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Seasonal Variations of Physico-Chemical Parameters of Otamiri River in Owerri Urban, Nigeria

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ABSTRACT

This study was conducted to assess the physiochemical parameters of Otamiri River in Owerri Urban, Imo State. it investigated the following physico-chemical parameters of the river water namely pH, Temperature, Electrical Conductivity, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Turbidity, Total Solids, Total Dissolved Solids Nitrate, Phosphate and Ammonia. River water samples were collected between October 2023 to January 2024 from three sampling locations using standard methods. Results were analyzed using descriptive and inferential statistics. The Principal Component Analysis (PCA) extracted two components with high loadings that are responsible for the variations in sampling locations of Otamiri river in wet and dry seasons respectively. The study identified physico-chemical contamination of the river water from urban runoff, industrial, agricultural discharges and domestic/residential wastes. The study recommended seasonal treatment of the physico-chemical and microbial pollutants in the river water.

Keywords: Seasonal variations, Otamiri river, Owerri Urban, Physico-chemical.

INTRODUCTION

The physico-chemical parameters of river water bodies are constantly changing due to natural perturbations and land use activities within and around it which includes residential, agricultural, industrial and commercial activities. These activities produce effluents, sewage, and all manner of wastes that are continuously washed into the water bodies during runoff thereby influencing the physico-chemical characteristics. Variation in the physico-chemical parameters of river water is dependent on the nature and quantity of pollutants they receive seasonally (Ioryue , Wuana and Augustine , 2018).

River water bodies are faced with problems such as water shortages, excess water and water pollution (Okolo, Onuorah.and Madu,2023).

River water pollution is a condition that changes the physical, chemical and biological characteristics of water.

Otamiri river is sensitive to seasonal changes, during the wet season, run-off carries particles into the river and similarly, in dry season, the resident time of the pollutants in the river water increases thus affecting the quality. This seasonal variation alters the chemical composition of the rivers, aggravating phytoplankton reduction leading to a downward trend in the yield of fishes and other aquatic animals. It also reduces the aesthetic value of the river water. Apart from its impact on biodiversity, when ingested by humans, it can lead to the outbreak of diseases such as acidosis, cholera, dysentery, death, vector-borne diseases post-traumatic mental disorders, respiratory infections and skin and eye infections (Chukwu,2018)

Otamiri river has a huge potential for sustainable source of water supply which has a diverse range of functions and needs to be monitored regularly to ascertain its suitability in different seasons of the year.

Therefore, this study aims at extracting those physico-chemical parameters that are most important in assessing seasonal variations of Otamiri river.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

MATERIALS AND METHODS

Study site

The study was conducted on Otamiri River, Owerri, Imo State, Nigeria. It is a major fresh surface water resource of South-eastern Nigeria which is located within geographical co-ordinates of latitude 5˚23'N and 5˚30'N, and Longitude 6˚58'E and 7˚04'E (Fagorite, Ahiarakwem, Okeke and Onyekuru, 2019). The source of the river is from Egbu where it runs South past Owerri city and through Nekede, Ihiagwa, FUTO, Eziobodo, Olokwu, Umuisi, Mgbirichi and Umuagwu to Ozuzu in Etche, Rivers State where it joins Oramirukwa river to form a confluence, both rivers flow into the Atlantic Ocean (Okechi and Chukwura, 2020). The watershed covers about 10,000 square kilometres and experiences the wet and dry seasons. The average humidity is about 80% with mean daily average temperature ranging from 28◦ to 35◦C and a mean annual rainfall of 1150-1200mm (Bibiye, 2022).

The sampling locations are shown in Table 1 while the map showing the sampled locations is shown in Fig 1.

Table 1: Sampling locations for Otamiri River.

