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Assessment of Water Quality of Odor River, Anambra State

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Authors' contributions

This work was carried out in collaboration among all authors. Author GOE was responsible for initiating the work and drafting the introduction. Authors COA and NUO were responsible for drafting the literature review, methodology, analysis and interpretation of results. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study examined the physicochemical and bacteriological parameters of Odor River in Orumba North, Anambra State. The parameters considered were pH, turbidity, temperature, Dissolved Oxygen (DO), Alkalinity, total hardness, Sulphate (SO_4^{2-}), Chloride, Calcium (Ca^{2+}) hardness, Magnesium (Mg^{2+}) hardness, Iron (Fe), Nitrate (NO$_3$-), Conductivity, Total Dissolved Solids (TDS), Total coliform and Escherichia coli (E. coli). The objectives of the study were to assess the similarities that exist amongst the physicochemical and bacteriological parameters of Odor River in Orumba North, Anambra State. Also, to test whether water from Odor river is safe for drinking by the people of Orumba North and its environs.

Methodology: The Cluster analysis and the one-sample T-test method were used to analyze the data obtained for this study.

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Results: The findings of the study revealed that the parameters can be grouped in two groups as follows: group A consists of pH, turbidity, temperature, Dissolved Oxygen (DO), Alkalinity, total hardness, Sulphate (SO_4^{2-}), Chloride, Calcium (Ca^{2+}) hardness, Magnesium (Mg^{2+}) hardness, Iron (Fe), Nitrate (NO_3-), and Conductivity while group B consists of Total Dissolved Solids (TDS), Total coliform and E.coli. The physicochemical parameters were found to impact significantly on the variation of the water quality at 5% significant level and their measures did not exceed the World Health Organization (WHO) standard. Further findings revealed that the bacteriological parameters such as the Escherichia Coli and Total Coliform do not significantly impact on the water quality variation of the river and their measures do not exceed the WHO standard.
Conclusion: The physicochemical and bacteriological parameters of Odor River were found to be within the WHO Standard. However, the physicochemical parameters were found to impact on the water quality variation of the river while the bacteriological parameters do not impact on the variation of the water quality of the river. The implication of the physicochemical and bacteriological parameters not exceeding the WHO standard indicates no risk for the users of the river. Hence, water from Odor River is safe for human consumption and agricultural purposes.

Keywords: Bacteriological; physicochemical; Odor River; similarities.

1. INTRODUCTION

Water is an important and abundant natural resource which is necessary for the survival of all living beings. However, the quality of water plays an important role in promoting agricultural production and human health standards. Population growth and the standard of living in most developing countries have increased, resulting in increased demand for drinking water. On the other hand, factors such as accelerated pace of industrialization, the lack of environmental education and the overexploitation of natural resources have seriously affected water resources by increasing the pressure on urban hydrology [1]. These factors have deteriorated the quality of surface water for drinking and have caused serious damage to most surface water bodies. This has called for constant monitoring of most river system with the task of evaluating the effects of environmental factors on water quality for correct use and sustainable development of the resource.

The deterioration of water has become a global problem. In many developing countries, the availability of drinking water has become critical and the majority of the communities in the rural areas depend on a non-public supply system. Direct contamination of surface water from anthropogenic activities such as municipal wastewater, industrial effluents and the influx of land is a long-standing phenomenon. In the developing countries, there are increasing evidence of contamination of surface water bodies, which are sensitive to leaching from landfills, septic tanks such as pit latrines which are commonly used in slums where there is no sewage system and industrial effluents. Organic manure, municipal waste and agricultural waste such as fungicides in runoff often contain fairly high concentrations of chemicals and substances found in most water bodies. These impurities can give the water a bad taste, colour, odour or turbidity and cause hardness, corrosivity, stains or foaming. The mixing and the reactions of the materials modify the physicochemical and biological characteristics of the drilling water, affecting the quality of the water. Water quality reflects the composition of water affected by natural processes and human activities, and therefore the need to establish water quality in the natural hydrological cycle.

