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Physico-Chemical Analysis of Oji-River in Enugu State, Nigeria to Ascertain its Pollution Level

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Abstract

Physico-chemical investigations were carried out on Oji-river using standard methods to ascertain the level and sources of pollution. The distribution of pollutants due to anthropogenic activities was reported. Evaluation revealed the mean range values of the following parameters; pH, 5.98 – 6.15, turbidity, 2.10 – 7.90 NTU, total suspended solid (TSS), 0.70 – 5.40 mgL^{-1}, total dissolved solid (TDS), 18.20 – 49.60 mgL^{-1}, electrical conductivity (EC), 39.60 – 107.90 μScm^{-1}, alkalinity, 20.0 – 34.0 mgL^{-1}, chemical oxygen demand (COD), 80.0 – 150.0 mgL^{-1}, biochemical oxygen demand (BOD), 20.10 – 37.50 mgL^{-1}, dissolved oxygen (DO), 2.82 – 4.68 mgL^{-1}, chloride, 15.88 – 21.55 mgL^{-1}, nitrate, 1.10 – 2.30 mgL^{-1}, phosphate, 0.45 – 0.64 mgL^{-1}, sulphate, 1.47 – 6.23 mgL^{-1}, calcium, 1.668 – 2.053 mgL^{-1}, sodium, 2.169 – 3.327 mgL^{-1}, potassium, 3.604 – 4.628 mgL^{-1}, magnesium, 0.974 – 2.015 mgL^{-1}, iron, 0.291 – 0.428 mgL^{-1}, copper, 1.055 – 2.034 mgL^{-1}, lead, 0.0001 – 0.011 mgL^{-1}. The study, showed vital physico-chemical and micro-biological properties not within water quality standard of the WHO, EPA and NAFDAC as mean COD, BOD, Fe, Cu and Pb values exceeded permissible limits indicating the need for treatment and monitoring by the Government, relevant regulatory agencies and parastatals to ensure public health and safety. The pollution index result also confirmed the river polluted.

Keywords: Oji-river, pollution, analysis, standard methods, quality.

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Introduction

No living creature can exist in the environment without water, which is essential to it [1, 2].The availability of clean drinking water is essential to human physiology and is a major factor in determining man's continued existence [3]. It is very necessary for every living thing to survive. Human welfare and water quality are closely related, making water quality a critical concern for all people. To avoid health risks, both rural and urban populations must have access to portable water [4, 5]. In order to guarantee that water is safe to drink, it must meet a number of physical, chemical, and microbiological requirements before it can be deemed drinkable [6].

Therefore, water that is free of chemicals that are harmful to health and microorganisms that cause disease is considered potable [7]. there are several places to find water, including streams, lakes, rivers, ponds, rain, springs, and wells [8]. Regretfully, pure, safe, and clean water are fleeting in nature, since they are quickly contaminated by human activity and prevailing environmental conditions. As a result, most sources of water should not be drunk right away without first being treated [9].The majority of people in Nigeria rely only on groundwater as their source of drinking water. It is thought that groundwater is cleaner and less contaminated than surface water.

However, over time, the discharge of solid waste dumps, home sewage, and industrial effluents pollutes surface water and poses health risks. In places with shallow groundwater tables, high industrialization, and high population densities, the issues related to surface water quality are far more severe. Because of overuse of resources and inappropriate waste disposal methods, the fast urbanization of the world has had an additional negative impact on the quality of surface waters. Preventive measures are the most efficient way to address contamination of surface and ground waters [10]. The need for and concern for the maintenance and preservation of surface water quality is thus constant.

The current study was conducted to look into the potential effects of surface water quality of specific sampling places on the Oji River, taking into account the aforementioned factors of surface water contamination. In order to compare the physical and chemical characteristics of surface water with the WHO/EPA standard for drinking water quality, an attempt was made to obtain these parameters in this study.Families and communities who rely on private water delivery systems find that the availability of water has become a serious and urgent issue in many developing nations.