Sample point	Location	Coordinates
Point 1	Egbu	N: $5^0$28’6.504’’ E: 7º3’28.644’’
Point 2	Akachi	N: $5^0$28’18.78’’ E: 7º2’29.376’’
Point 3	Nekede Mechanic village	N: $5^0$27’55.236’’ E: 7º2’4.65’’

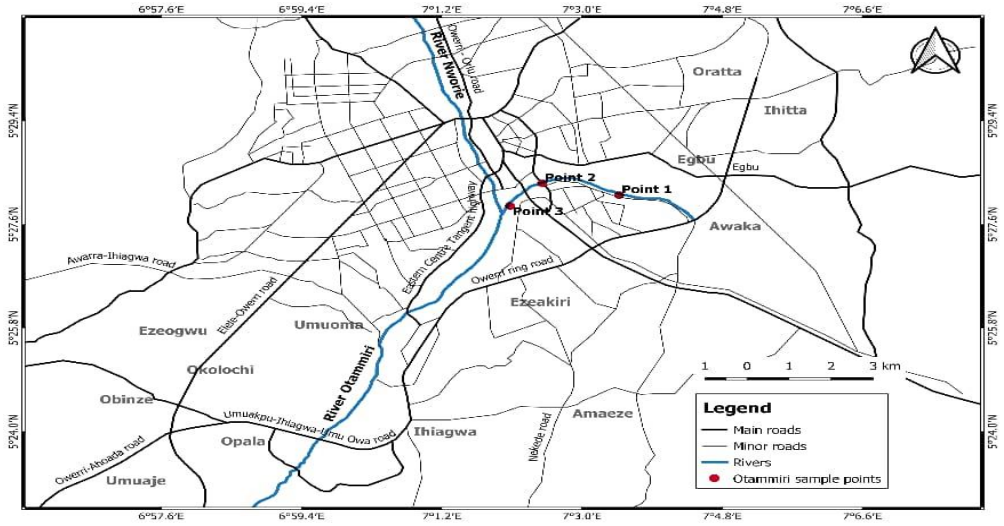

Fig 1: Map showing sampled locations

Sampling Procedure and Laboratory Analysis

Water samples were collected from Otamiri river located at Egbu, Akachi and Nekede Mechanic village. Sampling was carried out in October, 2023 and January, 2024 covering both the wet and dry seasons. Three clean and sterile plastic containers of a litre capacity were used in collecting the samples. Water sampling was done in duplicates in order to improve data reliability. This was done by first rinsing the containers with the river

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

water before collection. Each sample was immediately corked and properly labeled before preserving them at a low temperature of 4^0C using ice caps. The samples were taken to the laboratory for analysis.

In situ measurements were determined for temperature, pH, electrical conductivity, dissolved oxygen and Turbidity. The other parameters such as Biological Oxygen Demand, Chemical Oxygen Demand and Total dissolved solids were analyzed in the laboratory using standard procedures.

Temperature was determined using a mercury thermometer having a scale marked for every 0.1^{o}C. Turbidity was determined by a photometric method using a HACH DR/2010 spectrophotometer. That of pH was determined using the pH meter.

All parameters of water quality monitoring and their analytical methods are summarized in Table 2.

Table 2: List of Physicochemical parameters and their method of determination.

S/N	Physico-chemical parameters	Unit	Analytical method
1	Ph		pH meter
2	Temperature	oC	Thermometric method
3	Electrical conductivity	µS/cm	Conductivity meter
4	Dissolved Oxygen	mg/L	DO meter
5	Biological Oxygen Demand	mg/L	DO meter
6	Chemical Oxygen Demand	mg/L	Oxidation reaction
7	Turbidity	mg/L	Photometric method
8	Total Solids	mg/L	Gravimetric method
9	Total Dissolved Solids	mg/L	TDS meter
10	Nitrate	mg/L	Spectrophotometric method
11	Phosphate	mg/L	Spectrophotometric method
12	Ammonia	mg/L	Spectrophotometric method

Statistical analysis

In this study, Principal Component Analysis (PCA) was employed to collapse the physico-chemical and bacteriological parameters, extracting the ones that are most important in assessing seasonal variations of river water quality.

