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Assessment of Physicochemical Parameters in Selected Water Bodies in Oyo and Lagos States

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Assessment of Physicochemical Parameters in Selected Water Bodies in Oyo and Lagos States

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Abstract. Sustainable provision of safe access to potable water has continued to be a major challenge across the world. Water samples were collected from water bodies at Awba Dam and National Horticulture Research Institute (NIHORT) in Ibadan, Oyo State and the Ogun River in Lagos State. The aim of this study was to gauge the conditions of these frequently used water bodies. The locations were selected based on surrounding population and activities. Sampling was done in the months of April and June, 2021. The physicochemical parameters analysed were pH, electrical conductivity (EC), salinity, total dissolved solids (TDS), chloride, biochemical oxygen demand (BOD) and dissolved oxygen (DO). Average salinity value ranged between 0.2675 ± 0.14 mg/L (UI) and 0.6735 ± 0.22 mg/L (Berger). These values are quite high and significant when compared to the threshold level of 0.0000001 mg/L. Of the three sampling points, the samples obtained from Awba Dam at the University of Ibadan seem to have the better quality in relative terms. This follows from the BOD and TDS values of 3.75 ± 0.28 mg/L and 259.7 ± 156.89 mg/L respectively. This study shows that the mismanagement of our waters through unrestrained and unrestricted dumping of contaminants into it has caused these water bodies to have poor quality and should not be used for the purpose of consumption unless properly treated. The presence of aquatic plants that take in some of these pollutants and release oxygen may also help improve quality.

Keywords: Physicochemical parameters, pH, BOD, TDS

1. Introduction

Water is a vital resource that can be replenished and is required for the existence of life, production of food, economic development, and general contentment [1]. Water is difficult to substitute because of its unique functions, it is tough to cleanse, and it is certainly a one-of-a-kind gift from nature to humans [2]. Water's tremendous worth for humans is due to all of these properties. In total, 97% of available water on earth is constituted in the seas and oceans as well as saline groundwater and salty waters of closed lakes which stores significant amount of water [3]. The remaining 3% constitutes the fresh water, which has a salinity value below 1% [4]. Fresh to saline water ratio on earth is of the order of 1 to 50 [5]. Freshwater ecosystems account for only 0.5% of the earth's surface area and have a volume of 2.84 x 105 km^3. Of the water classified as non-saline water on earth, 3% flows in rivers and stream, 67% is locked in ice and glaciers and 30% is groundwater [6]. The available freshwater goes into domestic (10%), industrial (20%) and agricultural (70%) uses [7].

Surface waters from natural sources have a better quality than those from area that have been influenced by human activities. Most surface waters are subject to contamination from point and non-point sources through wastewaters from agricultural and industrial activities and runoff from rainfall [8]. Access to safe drinking water has been shown to be directly proportional to a healthy population. Sustainable provision of safe access to potable water has continued to be a major challenge across the world. The problem is more pronounced in the rustic areas of most emerging countries as there is a weak water supply infrastructure base [8]. The effect of industrialization is the basis of development of societies as it plays a major role in the expansion and advancement of economic growth. Industrial discharges into water bodies have the tendency to modify the physical, empirical and organic properties of the sinks. The solids content of the treated and untreated wastes from the industries are in suspended and dissolved forms and they have contaminated the water bodies around. Several Nigerian cities depend on waters from these polluted rivers [9].

Water pollution levels are determined by the amount of pollutant present, the pollutant's ecological impact, and the amount of water used [10]. Water residence time, which relates to the average duration a water molecule spends in a water reservoir, is critical for pollution issues since it influences polluting potential [12]. It is to be noted that contaminants spend more time in an ecosystem than water. Contaminants are introduced to water bodies from both point and nonpoint sources. Industries and farms which produce enormous quantities animals such as cows, pigs, and chickens in small spaces, are examples of point pollution sources [12]. Nonpoint sources of pollution include agricultural areas, cities, and abandoned mines. Storm water accommodates pollutants like pesticides and herbicides resulting from use on farmlands as well as those from domestic and traffic sources. This contamination then finds its way into the surface and groundwater [13].

The high levels of pollutants present in many rivers leads to an increase in chemical and biochemical oxygen demands, the solids (total and suspended). It is now not unusual to discover the presence of some environmental health hazardous wastes as part of Nigeria's domestic wastes as is present in many developed countries [14]. Access to good water quality guarantees the continued existence of animals and aquatic life. It has been established that the pollution of aquatic ecosystems is a major problem in both water and aquatic life [15]. It is, therefore, necessary to carefully observe the properties of water viz-a-viz its numerous uses. This study was aimed at ascertaining the values of physiochemical parameters of selected natural water bodies in south western Nigeria.