Because water has the potential to spread disease among a wide population, compliance with microbiological requirements is very important. While local requirements may differ, the goal is always to minimize the likelihood while also making the beverage enjoyable to consume, which suggests that it should be healthful and delicious in every way [11]. The production and distribution of clean, suitable-for-human consumption water are the cornerstones of municipal water systems [3]. To determine whether raw water is suitable for usage, one must have a solid understanding of its chemical properties.

Therefore, it is necessary to regularly analyze the physico-chemical properties of water at its sources in order to assess the efficacy of treatment procedures.Over the past ten years, nearly everywhere in the world has seen a steady and significant improvement in the availability of clean drinking water. The GDP per capita and the availability of clean water are positively correlated. Nonetheless, according to some analysts, over half of the world's population would be vulnerable to water-related issues by 2025 [12]. According to a recent assessment, there is a 50% chance that water supply would not meet demand in certain emerging regions of the world by 2030. Water is essential to the global economy because it can be used as a solvent for a wide range of chemicals and because it makes transportation and industry

Agriculture uses over 70% of freshwater resources [13]. Every day, some 5,000 individuals die from diarrheal illnesses that are completely preventable, the most of them being small children. This toll can be significantly reduced by providing adequate and higher-quality drinking water, practicing basic cleanliness, and installing low-cost, straightforward home water treatment systems.

This work is therefore, an attempt to examine the selected sampled locations of surface water of Oji river and compared with the WHO standard for conformity to physico-chemical standards for drinking water quality. The physical, chemical, and biological properties of water are referred to as its quality. The most common way to utilize it is in relation to a set of standards that might be used to gauge compliance. The most widely used standards for assessing the quality of water are those that deal with drinking water, human contact safety, and ecosystem health. Human health is concerned about the quality of drinking water in both developed and developing nations across the globe. Toxic chemicals, radioactive risks, and infectious agents are the sources of risk [14]. Experience shows how important preventive management strategies are, from water resources to the end user.

The World Health Organization (WHO) creates international standards for human health and water quality in the form of guidelines that serve as the foundation for laws and standard-setting in both developed and developing nations globally.

The first and second editions of the guidelines for drinking water quality were used by developing and developed countries worldwide as the basis for regulations and standard setting to ensure the safety of drinking water. They offer guideline values for a wide range of chemical risks and acknowledge that ensuring microbiological safety should come first. The guidelines' third version has been completely revised to reflect advancements in risk assessment and management since the publication of the second edition. It outlines a framework for the safety of drinking water and talks about the duties and obligations of various parties, such as the complimentary roles of community, independent surveillance agencies, suppliers, and national regulators.

Developments in the third edition of the guidelines include significantly expanded guidance on ensuring the microbial safety of drinking water -in particular through comprehensive system specific water safety plans. For the first time, reviews of many water-borne pathogens are provided.. The third section goes on to outline the key elements of each method, acknowledging the necessity for distinct instruments and strategies to support community and large-scale supplies.

New section deal with the application of the guidelines to specific circumstances, such as emergencies and disasters, large buildings, packaged/bottled water, traveler's desalination system, food production and processing and water safety on ships and in aviation. This volume includes the first and second addenda that update the third edition. The first contains further guidelines for handling unanticipated events and emergencies, as well as information on setting standards for volatile compounds, handling byproducts of chlorination, and multiple new fact sheets for chemicals. Additional guidelines about household water management, rainwater harvesting, temporary water sources, vended water, and pesticides used for vector control in drinking water sources are included in the second. A number of brand-new chemical and microbiological fact sheets are also included. Additionally, extended fact sheets are provided for important chemical risks such nitrate, fluoride, and arsenic.

Because the negative health consequences of chemical contaminants are typically linked to long-term exposures, while the effects of microbial contamination are typically acute, drinking water contaminants that are chemically contaminated are frequently ranked lower than microbial contaminants [15]. However, there are some very serious issues that contaminants in water sources can create. This aims to assist users at the local or national level in determining which chemicals in a specific environment should be prioritized when creating risk management and chemical monitoring plans for drinking water. Public health officials, individuals in charge of establishing guidelines and monitoring the quality of drinking water, and water supply organizations in charge of managing water quality will find this helpful.