Surface water quality has been identified as an irreplaceable element of the aquatic ecosystem and has become an interesting issue for researchers to deliberate. Also, Odor River is located in an area classified as a rural area in Anambra State and the majority of the people living in this area don't have access to the supply of pipe-borne water. Hence, the need to examine the similarities that exist amongst the physicochemical and bacteriological parameters of Odor river in Orumba North, Anambra State. Also, to test whether water from Odor river is safe for drinking by the people of Orumba North and its environs.

2. LITERATURE REVIEW

A study by Salah, et al. [2] used the cluster analysis (CA) to assess temporal and spatial variations in the water quality of Euphrates River, Iraq, for a period 2008-2009 using 16 parameters at 11 sampling sites. The Hierarchical cluster analysis grouped the 8 months into three periods (I, II and III) and classified the 11 sampling sites into two groups (I and II) based on similarities of water quality characteristics. The temporal pattern shows that April has higher pollution level relative to the other months. Spatially, sampling site 7 was found to have the lower pollution level while the other sampling sites have higher pollution level. Considering the case of Tanzania, Basamba et al. [3] analyzed water samples obtained from the borehole for physicochemical and microbiological characteristics of the underground water. The statistical tool employed to analyze the obtained data were the Pearson correlation coefficient, Factor analysis and Cluster analysis. The findings of the study revealed that calcium was significantly correlated with electrical conductivity, total dissolved solids, and total hardness for underground water sources. Also, it was found that calcium concentration was attributed to anthropogenic activities, and/or natural processes within the aquifers. The findings showed that the parameters can be classified into five groups; Group I comprises of total and faecal coliform, Group II contains aluminium, Group III contains manganese, ammonia, and watercolour, Group IV contains electrical conductivity, total dissolved solids, calcium, total hardness and turbidity, and Group V contains alkalinity and chlorides. Further findings identified three sources of pollutants in the underground water to comprise a mixed origin of human wastes and soil in the runoff, the dual origin of turbidity (human wastes and soil/organic matter) and natural/geochemical processes in aquifers.

In a similar study by Ewa et al. [4] which focused on assessing the variations of water quality, statistical tools such as the principal component analysis (PCA), cluster analysis (CA) and discriminant analysis (DA) was used to identify probable pollution sources of the Calabar River in Nigeria. The findings of the study showed that the PCA extracted eight (dry season) and seven (wet season) latent components responsible for the pollution of the Calabar River. The latent components were found to explain about 94 – 98% of the total variance in the water parameter data set. It was found that in the dry season, the Calabar River received pollutants from residential and industrial sectors, whereas in the wet season, its pollution sources came from non-point sources such as surface runoff from agriculture, industrial and residential areas. The 25 water parameters were classified into two groups of homogenous sources of pollution for each season, being agricultural, residential and industrial wastes. Also, it was identified that transparency, DO, salinity, calcium, magnesium, sodium and potassium are the most significant water parameters responsible for the spatial and temporal variations in water quality of the Calabar River with 100% correct assignment. The findings of the study indicate that industrial and residential wastes were largely responsible for the temporal and spatial variation in water quality of the Calabar River.

Dabgerwal and Tripathi [1] assessed the physicochemical quality of river Varuna in Varanasi, India. The study employed the Pearson correlation analysis and the Cluster analysis to assess the extent of the relationship among physicochemical parameters and to determine the sources of pollution in the river Varuna respectively. The finding of the study shows a high value of Dissolved Oxygen (DO), Nitrate, and Total Alkalinity, above the WHO Standard. Also, findings identified the key water parameters to comprise of pH, electrical conductivity, total alkalinity and nitrate, which were found to influence the concentration of other water parameters. Also, findings identified three major clusters of sampling sites out of a total of 10 sites considered in the study based on the similarity in water quality.

A study by Aydin [5] examined the water quality of the pond in Bektaş, Turkey based on the sites and seasons, the water quality classes were determined and pollution problems were detected. The study considered the suitability of aquatic life forms by examining 21 physicochemical parameters and seven heavy metal parameters in the pond water. Pearson correlation, hierarchical cluster analysis and principal component analysis were used to test the relationships of all parameters and loads of pollutants. The results of the study revealed that the main source of pollution could be non-punctual pollution, i.e. agricultural pollution and soil leaching in this region.