2. Materials and Methods

2.1. Sampling Locations

Water samples were collected from three water bodies in Ibadan, Oyo State and Lagos State. The locations were selected based on surrounding population and activities. The first location is Awba dam located within the University of Ibadan. The second location is the National Horticulture Research Institute (NIHORT) which receives waters polluted mostly with agricultural and domestic solid wastes, Jericho Ibadan. The third water body is the Ogun River by Kara cattle market, Berger bus stop, Lagos state, which receives wastewaters from manufacturing industries and solid wastes from the nearby market.

2.2. Sample collection

Sampling was done in the months of April and June, 2021 and collection of samples was done in the morning. Three water samples were collected in 1 litre bottles from each location and placed in coolers with ice packs. The water samples were then transported to the central laboratory at the University of Lagos for analysis of physicochemical parameters.

2.3. Analysis of physicochemical parameters

i. pH and Conductivity: This were done with the use of a Hanna Instruments HI 9813-6N pH/EC/TDS Meter. The meter was calibrated before the electrode was infused into the sample.

ii. Total Dissolved Solids (TDS): A filtered water sample quantity of 50ml was oven-dried in a beaker. The difference in the weight of the empty beaker and the oven dried content was used to estimate the TDS [16].

iii. Biological Oxygen Demand (BOD) and Dissolved Oxygen (DO): About 10 mL of the water sample was taken into 1000 mL volumetric flask, 2 mL each of ferric chloride solution, Magnesium sulphate and phosphate buffer were added and later made of to 1L with deionized water. The Dissolved oxygen was measured for day zero (D0). Then the remaining sample was seeded for 5 days and the dissolved oxygen was measured at the fifth day (D5) [17]. The difference between D5 and D0 divided by the dilution factor gives the 5-day BOD.

Calculation: BOD = D0-D5/Dilution factor

iv. Salinity and Chloride: Salinity was determined using the electrical conductivity (EC) methods while the Chloride content was estimated using the potentiometric method [18]. The EC of the water is measured with an EC meter. The obtained value (in µS/cm) is raised to a power of 1.0878 and multiplied by 0.4665 to give salinity in milligrams (of salt) per liter (of solution). For the Chlorides, a standard solution of sodium chloride is prepared for use with an Accumet Model 15 Specific Ion Potentiometer.

3. Results

The physicochemical characteristics that were investigated in water are proffered in Tables 1 and 2. Table 1 shows the physicochemical parameters that were measured in the month of April, while table 2 shows parameters measured in June. The parameters were compared with WHO standards for water. The pH of the water samples ranged between 6.85 (Berger) and 7.56 (NIHORT). The conductivity values range from 360.6 uS/m (University of Ibadan) to 1715 uS/m (Berger). The TDS ranged between 148.8 mg/L (University of Ibadan) and 823 mg/L (Berger) in the samples. Salinity value ranged between 0.169 (University of Ibadan) and 0.830 (Berger). These values are quite high and when tested to the threshold level of 0.000001 mg/L. The chloride values for the samples fell between 83 mg/L (University of Ibadan) and 402 mg/L (Berger). The average values (±S.D.) of all the water parameters in the different sampling locations are presented in table 3. Average pH value extended from 6.965 ± 0.16 (University of Ibadan) to 7.32 ± 0.34 (NIHORT). The average conductivity ranged from 574.6 ± 302.64 µS/cm (University of Ibadan) to 1439.25 ± 229.98 µS/cm (Berger). Average BOD values fell between 3.75 ± 0.28 mg/L (University of Ibadan) and 6.61 ± 2.74 mg/L (NIHORT) while DO ranged from 5.15 ± 0.14 mg/L (NIHORT) to 5.81 ± 0.29 mg/L (University of Ibadan).

Table 1: Physicochemical parameters analysed in water for the month of April

Sample code	Ph	EC (µS/cm)	TDS (mg/L)	Salinity (mg/L)	Chloride (mg/L)	BOD (mg/L)	DO (mg/L)
Standard	**6.5-8.5**	**300**	**500**	**0.000001**	**250**	**5**	**5**
U	7.18	788.60	370.64	0.366	177.50	3.55	5.60
B	7.08	1715.50	823.44	0.830	402.52	5.06	5.25
N	7.56	1152.05	552.98	0.482	233.76	8.55	4.65

U= University of Ibadan, B= Berger, N= NIHORT

Table 2: Physicochemical parameters analysed in water for the month of June

Sample code	pH	EC (µS/cm)	TDS (mg/L)	Salinity (mg/L)	Chloride (mg/L)	BOD (mg/L)	DO (mg/L)
Standard	**6.5-8.5**	**300**	**500**	**0.0000001**	**250**	**5**	**5**
U	6.96	360.60	148.76	0.169	83.33	3.95	6.02
B	6.85	1163	498.20	0.517	254.90	5.08	5.05
N	7.08	907.70	425.68	0.434	213.98	4.67	5.75