It will be especially useful in situations where there is a lack of information on the real quality of drinking water, as is the case in many developing nations and in rural areas of several industrialized nations. Regarding naturally occurring water bodies, they also provide some accurate approximations of immaculate states. Different criteria are taken into consideration since different uses give rise to different problems. Natural water bodies will change according to the surrounding circumstances. Most of the planet's surface water is not poisonous or drinkable. This holds true even if seawater—which is too salty to drink—in the oceans is not taken into account.

The idea of a sample attribute that determines whether or not water is contaminated is another common concept of water quality. It's actually a pretty complicated topic, partly because water is a complex medium that is inextricably linked to Earth's environment.

Water pollution is mostly caused by industrial pollution, runoff from agricultural areas, urban storm water runoff, and treated and untreated sewage discharge (particularly in developing nations). The environmental protection agency (EPA) of the United States sets limitations on the quantity of specific contaminants that can be found in tap water that is supplied by public water systems. The EPA is permitted to issue two different kinds of standards under the Safe Drinking Water Act.
Primary standard regulate substances that potentially affect human health and secondary standard prescribe aesthetic qualities, those that affect taste, odour, or appearance.

It is reasonable to assume that drinking water, even bottled water, will include some pollutants, albeit in trace amounts [16,17, 18]. These pollutants may not always mean that drinking the water is dangerous for your health. The variety of methods used to measure water quality indicators reflects the complexity of the topic of water quality [19]. On-site measurements of temperature, pH, dissolved oxygen, electrical conductivity, and oxygen reduction potential (ORP) can be conducted in close proximity to the water source under investigation.

A water sample must be taken, stored, and examined at a different site in order to do more intricate measurements in a lab setting.

Materials and Methods

Materials

Centigrade mercury-in-glass thermometer; digital pH meter; turbidity meter; conductivity meter of Hanna EC 215 model; AAS spectrophotometer of Unicam solar 969 type; UV-visible spectrophotometer of Jenway 6305 model; digital spectrophotometer of DR 2010 model.

Study Area

Enugu, a mainland state in southeast Nigeria that was formed in 1991 from the former Anambra State, contains the Oji River. Its main cities include Enugu, Nsukka, Awgu, Udi, Ozara, and Agbani. The state shares boundaries with the following states: Kogi State to the north-west, Anambra State to the west, Benue State to the east, Ebonyi State to the east, and Abia and Imo States to the south.Despite being landlocked, Enugu can be reached by car in about 2.5 hours from the coastal cities of Port-Harcourt, Calabar, and Warri, which all have important shipping ports.Enugu may be reached by car in approximately one hour from Onitsha, two hours from Aba, five hours from Abuja, and seven hours from Lagos.

Partially located in the southern semi-tropical rain forest zone, the state stretches across an area of around 8727.1 km2 in a northerly direction. Its physical characteristics progressively transition from open woods to savannah, from tropical rainforest to open woods. With the exception of a low hilly chain that passes through Abakaliki, Ebonyi State, to the north-west, and through Enugu and Agwu to the south, the majority of the state is composed of low land divided by several streams and rivulets, the most significant of which are the Adada and Oji rivers. At roughly 223 meters above sea level, the state boasts excellent soil and a well-drained soil.

February is the hottest month with an average temperature of roughly 36.20 oC (97.16 F), while November has the lowest average temperature of 20.30 oC (68.54 F). About 0.16 cm3 of rain falls on average in February, whereas about 35.70 cm of rain falls on average in July.Oji River is located in Nigeria's Enugu state at Udi. Its coordinates are 7o 16I 0II east and 6o 16I 0II north. It is among the most well-known and significant river systems in the country in many respects.

The river's quality is critical to maintaining its numerous uses, such as providing drinking water, supporting economic and recreational activities, and supporting the ecosystem of the river and the environmental goods and services it provides.

Apart from its use as a source of drinking water for many millions of people in cities along the river which clearly ensures its adequate quality a national concern, the river supports numerous economic activities including boating, commercial and recreational fishing, hiking and hunting.