Guptaa et al. [6] considered for the development of water quality index using eight parameters pH, Temperature, Total Dissolved Solids (TDS), Turbidity, Nitrate-Nitrogen, Phosphate, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO) measured at six different sites along the river Narmada. The findings of the study showed that the water quality was between excellent - good in the season summer and winter and poor to unsuitable for human consumption in the season monsoon along the river Narmada. The fall in the quality of water in the rainy season was attributed to poor sanitation, turbulent flow, soil erosion and high anthropogenic activities.

A study by Ibrahim [7] considered the suitability of groundwater in Jordan's main groundwater reservoirs for drinking purposes. The study used the weighted arithmetic water quality index to ascertain the quality of the water concerning the Jordanian standards for drinking water. All physical and chemical parameters were found to be below the Jordanian drinking standards. Also, the microbiological parameter such as the E. coli count was found to exceed the standard. The study emphasized the importance of the microbiological parameters in determining the water quality index for groundwater regarding its role in ascertaining actual condition of water quality for different purposes. A similar study by Vedde et al. [8] also examined the physicochemical and microbiological parameters from 25 locations of Tiaoxi River, China. The objective of the study was to determine the spatial and seasonal variations in water quality. The physicochemical parameters such as total nitrogen (TN), Total phosphorus (TP), nitrite-N (NO_2-N), and ammonium-N (NH4-N) were found to be above the standard in most of the locations. Also, the microbiological parameter faecal coliform count was equally found to exceed the standard in most of the locations under study. Further findings showed that parameter such as pH, conductivity, TP, and NO_3-N was able to explain about 83% of the total variation in the water quality of the River. The finding of the study indicates that water from the River Tiaoxi is not safe for human consumption. A study by Achieng et al. [9] examined the water quality of Nyando River using four sampling stations (Muhoroni, Homalime, Kipchui and Wasao) in Muhoroni sub-catchment area. The result of the study revealed that parameters such as Total Viable Counts (TVC), Fe, and Mn have a significant impact on changes in water quality parameters for the calculation of WQI in the Nyando River. The study by Shil et al. [10] examined the water quality of the Mahananda River and its suitability for human consumption, agricultural and industrial uses. The study found that parameters such as pH and magnesium were above the acceptable standard.

3. MATERIALS AND METHODOLOGY

3.1 Data Collection

The primary source of data collection was adopted in this study. Water samples were collected from Odor River in Amaokpala, Orumba North L.G.A of Anambra State from March – November 2019 in polyethene bottles, transported to the laboratory, and analyzed. Water samples were analyzed for most water quality influencing physiochemical and bacteriological parameters. The physicochemical parameters comprise of pH, turbidity, temperature, Dissolved Oxygen (DO), Alkalinity, total hardness, sulphate, chloride, Ca hardness, Mg hardness, Iron, Nitrate, conductivity, and Total Dissolved Solids (TDS) while the bacteriological parameters are total coliform and *E.coli*.

3.2 The Study Area

Orumba North is one of the 21 areas of local government in the state of Anambra and was created on August 27, 1991. Orumba North was part of the local government of Aguata until 1989 when the local government of Orumba was created based in Umunze.

It was later sculpted by the local government of Orumba so that what remained became Orumba South. Orumba North is located in the southern senatorial area of Anambra and forms a federal constituency with Orumba South. The national population census put its population at one hundred and seventy-two thousand people.

Local government is delimited by Aguata, Anaocha, Awka and Oji-River. It is made up of sixteen communities. They are Ajalli, Amaetiti, Amaokpala, Awa, Awgbu, Nanka, Ndikelionwu and Ndiokolo. Others are Ndiokpaleze, Ndiokpaleke, Ndiowu, Ndiukwuenu, Oko, Okpeze, Omogho and Ufuma. Orumba North is a markedly fertile land for agriculture with prominent products around rice, yam, cassava and palm oil. Most of the people are subsistence farmers and traders. There is also a large student community following the presence of the Federal Polytechnic, located in Oko.