Descriptive statistics was used to determine the mean of the data set. Data were also presented on tables and graphs. The analysis was done with the aid of Statistical Package for Social Sciences version 21 (SPSS 21).

RESULTS AND DISCUSSIONS

To ensure sustainable water resource management, physicochemical analysis was performed on the parameters of sampled locations of Otamiri river wet and dry seasons in comparison with World Health Organization (WHO) 2017 standard.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

The results obtained for the physico-chemical parameters in the sampling locations studied during the wet and dry seasons are shown in Table 3.

Table 3: Results for Physicochemical parameters in wet season in comparison with WHO standards.

S/N	Physico-chemical parameters	Unit	Egbu	Akachi	Nekede mechanic village	Mean of sample	WHO guideline
1	Ph		4.9	5.1	5.3	5.1000	6.5-8.5
2	Temperature	oC	28.4	28.45	28.94	28.7333	20-30
3	Electrical conductivity	µS/cm	41	46	86	57.5000	1000
4	DO	mg/L	13.35	12.1	17.35	14.2667	NS
5	BOD	mg/L	10.45	9.3	9.95	9.9000	NS
6	COD	mg/L	192	120	248	186.6667	150
7	Turbidity	mg/L	68	23.25	20.45	37.1833	5.00
8	Total Solids	mg/L	112	82	135	109.6667	500-1500
9	TDS	mg/L	26.65	29.9	55.9	37.4833	500
10	Nitrate	mg/L	9.39	7.63	12.255	9.7550	50.00
11	Phosphate	mg/L	0.25	0.135	0.15	0.1783	5.00
12	Ammonia	mg/L	0.23	ND	0.74	0.3233	0.30

The results for Physicochemical parameters of in dry season in comparison with WHO standards are shown in Table 4

Table 4: Results for physicochemical parameters in dry season in comparison with WHO standards.

S/N	Physico-chemical parameters	Unit	Egbu	Akachi	Nekede mechanic village	Mean of sample	WHO guideline
1	Ph		4.7	5.1	5.3	5.03	6.5-8.5
2	Temperature	oC	29.7	30.15	30.25	30.03	20-30
3	Electrical conductivity	µS/cm	183.5	172.5	119	50.83	1000
4	DO	mg/L	11.3	13.1	15.75	13.38	NS
5	BOD	mg/L	11.35	9.75	9.3	10.13	NS
6	COD	mg/L	190.5	112.5	241	181.33	150

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

7	Turbidity	mg/L	65.1	21.25	20.85	35.73	5.00
8	Total Solids	mg/L	105.1	82	134	107.17	500-1500
9	TDS	mg/L	82.65	68.75	86.75	38.05	500
10	Nitrate	mg/L	6.25	4.23	8.215	6.23	50.00
11	Phosphate	mg/L	0.18	0.12	0.105	0.14	5.00
12	Ammonia	mg/L	0.11	ND	0.43	0.27	0.30

Otamiri river recorded values of 4.9, 5.1 and 5.3 for wet season (Table 3) while that of dry season are 4.7, 5.1 and 5.3 respectively at Egbu, Akachi and Nekede Mechanic village (Table 4). In this study, the pH range observed indicated that the water sample in all the sampling locations of both rivers were acidic in nature. High pH value was observed in Otamiri during the wet season.

The results in this study agreed with the report of Ogbomida and Emeribe (2014) in analysis of the impact of urbanization on Otamiri and Nworie rivers in Owerri with a pH 5.2 – 5.8. The study stated that the acidic nature of these rivers may be attributed to the geological state of the Imo Shale, which characterize the study area.

The temperature of Otamiri river was found to be in the range of 28.4^0C-28.9^0C in wet season and 29.7^0C-30.25^0C in dry season as shown in tables 3 and 4 respectively. The temperature ranges of Otamiri river falls within WHO (2017) standard for drinking water hence not expected to cause any harm to the aquatic environment.