The foundation for protecting surface water quality in the US is the Clean Water Act, which was approved by Congress in 1972 and uses both regulatory and non-regulatory methods to cut down on direct pollutant discharges into rivers. It has significantly decreased pollution in the Oji River from point sources, such factories and water treatment facilities, but it has been more challenging to manage issues arising from non-point sources, like farmland and urban runoff.

From the perspective of water quality monitoring and assessment, this work finds that the river is an orphan due to the lack of coordination among the states along its course. To solve these issues, the US Environmental Protection Agency (EPA) has to take a more proactive leadership role. In particular, the EPA has to set up a mechanism for exchanging data on water quality along the entire river and collaborate with the states to set and meet water quality criteria. In their efforts to improve water quality, the states in the Oji River corridor ought to operate more independently and together. The EPA and the states along the Oji River should use their extensive history of federal interstate cooperation in water quality management for this endeavor.

Sample Collection

Freshly collected surface water samples from five select locations on Oji-river namely; Ndiagu Obinofia (Sample A), Ugwuoba (Sample B), Oji-River settlement (Sample C), Ohaliachi Ehuke (Sample D) and Enugu Aku (Sample E) in Enugu State, Nigeria not less than 2 km apart, being analyzed physico-chemically using standard methods to ascertain the level and sources of pollution and compared with the WHO, EPA standard for drinking water.

Sample Preparation

The samples were collected in plastic cans of 3 litre capacity properly washed with detergent, HNO_3 and rinsed with distilled water, de-ionized water, then the river water without air-bubbles as per standard procedure.. The samples were kept in a refrigerator with a consistent temperature of 4 oC once their temperature was established at the time of collection. HNO3 was added to the samples in order to stabilize the ions and prevent precipitation for the measurement of metallic ions.

Metallic-ion Determination

The heavy metals in the rainwater samples were analyzed using the Atomic Absorption Spectrophotometer (AAS) –Unicam Model 919. The Metallic ions determined include; Zinc (Zn), Copper (Cu), Iron (Fe), Lead (Pb) and Cadmium (Cd). Stock solutions from which working standards were prepared by serial dilution as reported by Franson, 1995 using various cathode tubes specific for each element to be determined. The turret assembly of the atomic absorption spectrophotometer held the analyte element and the hollow cathode lamp of the element that was being investigated.

The instrument was switched on. The fuel and oxidant used are acetylene and compressed air respectively. Acetylene and compressed air were used as fuel and oxidant to light the burner and create a flame. The digital readout of the Atomic Absorption Spectrophotometer was used to get the corresponding absorbance readings for each element under examination. The standard solution of each element was inhaled into the analyzer-burner assembly. The aspiration of the sample solution of rainwater and the reading of absorbance from the digital readout came next. Extrapolating from the standard curve allowed for the determination of the element's concentration in the rainwater sample.

This was repeated for all the elements under investigation using their wavelengths in turn. Atomic Absorption Spectroscopy (AAS) obeys Beer Lambert law otherwise known as Beer’s law which states that absorbance of a solution (A) is directly proportional to concentration of absorbing species (C) and the path length (L).

Mathematically
A α C (1.1)

The absorbance (A) could be defined via the incident intensity (Io) and transmitted intensity (I) by
A = log10 (Io/I) (1.2)

Assumption two can be expressed as
A α L (1.3)

Combining 1.1 and 1.3
A α (1.4)

This proportionality can be converted into equality by including proportionality constant (K).
A = KCL (1.5)

This formula is the common form of Beer Lambert Law, although it can also be written in terms of intensities:
A = log10 (Io/I) = KCL(1.6)

The Constant K is called Molar Absorptivity or Molar Extinction Co-efficient and is a measure of the probability of the electron transition. On most diagrams the absorbance ranges from 0 - 1, but it can go higher than that. An Absorbance of zero at some wavelength means that no light of that particular wavelength has been absorbed. The intensities of the sample and reference beam are both the same, so the ratio Io/I is 1 and the log10 of 1 is zero.

