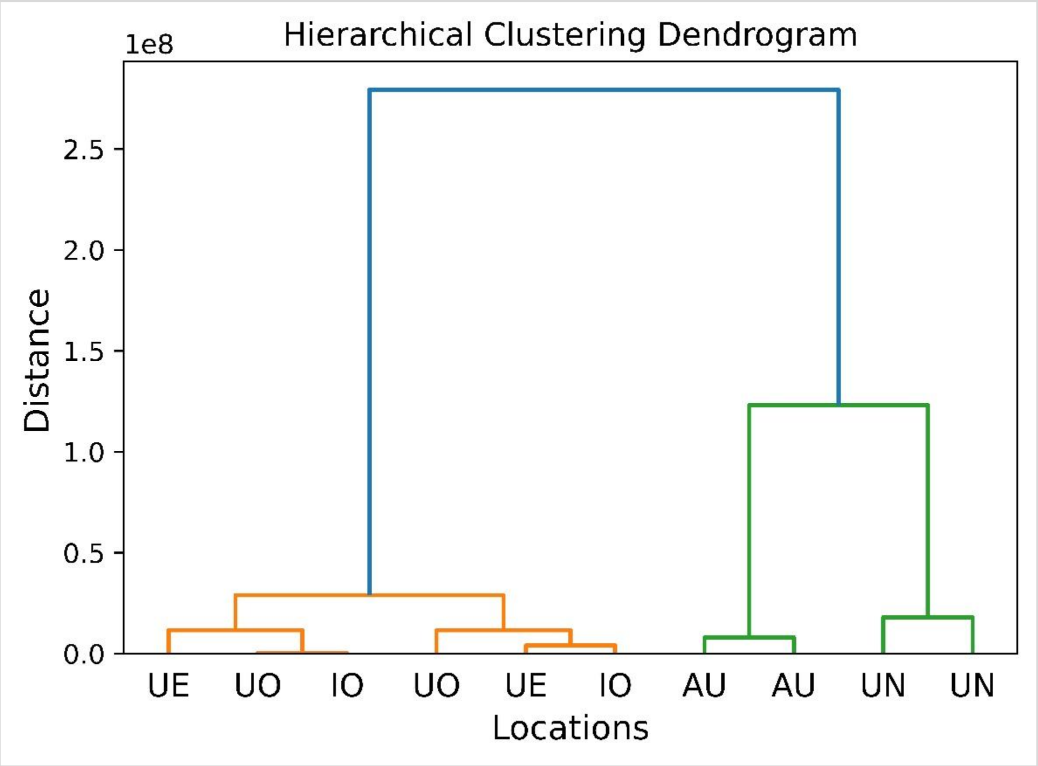

Figure 3: Dendrogram Plot after clustering the physiochemical parameters of the five locations. Note: OlakwoEnyiogugu = OE, UmuabazuOkwuato = UO, IbekuOkwuato = IO, Ama-UkwuUmuelem = AU, UmuanumaNguru = UN