U= University of Ibadan, B= Berger, N= NIHORT

Table 3: Average physicochemical parameters analysed in water for the months of April and June

Sample code	pH	EC (µS/cm)	TDS (mg/L)	Salinity (mg/L)	Chloride (mg/L)	BOD (mg/L)	DO (mg/L)
U	7.07 ±0.16	574.6 ±302.64	259.7 ±156.89	0.268 ±0.14	130.42 ±66.59	3.75 ± 0.28	5.81 ±0.29
B	6.97 ±0.16	1439.2 ±229.9	660.82 ±390.68	0.673 ±0.22	328.71 ±104.38	5.07 ±0.01	5.15 ±0.14
N	7.32 ±0.34	1029.875 ±172.78	489.33 ±90.02	0.458 ±0.03	223.87 ±13.99	6.61 ±2.74	5.20 ±0.78

U= University of Ibadan, B= Berger, N= NIHORT

4. Discussion

Water physicochemical parameters are indices used in determining water quality. The parameters analyzed in this study were pH, electrical conductivity, salinity, total dissolved solids, chlorides, biochemical oxygen demand and dissolved oxygen.

In determining the quality of water, pH is a significant consideration as it has an impact on a variety of biological and chemical processes in watercourses. It is a method of determining acidity or alkalinity, as well as the sum of hydrogen ions in water. The existence of some pollutants can lead to varying pH values, like oxides of sulphur and nitrogen which are converted to nitric and sulphuric acids, especially when calculated and documented continuously, together with the electrical conductivity of a water body [19]. A pH range of 6.5 - 8.5 is permissible according to the WHO [20]. The pH of water as presented in Tables 1 and 2 falls within acceptable limits. Furthermore, the average pH values as shown in table 3 are also within the permissible range. However, pH levels across locations in June are lower than in April. This is likely due to an increase in rainfall during the period. The pH value ranged from 7.08 to 7.56 in April and 6.85 to 7.08 in June. This is similar to a report by Adeogun *et al*. [21] on Impact of Abattoir and Saw-Mill Effluents on Water Quality of Upper Ogun River, where the pH values recorded in the dry season were higher than those in the rainy season implying that rainfall affects pH. Minor changes in pH may result in protracted consequences; the solubility of phosphorus and other nutrients can be improved by changing the pH of water [22]. The more the nutrients, the more aquatic plants and algae thrive thereby causing an increase in the demand for dissolved oxygen [2].

The ability of water to allow the flow of electric current is measured by its electrical conductivity (EC). The ion concentration in water determines the EC.. These ions come from dissolved salts and inorganic elements. In the two sampling months, EC ranged between 1715.5 and 1163 µS/cm in Berger, between 788.60 and 360.60 µS/cm in UI and between 1152.05 and 907.70 µS/cm in NIHORT. There was a dramatic drop in EC between the months. According to the WHO [23], the permissible limit for EC is 300 μS/cm. Average EC values across all locations exceeded the acceptable limit (table 3). Solomon *et al*. [24] reported that water contamination is indicated by a high conductivity value. High quantities of cations and anions, on the other hand, may alter the chemical composition of the aquatic system. In tables 1 and 2, the electrical conductivity showed similar pattern of variation between the months. The reduction in the value of EC between April and June is contrary to a report by Yerima *et al*. [25] who recorded outstanding increase in EC between the months of January and February. Rainfall, temperature and mineral deposition are some of the factors that affect EC in water. Between the periods of April and June, rainfall increased drastically. Reduction in industrial activities, especially as industries are still trying to peak post-covid, could also be a reason for the decrease of EC in June.

The total content from all salts dissolved in water is known as salinity. Dissolved ions increase salinity. As these electrolytes dissolve, they generate ionic particles, each with a negative and positive charge. As such, salinity is a strong contributor to conductivity. Salt concentration was lowest in UI (0.366 and 0.169 mg/L), and highest in Berger (0.830 and 0.517 mg/L) in April and June respectively. A similar trend is observed in the average salinity values. The recommended concentration for salinity in freshwater is 0.0000001 mg/L [20]. The salinity levels found in this investigation are over the legal limit. The decrease in salinity between the months can be attributed to an increase in rainfall as reported by CWT [26] which affirms that, rain falling into a stretch of water, or runoff from rain flowing into it, decreases salinity due to the fact that salinity of coastal waters is influenced by sea sprays carrying salts into the air, which then fall back into the waters with rainfall.