Results

S/N	**Parameters**	**Units**	**A**	**B**	**C**	**D**	**E**	**Range**	**Mean**	**WHO (1993)**
1.	Temperature	ºC	26.80	27.30	28.0	27.10	27.40	26.80 – 28.0	27.32	25.0 – 30.0
2.	pH	@ 29 ºC	6.15	6.03	5.98	6.05	6	5.98 - 6.15	6.04	7.0 - 8.5
3.	Turbidity	NTU	2.10	2.50	7.90	2.40	2.80	2.10 - 7.90	3.54	5.0
4.	TSS	mgL^{-1}	0.70	10	5.40	0.80	1.20	0.70 - 5.40	1.82	50
5.	TDS	mgL^{-1}	18.20	25.0	49.60	21.30	37.10	18.20 - 49.60	30.24	1000
6.	EC	μScm^{-1}	39.6	54.3	107.9	45.7	80.5	39.6 - 107.9	65.6	1250
7.	Alkalinity	mgL^{-1}	20.0	30.0	34.0	26.0	32.0	20.0 – 34.0	28.40	100
8.	COD	mgL^{-1}	80	110	150	100	120	80 - 150	112	40
9.	BOD	mgL^{-1}	20.10	27.50	37.50	25.40	30.22	20.10 - 37.50	28.14	10
10.	DO	mgL^{-1}	4.68	3.70	2.82	4.25	3.34	2.82 - 4.68	3.76	9.20
11.	Chloride	mgL^{-1}	16.7	15.88	21.55	16	19.85	15.88 - 21.55	17.89	250
12.	Nitrate	mgL^{-1}	1.10	1.30	2.30	1.70	2.0	1.10 - 2.30	1.68	45
13.	Phosphate	mgL^{-1}	0.64	0.50	0.45	0.57	0.47	0.45 - 0.64	0.53	5.0
14.	Sulphate	mgL^{-1}	1.47	4.10	6.23	3.28	5.24	1.47 - 6.23	4.06	250
15.	Calcium	mgL^{-1}	1.5519	1.0668	2.0527	1.3094	1.6811	1.668 - 2.0527	1.5324	75
16.	Sodium	mgL^{-1}	3.0582	2.1690	3.3265	2.6136	2.9701	2.169 - 3.3265	2.8275	200

17.	Potassium	mgL^{-1}	4.2076	3.6040	5.3496	3.9058	4.6277	3.604 – 5.3496	4.3389	10
18.	Magnesium	mgL^{-1}	1.0911	0.8567	2.0145	0.9739	1.4942	0.9739-2.0145	1.2861	50
19.	Iron	mgL^{-1}	0.4100	0.2910	0.4281	0.3505	0.3893	0.291 - 0.4281	0.3738	0.30
20.	Copper	mgL^{-1}	1.0549	1.1704	2.0337	1.1127	1.0735	1.0549-2.0337	1.2890	1.0
21.	Lead	mgL^{-1}	<0.0001	<0.0001	0.0110	<0.0001	<0.0001	0.0001 - 0.011	0.0023	0.50

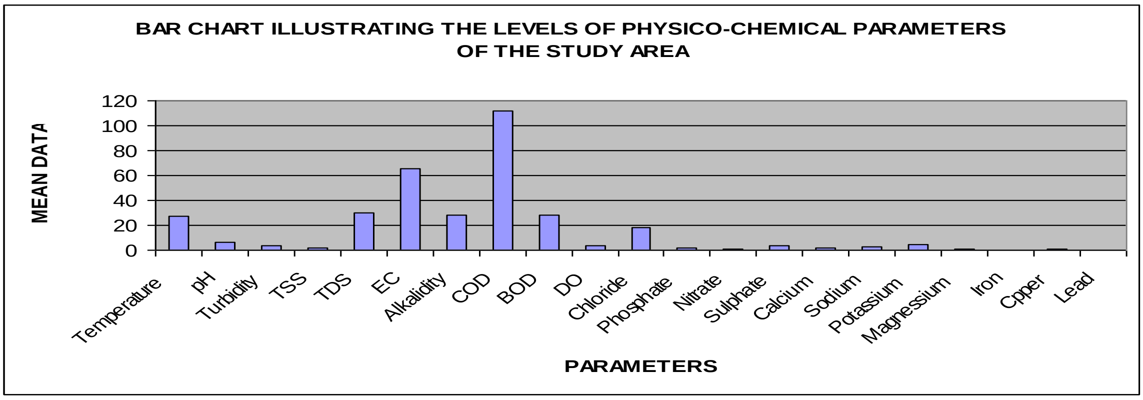
Table 1: Results Of Physico-Chemical Analysis Of Oji River

The experimental results obtained from the physico-chemical analysis of surface water quality from different sampled points are shown in tables 1 and 2. Plot Fig.1graphically illustrate the physico-chemical parameters level on bar chart and 3.1, shows the pollution index.