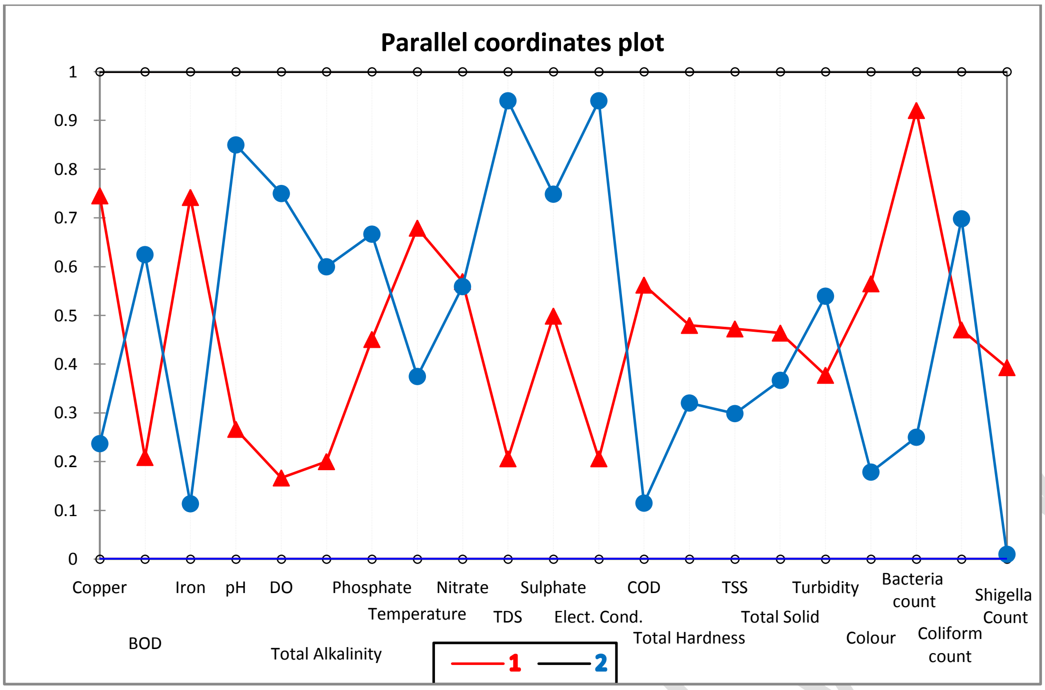

Figure 4: Parallel Coordinate plot of physiochemical parameters for cluster 1 and 2. Cluster 1 (red line) = OlakwoEnyiogugu, UmuabazuOkwuato, and IbekuOkwuato. Cluster 2 (blue line) = Ama-UkwuUmuelem, UmuanumaNguru

3.2 Discussion

3.2.1 Descriptive Statistics of Water Quality Parameters

The physiochemical parameter values obtained in the five ponds were compared with established benchmarks, such as those defined by WHO [6] and the Federal Environmental Protection Agency, (FEPA) [17].

3.2.2 Comparative Analysis of Selected Physiochemical Parameter for the Five Sampling Locations

Descriptive statistics and a comparative analysis to identify potential variations among the sampled ponds. Statistical tools such as Analysis of Variance are employed to discern significant differences in concentration levels, while the Tukey multiple comparison test identifies specific areas of distinction.

Figure 2, showed that the DO in the pond water at AU location had significant higher concentration level than in other locations. The DO concentration level at UO and IO were the same, as no significant difference was established between the two locations. The results from the ANOVA as presented in Table 3 indicate that significant differences exist in copper concentrations among the five sampling locations ($F(4,5) = 12.452$, p-value = 0.008). This statistical finding implies that copper levels in the pond water significantly vary across the different locations. Further investigation through a Tukey multiple comparison test revealed that the DO concentration in the pond water at AU location had significantly lower levels than in other locations. However, there was no significant difference in DO concentration between UOand UN. Also, no significant difference in the copper concentration in the pond water at locations OE and IO. The ANOVA results indicate that there are significant differences in BOD concentrations among the five sampling locations ($F(4,5) = 28.750$, p-value = 0.001). This statistically significant finding suggests that BOD levels in the pond water exhibit considerable variation across the different locations. BOD concentration in the pond water at AU was significantly higher than what was observed from other locations. There was no significant difference in the BOD concentration in the pond water at locations OE, UO, and IO. The ANOVA results indicated statistically significant differences in pH levels among the five sampling locations ($F(4,5) = 29.167$, $p < 0.001$). The Tukey multiple comparison test showed that the pond water OE and UO was significantly more acidic that the other three sampling locations.

3.2.3 Relationship between the physiochemical parameters found in the ponds

Through Pearson correlation analysis, we uncover the interdependencies and associations that exist within this parameter set. The result from Table 4 showed that the Pearson correlation coefficient between copper and BOD was -0.68 which indicate a negative correlation. The result was statistically significant and the result indicate that increase in the biochemical oxygen demand result in a decrease in the copper concentration in the pond waters and vice versa. Additionally, it was observed a strong negative correlation between iron (Fe) and BOD, with a Pearson correlation coefficient of -0.72. This correlation was statistically significant at the alpha=0.05 level. Consequently, an increase in BOD levels is associated with a decrease in iron concentration in the pond water. There was negative correlation (-0.34) between pH and copper (Cu), suggesting that higher copper concentrations are associated with slightly lower pH levels. Furthermore, pH exhibited a positive correlation (0.45) with dissolved oxygen (DO), indicating that as pH levels increased, the concentration of dissolved oxygen in the water also rose. The correlation discovered was between dissolved oxygen (DO) and copper (Cu) was relatively strong. The Pearson correlation coefficient was -0.79, and this strong negative correlation was statistically significant at the alpha=0.05 level. This result underscores the critical role of copper in influencing the availability of dissolved oxygen in these aquatic ecosystems. A higher concentration of copper is associated with lower levels of dissolved oxygen, which has direct implications for the well-being of aquatic life. The statistically significant negative relationship between iron and DO was established (r = -0.89) relationship between iron and DO was negative. Increase in the iron content in the pond water result to decrease in the dissolved oxygen of the pond water. There was a very strong positive relationship between electrical conductivity and total dissolved solid. Increase in the dissolved solid result in increase in the electric conductivity of the pond water and vice versa.