Total dissolved solids (TDS) is a measure of the combined dissolved content of all inorganic and organic substances present in water - molecular, ionized, or micro-granular suspended form. Natural sources, wastewater, municipal and agriculture run-off and industrial effluents are all sources of TDS in bodies of water. [27]. In both months, Berger had the highest TDS content at 823.44 mg/L and 498.20 mg/L. UI had the lowest TDS content at 370.64 and 148.76 mg/L in April and June respectively. The prescribed limit of TDS by WHO [21] is 500 mg/L. All the water samples had TDS concentrations below the permissible limits across all three locations in June. However, TDS value in UI had an acceptable concentration in April. The TDS varied across the months but consistently similar in the three locations, similar to EC. This is similarly reported by Yerima *et al*. [25]. TDS is important to aquatic life because they help to keep cell density balanced [28]. Water will flow into the cells of an organism, causing them to swell. Water bodies with very high TDS concentration cause cells to shrink. TDS can also affect the taste of water, and often indicates a high alkalinity or hardness [29].

The maximum chloride content recorded in this study was in the month of April and the minimum was recorded in June consistently across the locations. Berger, with values of 402.52 mg/L in April, and 254.9 mg/L in June, surpasses the acceptable limit. UI had the lowest values in both months with average concentrations of 130.42 ± 66.59 mg/L (table 3). Chloride has been associated with pollution and the legal level is set at 250 mg/L by the WHO [20]. Etesin *et al*. [30] recorded high levels of chloride across seasons, with 441.1 mg/L in the dry season and 410.3 mg/L in the rainy season. Chloride levels above 250 mg/L give water a saline flavor, and persons not used to high chloride levels may experience laxative effects. Natural and anthropogenic sources of chloride in surface and groundwater include runoff, inorganic fertilizer use, landfill leachates, septic system effluents, industrial emissions, irrigation discharge, and animal feed [31].

Biochemical oxygen demand (BOD) is the amount of dissolved oxygen that is needed for stabilization of organic matter that are biodegradable through the action of aerobic microorganisms and the oxidation of certain inorganic materials [32]. It refers to the amount of oxygen required to decompose organic materials in water. Tables 1 and 2 revealed the values of BOD as 8.55>5.06>3.55 mg/L in NIHORT, Berger and UI respectively, in the month of April. In June, BOD values were of the order 5.08 >4.67>3.95 mg/L in Berger, NIHORT and UI respectively. Average values for the two months is in the order 6.61>5.07>3.75 in NIHORT, Berger and UI. The permissible limit prescribed by WHO [23] for BOD is 5 mg/L. Reports by Clair et al. [33] opined that water bodies with BOD in the range of 2 – 8 mg/L are moderately polluted. Edori and Nna, [34] observed average BOD values of 4.92 mg/L, which was higher than the WHO endorsed value of 4.0 mg/L when they studied effluents at discharge points into the new Calabar river. BOD concentration can be affected by various types of inorganic and in organic substances in water [35].

Dissolved oxygen (DO), refers to the quantity of oxygen gas present in a water body. All types of life, including species responsible for self-purification mechanisms in aquatic ecosystems, require oxygen [36]. DO concentrations in June range from 5.05 to 6.02 mg/L and were higher than those in April. UI had the highest concentrations of DO at 5.60 mg/L and 6.02 mg/L in April and June singly. The WHO permissible level for DO [37] is 5 mg/L. Most concentrations across locations were higher than the permissible limit. Studies by Ikotun *et al*. [38] reported values of 3.9 to 6.55 mg/L for the dry season and 4.1 to 7.7 mg/L for the rainy season which are consistent with the fact that dissolved oxygen tends to be lower in dry seasons. Apart from temperature and organic matter, DO levels in water reflects the physical and biological reactions that endure in water and is usually influenced by aquatic plants and plankton concentration [39]. Temperature, salinity, turbulence, algae and plant photosynthetic action, and atmospheric conditions all affect oxygen levels. Salinity and temperature are inversely proportional to oxygen solubility in water [40].

Samples from UI were discovered to be the least polluted. This follows from the BOD, chloride and TDS values. This may be due to the fact that the location is in a controlled or protected environment which reduces the possibility of indiscriminate dumping of wastes and pollutants. Using the same yardstick, samples from Berger seems slightly better than that of NIHORT.

5. Conclusion

No surface water is pure. Based on the results obtained, all the sample locations, though subjected to varying levels of pollution, still has the tendency and ability to sustain aquatic life and the ecosystem. Of the three sampling points, the samples obtained from Awba dam at the University of Ibadan seem to have the better quality in relative terms. From this study it can be deduced that the mismanagement of our waters through unrestrained and unrestricted dumping of contaminants into it has caused these water bodies to have poor quality and should not be used for the purpose of consumption unless properly treated. In-spite of these issues, the water bodies have managed to sustain the ecosystem and most aquatic life. The presence of aquatic plants that take in some of these pollutants and release oxygen may also help improve quality. Turbulence in the waterways may also have improved the re-aeration processes.

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7. Conflict of Interest

The authors declare no conflict of interest in this study

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