Table 2: Comparisons Of Results Of Physico-Chemical Analysis Of Oji River

Parameters	**N**	**Minimum**	**Maximum**	**Mean (Ci)**	**Standard Deviation**	**WHO (Lij)**	**Mean/WHO Ci/Lij**
Temperature	5	26.8	28.00	27.32	0.3970	25 - 30	0.9935
pH	5	5.98	6.15	6.04	0.0592	7 - 8.5	0.7794
Turbidity	5	2.10	7.90	3.54	2.1914	5.0	0.708
TSS	5	0.70	5.40	1.82	1.7892	50	0.0364
TDS	5	18.2	49.6	30.24	11.6122	1000	0.0302
EC	5	39.60	107.90	65.60	25.34	1250	0.0525
Alkalinity	5	20.0	34.0	28.40	4.9639	100	0.284
COD	5	80	150	112	23.1517	40	2.80
BOD	5	20.1	37.5	28.14	0.6558	10	2.8140
DO	5	2.82	4.68	3.76	5.7358	9.2	0.4087
Chloride	5	15.88	21.55	17.89	2.3583	250	0.0716
Nitrate	5	1.10	2.30	1.68	0.4400	45	0.0373
Phosphate	5	0.45	0.64	0.53	0.0701	5.0	0.106
Sulphate	5	1.47	6.23	4.06	1.6383	250	0.0162
Calcium	5	1.6680	2.0527	1.5324	0.3346	75	0.0204
Sodium	5	2.1690	3.3265	2.8275	0.4001	200	0.0141
Potassium	5	3.6040	4.6277	4.3389	0.6082	10	0.4339
Magnesium	5	0.9739	2.0145	1.2861	0.4228	50	0.0257
Iron	5	0.2910	0.4100	0.3738	0.0486	0.30	1.2460
Copper	5	1.0549	2.0337	1.2890	0.3744	1.0	1.2890
Lead	5	0.0001	0.0110	0.0023	0.0045	0.50	0.046
							12.2129

Fig.1: Bar Chart Representing Levels Of Investigated Physico-Chemical Parameters Of Oji River



Pollution Index

$$Pij = \sqrt{\frac{(\max Ci/Lij)^2 + (\text{mean } Ci/Lij)^2}{2}}$$

$$= \sqrt{\frac{(2.8140)^2 + (0.5816)^2}{2}}$$

2.0319

Where,
Pij = Pollution index
Ci = Value determined at analysis
Lij = WHO Standard

DISCUSSION

The average results of physio-chemical parameters of Oji river was presented in tables1 and 2. Analysis was carried out for various water quality parameters as pH, turbidity, TSS, TDS, electrical conductivity, alkalinity, COD, BOD, DO, chloride, nitrate, phosphate, sulphate, calcium, sodium, potassium, magnesium, iron, copper and lead using standard methods.

Double distilled water was utilized to prepare the solutions, and AR grade regents were employed for the analysis.

Temperature

There's not much variation in temperature of the samples. Values ranged between 27.10 – 28.0 ^oC with a mean value of 27.32 ^oC and a deviation of 0.397. The temperature is attributed to the insulating effect of increased nutrient load resulting from industrial discharge and is believed to be influenced by the intensity of sunlight as it rose to 28.0 ^oC in Sample C.

pH

This phrase is commonly used to describe how strongly an acidic or alkaline solution is.

All the samples were slightly acidic as the pH at 29.0 ^oC ranged between 5.98 - 6.15 with a mean value of 6.04 and a standard deviation of 0.059. This is due to high levels of free CO_2 which may consequently affect the bacteria count and toxicity of poisons in the water body.