The local government hosts beautiful tourist attractions such as the mythical Odor river that appears and disappears at will. It is perhaps the first of its kind in the world. The always peaceful Obutu lake; the beautiful rivers Agho-mmili and Nama, with other small rivers, have made this area unique. Orumba North has some undeveloped tourist water resources such as Iyi-Ocha lake, Orizu torrent, Ivolo torrent, Nju-Oyi and Nchioku streams.

Table 1. List of physiochemical parameters and their methods

S/. no.	Parameters	Units	Method used for measuring parameters
1	pH		pH meter
2	Alkalinity	mEq/L	Winkler titration
3	Total dissolved solids	mg/L	Digital conductivity meter
4	Chloride	mg/L	Argentometric titration
5	Sulphate	mg/L	Gravimetric method
6	Turbidity	Nephelometric turbidity units (NTU)	Nephelometric
7	Ammonia-Nitrogen	mg/L	Spectrophotomeric (Phenate method)
8	Total Hardness as $CaCO_3$	mg/L	Ethylenediaminetetracetic acid (EDTA) titration
9	Conductivity	S/m	Electrical conductivity meter (EC meter)

Source: (Patel and Parikh [11])

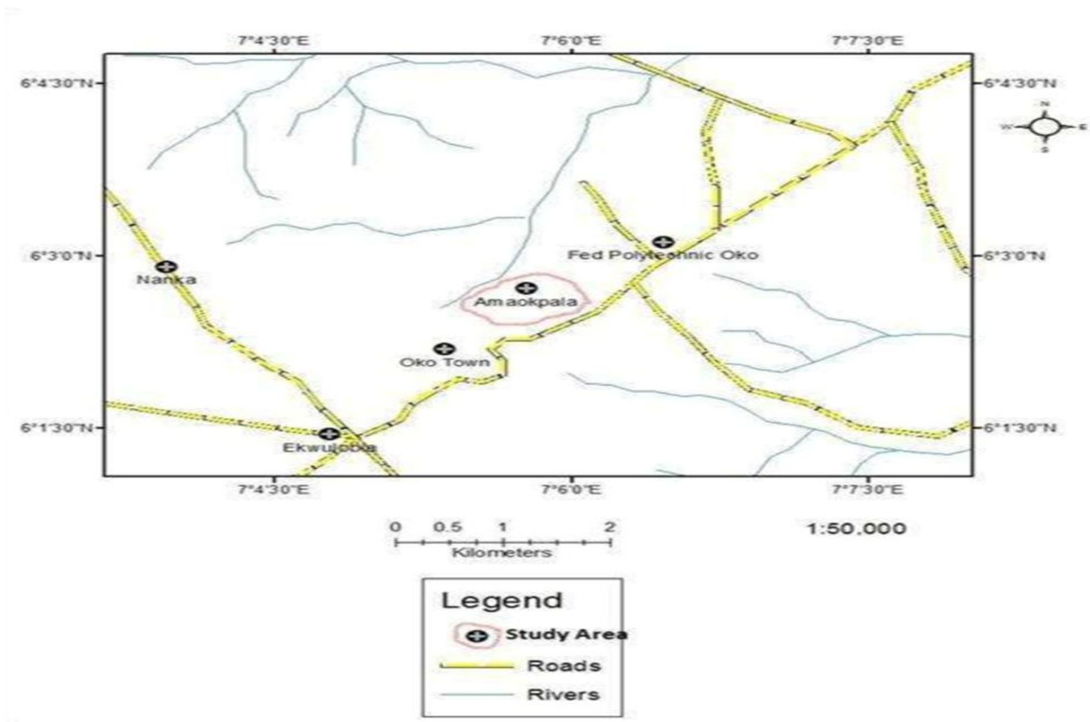

Fig. 1. Amaokpara town and the surrounding rivers

3.3 Method of Data Analysis

Cluster analysis helps to identify natural groupings among a group of variables or individual measurements with no direct relationship. Also, cluster analysis is an exploratory data analysis tool for solving classification problems. Its purpose is to sort cases, data or objects (events, people, things, etc.) into groups or clusters. The resulting clusters of objects should exhibit high internal homogeneity (within clusters) and high external heterogeneity (between clusters) [8].