For microbial parameters, intriguing relationships was observed. Total Bacteria count exhibited a strong positive correlation (0.85) with Total Coliform count, and this correlation was statistically significant at the alpha=0.05 level. This suggests that an increase in total bacteria count corresponds to a higher total coliform count in the pond water. While both are indicators of microbial contamination, further investigation is warranted to understand the specific sources and implications of these microbial populations.

3.2.4 Water Quality Index (WQI)

Water Quality Index (WQI) analysis, a crucial metric for evaluating the overall water quality in each pond. This assessment aids in identifying the quality of water in each pond.

The result from the WQI showed that the pond water being investigated did not fall within the bracket of good water quality, as per the WQI range of 0 to 50 [6], thereby affirming the unfavorable quality of water across the study area. The WQI for the five ponds ranges from 1338.71 - 3322.81. In a study on Water Quality for Babatunde et al.,[16] for Nigerian Port Authority Waterway, the WQI values range from 3192.63 – 5061.35 and these are much higher than those of the pond water. Nevertheless, discernible variations exist among these locations, warranting further exploration. The pond water at UO had the highest WQI of 3322.81, signifying extremely poor and unfit water quality. AU while displaying a slightly lower WQI value, remains firmly within the realm of utterly unfit water. OE and UN, despite registering lower WQI values compared to the previous two locations, still underscore the grave issue of poor water quality. IO exhibits the lowest WQI value of 1338.71, which, although slightly less dire than other locations, still confirms the unsuitability of the water for any practical use.

3.2.5 Analytical Hierarchical Clustering (AHC) of Physiochemical and Microbial Parameters

Analytical Hierarchical Clustering (AHC)uncovers discernible patterns and relationships among locations based on our data (physiochemical and microbial parameters).The result of the Agglomerative Hierarchy Clustering is presented in Figures3 and 4. Figure 3 present the result of the dendrogram which showed the clustering of pond water at different sampling location with similar physiochemical parameters. The result from Figure 3 showed that the AHC algorithm obtained two distinct clusters indicated by the orange and green legs of the dendrogram. Figure 3 showed that cluster 1 comprised of pond water obtained from OE, UO and IO. The result indicates that the pond water of these three-sampling location had relative similar physiochemical parameters. Cluster 2 comprised of pond water obtained from AU and UN sampling locations. Also, the pond water obtained in these two-sampling location had similar physiochemical parameters. The parallel coordinate plot shown in Figure 4 shows the level of concentration of the physiochemical parameters of the two clusters. Figure 4 showed that cluster 1 (orange) had relatively lower concentration of the physiochemical parameters than cluster 2 (green). The result from the parallel plot showed that cluster 2 had higher DO, pH, total alkalinity, phosphate, TDS, sulphate, electrical conductivity than cluster 1. But cluster 1 had higher total hardness, TSS, total solid, and more bacteria count than cluster2.

4. CONCLUSION

The pond water within the study area did not fall within the bracket of good water quality, as per the WQI range of 0 to 50, thereby affirming the unfavorable quality of water.The WQI for the five ponds ranges from 1338.71 - 3322.81. The aroma, color, and visual appearance of the examined water all pointed to aquatic pollution, which is supported by the values of the physicochemical parameters measured.The water samples were dark in color and had an unpleasant odor. Most of thephysico-chemical parameters, such as pH, color, dissolved oxygen (DO), turbidity, and total suspended solids, were in excess of the recommended and allowed levels set by the Federal Ministry of Environment and the World Health Organization. There is a direct correlation between the presence of Total Bacterial Counts from Shigella and Salmonella counts and the presence of fecal contamination from both human and animal wastes. Given the poor quality of the pond water it is unhealthy for the inhabitants in the study area to use pond water for food preparation and other household tasks, except if it is treated.

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