Turbidity

Turbidity in most rivers is caused by extremely tiny dispersions and colloidal particles.

The values for the investigated samples varied between 2.10 and 7.90 NTU with a mean value of 3.54 NTU and a standard deviation of 2.191. Turbidity was observed to increase if the colour of water changes to light-yellow, reddish or grayish, to greenish or brown.

Total Suspended Solids (TSS

Values for investigated samples ranged between 0.70- 5.40 mgL^{-1} with mean value of 1.82 mgL^{-1} and a standard deviation of 1.789. TSS measures anthropogenic activity and in sufficient quantity, impairs respiration in organisms.

Total Dissolved Solid (TDS)

This indicates the salinity behavior of surface water and is a measure of anthropogenic activity. While 500 mgL-1 TDS or more is not deemed desirable for drinking water sources, 1500 mgL-1 is acceptable in certain unavoidable situations.

Values varied between 18.20 and 49.60 mgL^{-1} with a mean value of 30.24 mgL^{-1} and a deviation of 11.612**.**

Electrical Conductivity (EC)

The ability of water to carry electric current is measured by its electrical conductivity. It represents the entire amount of dissolved salts.

The specific conductance measures the total concentration of ionic solutes and is observed to increase as TDS increases and as pH decreases. With a mean value of 65.60 and a standard deviation of 25.34, the EC values were determined to be within the range of 39.60 - 107.90 µScm-1, indicating a low concentration of dissolved inorganic compounds in ionized form and the impact of human activity.

Alkalinity

The ability of water to neutralize a strong acid is known as alkalinity, and it is typically caused by the presence of calcium, sodium, and potassium hydroxide, bicarbonate, and carbonate compounds.The values of total alkalinity varied from 20.0 to 34.0 mgL-1, with a mean of 28.40 mgL-1 and a variation of 4.964.

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) test provides a rapid measure of organic matter oxidation. Here, the bio-degradable matter in water sample will oxidize the orange colour of potassium dichromate to leave an excess which is titrated with ferrous ammonium sulphate or iron II sulphate. The Iron II reduces the dichromate to Chromium III and will itself be oxidized to iron III. The chemical oxygen demand (COD) values for the water sample varied between 80 – 150 mgL^{-1} with a mean value of 112 mgL^{-1} and a standard deviation of 23.152

Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand (BOD) test measures the quantity of dissolved oxygen, in mgL^{-1}, required during stabilization of biodegradable organic matter. Values ranged between 20.10 – 37.50 mgL^{-1} with a mean value of 28.14 mgL^{-1} and a standard deviation of 0.656

Dissolved Oxygen (DO)

One of the most important characteristics of surface water is its oxygen content. Organic waste entering the river may consume this oxygen by bio-oxidation or chemical oxidation. The dissolved oxygen concentration is a measure of the corrosiveness of water, shows the photosynthetic activity and the septicity of water. Values obtained from study area ranged from 2.82 – 4.68 mgL^{-1} with a mean value of 3.76 mgL^{-1} and a standard deviation of 5.736

Chloride

Chloride content serves as an indicator of pollution by sewage. People accustomed to high concentrations are subjected to laxative effects. In this analysis, concentration was found in the range 15.88 -21.55 $mgL^{-1}$with a mean value of 17.89 $mgL^{-1}$and a deviation of 2.358

Nitrate

Surface water contains nitrate due to leaching of nitrate with the percolating water. It can also be contaminated by sewage and wastes rich in nitrate The research area's nitrate level ranged from 1.10 to 2.30 mgL-1, with a mean of 1.68 mgL-1 and a deviation of 0.44.

Phosphate

Appear on surface water because to detergents, industrial waste water, agricultural runoff, and home sewage. Eutrophication is the outcome of high phosphate content. The study area's phosphate concentration was determined to be between 0.45 and 0.64 mgL-1, with a mean value of 0.53 mgL-1 and a variance of 0.07.

Sulphate

Arise spontaneously in rivers from the leaching of common minerals such as gypsum. Its contamination tends to increase with the discharge of home sewage and industrial garbage. The sulfate content ranged from 1.47 to 6.23 mgL-1, with a standard deviation of 1.638 and a mean value of 4.06 mgL-1.