In this study, the conductivity values of Otamiri river were found to be well below the WHO threshold of 1000µS/cm, the conductivity values of Otamiri river were 50.83 S/cm and 57.5 S/cm at wet and dry seasons. The high conductivity values of Otamiri may be attributed to the fact that it receives more influx pollutants such as soap and detergent by local residents who use it for domestic purposes. These elements are highly soluble in water and this leads to high electrical conductivity.

The mean of dissolved oxygen in Otamiri River were 14.27mg/L and 13.38mg/L respectively in wet and dry seasons. According to Oram (2014), the acceptable minimum DO level that can maintain balance in an aquatic environment is between 4 and 5 mg/ L. Thus, the DO levels in Otammiri river are at acceptable levels.

The result obtained from the study indicated biochemical oxygen demand (BOD) values ranging 9.3-10.45mg/L (wet season) and 9.3-11.35mg/L (dry season). This is in consonance with the study of River Benue by Akaahan and Azua (2016) where the BOD values ranged from 8.51–9.79mg/L (wet season) and 7.95–11.23mg/L (dry season). In surface water bodies, BOD concentrations up to or more than 10mg/L are classified to be heavily polluted while unpolluted water bodies typically have BOD values of 2mg/L or less (Olawale, 2016). Aquatic organisms thrive well in BOD level below 10 mg/L. This implies that Otamiri river is heavily polluted at different seasons of the year.

COD values range is from 120-248mg/L and 112.5-241 mg/L in both wet and dry seasons as seen in Tables 3 and 4. These values were above the WHO acceptable limits of 150 mg/L for COD. The high values of COD observed are indications of large amounts of organic materials which are chemically oxidized. Consumption of water with high COD levels can cause water related diseases such as dysentery and can also lead to fish mortality.

The turbidity found to be 37.8 NTU in wet season and 35.73 NTU in dry season. All the locations observed lower turbidity values during the dry season except Nekede mechanic village as seen in Table 4. This could be attributed to the sand dredging occurring at the location. Also, the water samples recorded high turbidity levels in all the seasons which is above WHO permissible limit of 5 NTU.

Total solid obtained ranges a mean value of 109.7 and 107.17 in wet and dry seasons respectively. All the values

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

in both rivers were all found to be within WHO acceptable limits of 500-1500 mg/L. Total dissolved solids fell between 26.65-55.9 mg/L and 68.75-86.75 mg/L for wet and dry seasons. The TDS values were observed to be lower than the WHO limit of 500 mg/ L.

The mean Nitrate concentrations recorded in wet and dry seasons respectively are 9.76mg/L and 6.23mg/L. The values recorded in all the sampling points are higher than the WHO recommended permissible range of 5mg/L. Nitrates find their way into water bodies through agricultural activities such as the application of fertilizers during farming.

Human activities such as animal grazing, open defecation, bathing in the river, washing with detergents as well as waste disposal along the river courses can contribute to high concentration of nitrates (Ilechukwu, Olusina. and Echeta, 2020).Phosphate content ranges between 0.13- 0.25mg/l in wet season and 0.11-0.18mg/l in dry season).Phosphate level in all the locations were lower than the WHO standard value of 5.0mg/l.

Ammonia levels ranged from 0.23 and 0.11 mg/L, 0.74 and 0.43mg/L at Nekede Mechanic village in wet and dry seasons but none was detected at Akachi.

Ammonia concentration was observed to be above the permissible level of 0.30mg/L in Otamiri river at Nekede Mechanic village during the rainy and dry seasons when compared to the WHO standard limit for drinking water.

The mean distribution of Physico-chemical parameters in wet and dry seasons is presented in Fig 1.