Cluster analysis (CA) was used in the present study to develop significant aggregations or mutually exclusive groups of water parameters based on multivariate similarities between entities [12]. This technique divided a large number of water parameters into a smaller number of homogeneous groups based on their correlation structure [13]. Hierarchical cluster analysis was used to group each of the water parameters in two groups using the ward linkage based on Pearson's distance. The groups or clusters should be as homogeneous as possible and the differences between the various groups as wide as possible.

The one-sample t-test was used to use to test the quality of the water against the WHO Standard. The one-sample t-test is a statistical procedure that can be used to examine whether the sample of observations was significantly different from a test value (e.g. the WHO standard for each parameter) considered in this study. The one-sample t-test was considered adequate for testing the parameters because the number of observation was less than 30 and the variables passed the normality test, homogeneity test and constant variance test after taking the logarithm of the various variables.

The appropriate test statistic for the one-sample t-test when the sample meets the normality requirement is given as:

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}} \quad (1)$$

where,

μ is the mean or test value (for example the WHO standard in the present study)

$\bar{x}$ is the mean of the sample
s is the sample standard deviation
n is the number of observation

The decision rule for the test of hypothesis is, given α level of significance, is to reject the null hypothesis when the *p*-value is less than the α level of significance.

4. DATA ANALYSIS AND RESULTS

The result of the Cluster Analysis of the parameters obtained from Odor River was presented in the dendrogram (Fig. 2) and summarized in Table 2.

The result of the cluster analysis presented in Fig. 1 and Table 2 shows that the parameters can be clustered in two groups (Group A and Group B). Where group A comprises of pH, turbidity, temperature, Dissolved Oxygen (DO), Alkalinity, total hardness, Sulphate, Chloride, Ca hardness, Mg hardness, Iron, Nitrate, and conductivity while group B comprises of Total Dissolved Solids (TDS), total coliform and *E.coli*.

The result of the analysis obtained in Table 3 showed that all the physical parameters such as temperature, turbidity and conductivity were significantly different from the WHO standard since their *P*-value was less than the critical value of 0.05. However, the result of the mean difference shows that the measure of the parameters was all below the WHO standard. Hence, the physical properties of the river were found to be adequate and within the required standard.

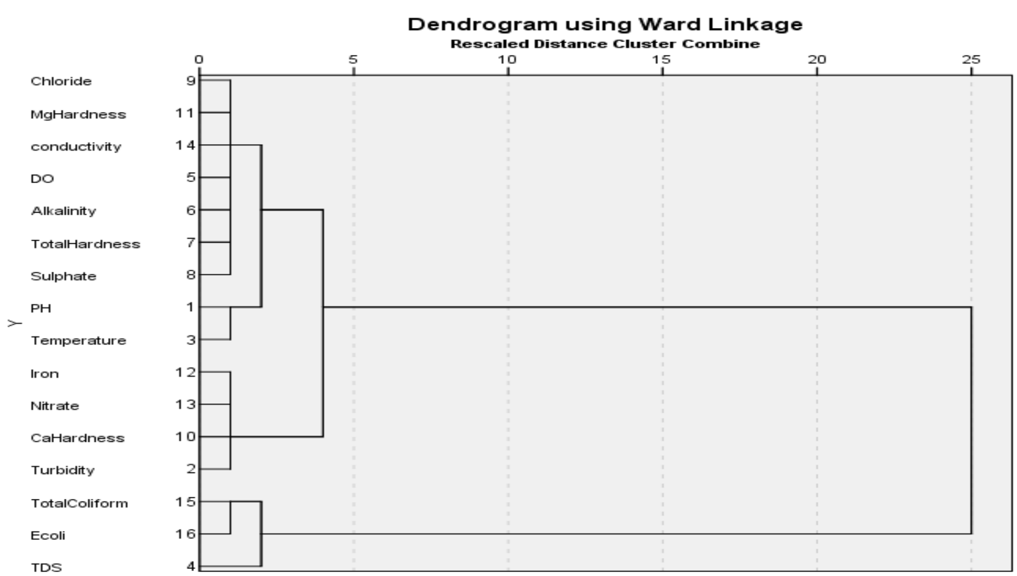

Fig. 2. Dendogram showing the relationship between different water quality parameters