Calcium

Calcium is directly related to hardness. Concentration in study area ranged between 1.668 and 2.0527 mgL^{-1} with a mean value of 1.5324 mgL^{-1} and a deviation of 0.335

Sodium

Sodium concentrations were found in between 2.1690 and 3.3265 mgL^{-1} with mean value of 2.8275 mgL^{-1} and standard deviation of 0.40

Potassium

The weathering of rocks is a major supply of natural fresh water, but the dumping of waste water causes a rise in the quantity of polluted water. The tested area's potassium concentration ranged from 3.604 to 5.3496 mgL-1, with a mean of 4.3389 mgL-1. And a deviation of 0.608

Magnesium

Closely associated with hardness as well. Between 0.9739 to 2.0145 mgL-1, the study area's content was found, with a mean value of 1.2861 mgL-1 and a standard deviation of 0.423.

Iron

The primary sources of iron in groundwater are residential and industrial processes. A high iron level makes drinking water taste quite bad. It also causes dark precipitate of ferric hydroxide, which can cause serious microbial issues in pipelines.

The allowed amount of Fe by WHO is 0.3mg/L. Iron concentration ranged from 0.2910 - 0.4281 mgL^{-1} with a mean value of 0.3738 mgL^{-1} and a deviation of 0.049. The values are not within the WHO permissible limit except for Sample B with value 0.2910 mgL^{-1}. High values above the WHO standard can cause health problems although iron is an important component of hemoglobin. Its presence in Oji river water could probably result from the lateric soil that is dominant in the area, also dumping of metal scraps.

Copper

One of the most prevalent heavy metals in water is Cu (ll). Cu is required in trace amounts for healthy bodily development and operation. On the other hand, high concentrations of copper in drinking water can be neurotoxic and cause mental illnesses like Alzheimer's. Potential primary sources in the environment could be home and industrial activities. The WHO has set a limit of 2000 µg/L for acceptable copper content in drinking water.The values collected from the research region had a mean value of 1.289 mgL-1 and a deviation of 0.374, ranging from 1.0549 to 2.0337 mgL-1.

Lead

Lead is a poison and most likely carcinogenic to humans. Chronic health hazards associated with lead exposure include blood pressure, gliomas, headache, irritability, stomach problems, and nerve damage. Pb poisoning is more likely to affect children. Their prolonged exposure to high Pb levels can result in anemia and brain damage, as well as significant health complications include behavioral abnormalities, memory loss, and diminished comprehension. The maximum amount of lead that can be present in drinking water is 10 µg/L, according to the WHO.

Evaluation of the surface water samples in the study area revealed Pb concentration ranging from 0.0001 - 0.011 mgL^{-1} with mean value of 0.0023 $mgL^{-1}$and a deviation of 0.005

According to recent studies, surface water pollution investigation is an effective way to find out how much pollution is there in the environment. The Atomic Absorption Spectrophotometer (AAS) Method was utilized by several scientists to determine the content of heavy metals in liquids. Due to its ability to support low detection limit thresholds, it is deemed to be the most effective method for this type of study.

Conclusion

The methods used are ideal for verifying the level of pollution of the study area. The different sampled points were examined critically for various physico–chemical standards. Also investigated were the possible impact of surface water quality on humans and the surrounding environment. The observed deviations from the WHO, EPA standard for water quality indicated surface water pollution. Thus, study area was found unfit for drinking purposes (though can be used for other purposes) without some form of treatment. Sample C showed poorest quality compared with other samples probably due to sewage pond close to it and large sewage flowing near it, landfill sites and scrap dumps. However, it is essential to monitor the levels of pollution due to environmental and other anthropogenic impacts on a continued basis so as to protect the surface water from the rapid population growth and rate of urbanization. This research work does not claim to have exhausted all the possible reasons for the observed deviations from water quality standard of the sampled points. It is therefore, very essential and however necessary that similar studies be carried out elsewhere and/or with other methods to confirm our observations.

Declarations Conflict of interest

The authors declare that they have no conflict of interest.

Consent forPublication

All authors agreed to publish this research work.

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