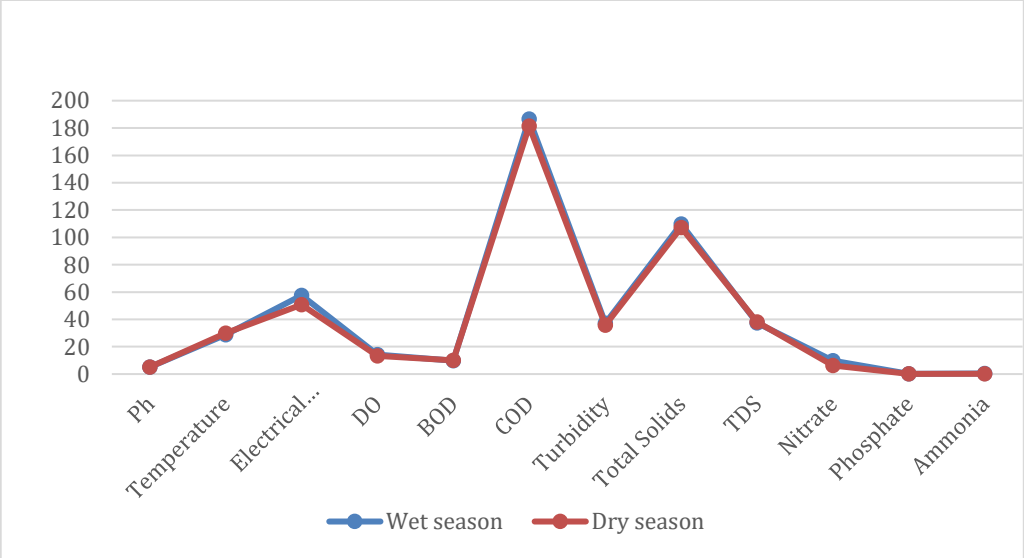

Fig 1 Mean distribution of Physico-chemical parameters in wet and dry seasons.

Principal Component Analysis (PCA) for Wet Season

From the extracted Table of the varimax rotated component matrix for water samples of wet season in Table 5 , it clearly depicted that all the components have eigen values greater than 1.00, that indicates that the two components explained 100% of the variance.

Table 5: Varimax Rotated Component Matrix of the variables for wet season.

Parameters	**Principal Components**	
	1	2
Ph	0.832	0.875
Temperature	0.902	-0.433

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

Electrical conductivity	0.794	-0.449
Dissolved Oxygen	0.791	1.33
Biological Oxygen Demand	0.425	0.905
Chemical Oxygen Demand	0.614	0.230
Turbidity	0.973	0.978
Total Solids	0.972	0.234
Total Dissolved Solids	0.894	-0.449
Nitrate	0.934	0.023
Phosphate	-0.040	0.999
Ammonia	0.798	-0.955
Eigen value	8.283	3.717
Percentage of variance explained	69.027	30.973
Cumulative percentage	69.027	100

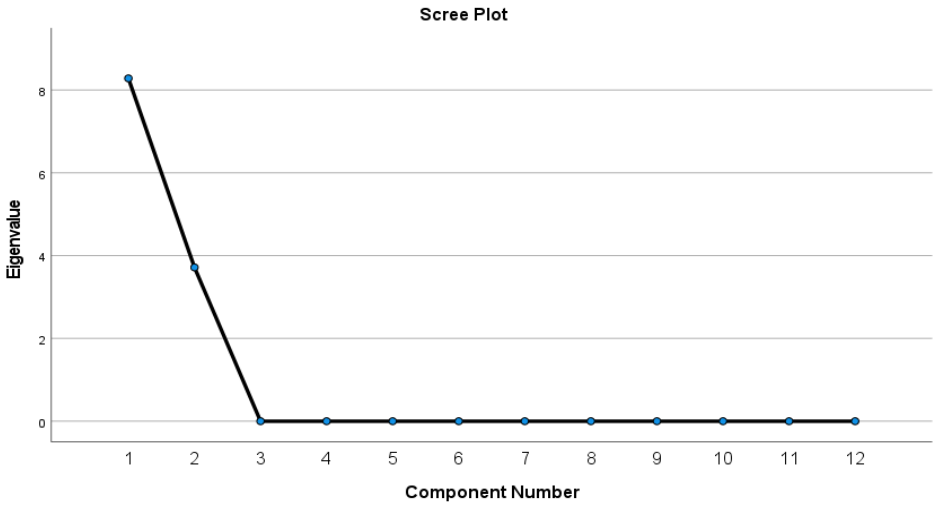

Fig 3: Scree Plot Spectrum of different Principal Components with their Eigenvalues for wet season