Table 2. A table showing the distribution of parameters in group

No	Cluster Analysis (CA)	Parameters
1	Group A	pH, turbidity, temperature, DO, Alkalinity, Total hardness, Sulphate, chloride, Ca hardness, Mg hardness, Iron, Nitrate, and conductivity
2	Group B	TDS, total coliform and E.coli

Source: Authors analysis

Table 3. Summary of one sample T-test of the parameters of Odor Rivers in Anambra state

S/N	Parameter	W.H.O standard	Mean difference	df	*t*-value	*P*-value	Decision
1	Temp ˚C	25	-1.07	39	-10.36	0.000	Significant
2	Turbidity (NTU)	10	-7.54	39	-20.30	0.000	Significant
3	Conductivity	500	-378.65	39	-79.83	0.000	Significant
4	Calcium	200	-190.00	39	-297.13	0.000	Significant
5	Magnesium	250	-249.24	39	-1541.22	0.000	Significant
6	Sulphate	400	-397.07	39	-1785.17	0.000	Significant
7	Chloride	250	-238.58	39	-115.93	0.000	Significant
8	Carbonate	500	-492.20	39	-1090.95	0.000	Significant
9	Nitrate	50	-51.09	39	-84.299	0.000	Significant
10	Total Hardness	100	-87.33	39	-212.75	0.000	Significant
11	Total Dissolved solids	500	-445.42	39	-125.73	0.000	Significant
12	pH	6.5 -8.5	-1.14	39	-39.01	0.000	Significant
13	E. Coli	0	-2.25	39	-1.387	0.260	Not significant
14	Total Coliform	0	-1.87	39	-1.469	0.238	Not significant

Source: Authors analysis

Also, the result shows that the chemical parameters of the river such as Calcium, Magnesium, Sulphate, Chloride, Carbonate, Nitrate, Total Hardness, Total Dissolved Solids, and pH were significantly different from WHO standard. Though, their measures were all below the WHO Standard. This indicates that the chemical parameters of the river are within the required standard.

Further findings showed that the bacteriological parameters of the river such as the *E. Coli* and Total Coliform were not significantly different from the WHO standard. Also, it was found from the result of the mean difference that the bacteriological parameters measure did not exceed the WHO standard.

5. CONCLUSION

This study examined the physicochemical and bacteriological parameters of Odor River in Orumba North, Anambra State. The parameters considered were pH, turbidity, temperature, Dissolved Oxygen (DO), Alkalinity, total hardness, Sulphate, Chloride, Calcium hardness, magnesium (Mg) hardness, Iron, Nitrate, conductivity, Total Dissolved Solids (TDS), total coliform and Escherichia coli (E. coli). The findings of the study revealed that the parameters can be grouped in two groups as follows: group A consists of pH, turbidity, temperature, Dissolved Oxygen (DO), Alkalinity, total hardness, Sulphate, chloride, Ca hardness, Mg hardness, Iron, Nitrate, and conductivity while group B consists of Total Dissolved Solids (TDS), total coliform and E.coli. Also, it was found the physicochemical parameters significantly impact on the water quality variation of the river and their measures do not exceed the required WHO standard.

Further findings of the study revealed that the bacteriological parameters such as Escherichia Coli and total Coliform does not impact on the water quality variation of the river and their measure was found to be below the WHO standard. Although the bacteriological parameters are not the best indicator of Escherichia contamination, low coliform bacteria measure indicates no risk for the users of the river. Hence, water from Odor River is safe for human consumption and agricultural purposes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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