From Table 5, the eigen value of component 1 is 8.283 with the percentage of explained variance as 69.027%. Thus, component 1 explains 69.027% of the variations in water quality of Otamiri river in wet season leaving 30.973% unexplained. In the Principal component analysis, pH, temperature, turbidity, total solids, Total dissolved solids and Nitrate were highly loaded on component I.

The eigen value of component II is 3.717 with the percentage of explained variance as 30.973 %. Thus, component II provides explanation to 30.973 % of the seasonal variations in water quality of sampled locations of Otamiri river leaving 69.027 % unexplained. It was clearly established that pH, turbidity, phosphate and Ammonia are highly loaded on component II.

Furthermore, variables with very high loadings on component I for the sampled locations of Otamiri river in dry season is presented in Table 6.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

Table 6: Varimax Rotated Component Matrix of the variables for dry season.

Parameters	Principal Components	
	1	2
pH	0.979	0.205
Temperature	0.999	0.044
Electrical conductivity	-0.725	-0.689
Dissolved Oxygen	-0.875	0.485
Biological Oxygen Demand	-0.697	-0.083
Chemical Oxygen Demand	0.004	-0.543
Turbidity	0.993	0.119
Total Solids	-0.190	0.982
Total Dissolved Solids	0.176	0.984
Nitrate	-0.118	0.293
Phosphate	0.608	-0.063
Ammonia	-0.391	0.920
Eigen value	7.751	4.249
Percentage of variance explained	64.590	35.40
Cumulative percentage	64.590	100

The eigen value of component I is 7.751 with the percentage of explained variance as 64.590 %. Thus, the component contributed about 64.590 % of variance leaving 35.41 % unexplained. as seen in Table 6. Parameters with high loadings during the dry season in component I were pH, temperature, dissolved Oxygen and turbidity. That of component II recorded an eigen value of 4.249, the percentage of explained variance as 35.40% leaving 64.6% unexplained.

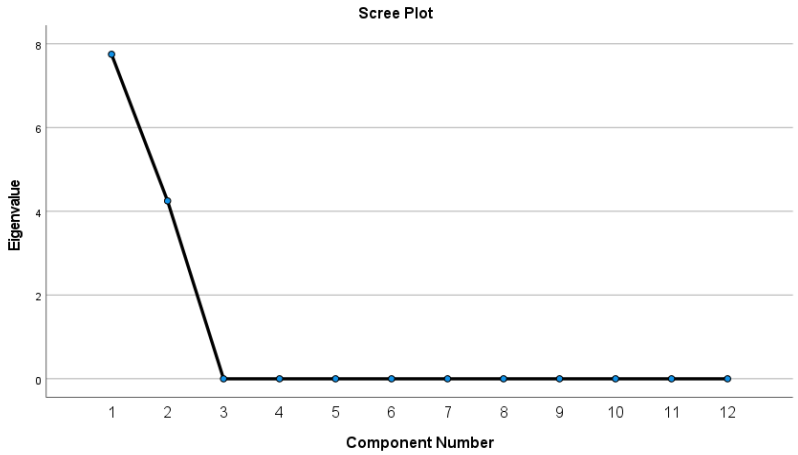

Fig 3: Scree Plot Spectrum of different Principal Components with their Eigenvalues for dry season

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

On each principal component, only variables with loadings ≥0.80 were considered significant and were extracted as seen in Table 7.

Table 7: Major physico-chemical parameters of river water quality variations at different seasons

Wet season	**Dry season**
Ph, Temperature, Turbidity, Total Solids, Ammonia and Nitrate	Temperature, Dissolved Oxygen, Turbidity, Ammonia, Ph, and Total Dissolved solids

These parameters shown in Table 7 contribute majorly to the seasonal influences in water quality of sampled locations of Otamiri river in both wet and dry seasons. The Principal Component Analysis (PCA) index indicates Physico-chemical contamination of the river water which is due to urban runoff, industrial, agricultural discharges, domestic/residential waste and other anthropogenic activities such as refuse dumping in river water bodies.

CONCLUSION

There were slight variations in some of the physicochemical parameters observed in the sampling locations of Otamiri river. These variations indicate various levels of inputs in different seasons. Some of the parameters were within the WHO standard for drinking water while some such as turbidity and total suspended solids had values that exceeded WHO guidelines.

Results from the Principal Component Analysis (PCA) revealed the parameters that contribute majorly to seasonal variations in the sampled locations of Otamiri River. It was observed that a parameter that contributes principally to river water quality variation for wet season may not be important for dry season.

Furthermore, the study identified physico-chemical contamination of the river water from urban runoff, industrial, agricultural discharges and domestic/residential wastes.

Based on the findings, the study recommends seasonal treatment of the physico-chemical and microbial pollutants and other treatment procedures such as using activated charcoal to eradicate compounds and sodium bicarbonate (soda ash) to correct pH.

REFERENCES

1. Akaahan, T. J. A., & Azua, E. T. (2016). Assessment of seasonal variation of oxygen demands as pollution indicators of river Benue, Nigeria. European Journal of Earth and Environment, 3(3).
2. Bibiye, Alaye A. S. (2022). In-Stream Sand Mining and Primary Productivity of Otamiri River in Owerri, South-East Nigeria, International Journal of Management Technology, 9, (2), pp.1-11
3. Chukwu, K. E (2018). The problems of surface water pollution management in Port Harcourt and Environs. International journal of advanced research in Management and Social Sciences 7(5) Retrieved from www.garph.co.uk
4. Fagorite, V. I., Ahiarakwem, C. A., Okeke, O. C. and Onyekuru, S. O. (2019). Physico-Chemical Characteristics of Otamiri River and its Sediments in Parts of Owerri. Available online at www.elixirpublishers.com (Elixir International Journal).
5. Ilechukwu, I., Olusina, T. A. and Echeta, O. C. "Physicochemical Analysis of Water and Sediments of Usuma Dam, Abuja, Nigeria", SCIENDO--Ovidius University Annals of Chemistry, 2020; 3(2), 80 – 87
6. Ioryue I. S, Wuana R. A and Augustine A. U (2018). Seasonal VarSiation in Water Quality Parameters of River Mkomon Kwande Local Government Area, Nigeria. International Journal of Recent Research in Physics and Chemical Sciences (IJRRPCS) 5(1), pp: (42-62), Month: April 2018 – September 2018,
7. Ogbomida, E. T., & Emeribe, C. N. (2014). Impact of urbanization on Nwaorie and Otamiri Rivers in Owerri, Imo State, Nigeria. Advances in environmental research, 2(2), 119-129

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

8. Okechi, R. and Chukwura, E. I. (2020). Physicochemical and Bacteriological Qualities of Otamiri River Water and Sediment in South Eastern Nigeria. Frontiers in Environmental Microbiology. Vol. 6, No. 2, 2020, pp. 18-26. doi: 10.11648/j.fem.20200602.12
9. Okolo C. M, Onuorah I. D.and Madu F.M. (2023) Seasonal Variation in Physicochemical properties of Water in Onitsha Metropolis, Southeastern, Nigeria. Asian Journal of Environment & Ecology.22 (4), Page 39-52, 2023;. DOI:10.9734/AJEE/2023/v22i4506.
10. Olawale, S.A. (2016). Physico Chemical Analysis of Water from Asa River, Ilorin, Nigeria. Imperial journal of interdisciplinary research, 2, 122-129.
11. Oram B (2014) Dissolved oxygen in water. Water Research Center. Retrieved from www.water-research.net/index.php/dissolved-oxygen-in-water. Accessed 12 Oct 2018