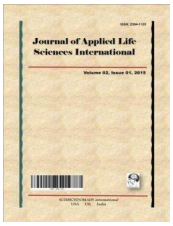

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Effect of Human Activities on the Physicochemical and Bacteriological Qualities of Ujiogba River, Ujiogba, Edo State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author KEE designed the study, managed the analyses of the study and wrote the first draft of the manuscript. Author EOO performed the statistical analysis. Authors KEE and PAI wrote the protocol. Authors KEE, EOO and PAI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Water is the second essential factor for life after oxygen and it offers a number of benefits and services to man and his environment. The effect of human activities on the physicochemical and bacteriological qualities of water samples from Ujiogba River was carried out using standard techniques. The concentrations of physicochemical parameters; electrical conductivity (17.5 ± 4.30 µS/cm), colour (0.07± 0.04), sulphate (0.88 ± 2.15 mg/l), nitrate (0.19 + 2.27 mg/l) and phosphate (0.56 ± 0.45 mg/l) were higher at the midstream. Iron had the highest concentration of all heavy metals analysed at the midstream (0.12 ± 1.37 mg/l) although all heavy metals were below the SON / FEPA limit. The midstream had the highest mean counts for heterotrophic bacterial and coliform counts of 6.33 ± 0.40 x 10^6 cfu/ml and 4.28 ± 0.52 x 10^6cfu/ml respectively, which were higher than the WHO recommended limit of 100 cfu/ml and 0cfu/ml for heterotrophic bacterial and coliform counts respectively. The bacterial isolates identified were *Escherichia coli*, *Klebsiella* (12.68%),

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Salmonella, *Pseudomonas*, *Shigella*, *Staphylococcus* (11.27%) and *Bacillus, Micrococcus*, *Enterobacter* sp (9.86%, 9.86%, 9.68%) respectively. The midstream showed a significant difference for electrical conductivity, turbidity and coliform counts (P<0.05). Antibiotics resistance profile revealed multiple resistance patterns. Consumers of the water are advised to reduce the human activities in Ujiogba river so as to prevent continuous pollution of the water body.

Keywords: Drinking water; public health; coliform; set limit; Ujiogba river; physicochemical and bacteriological qualities.

1. INTRODUCTION

Water is one of the most important necessities of life and according to [1], it occupies about 70% of the earth's surface, yet access to safe and portable water is not an easy task. Water bodies are increasingly being polluted and threatened on a global scale by anthropogenic activities such as human or animal excreta which rank among the most common reason for it to be considered unsafe for drinking because of the high probability of the presence of pathogenic organisms [2]. In addition, high concentrations of bacteria and nitrates discharged into water can occur from animal husbandry operations like grazing and this can result in health hazards to man due to the presence of pathogens [3].

It should be stated that water pollution should be regarded as a gross mismanagement of an indispensable natural resource that is freely unavailable. The roles of rivers are not primarily to carry industrial wastes but their capability to do so is massively exploited which impacts negatively on the ecosystems and human health. However, when the absorptive capacity of sewage and fertilizer from farmland is exceeded, eutrophication arises which leads to the consumption of dissolved oxygen resulting in the loss of aquatic lives which contaminates surface water. Other contamination sources of river water are household wastes, sewage water, industrial effluents, synthetic detergents, agrochemicals and oil spillage. Agricultural runoff includes pesticides and herbicides as well as toxic chemicals waste which originate from industries [4,5].

The most dangerous form of water pollution occurs when faecal contaminants like *Escherichia coli* enter water supply. The transmission of diseases ranging from mild gastro-enteritis to severe and sometimes fatal dysentery, diarrhoea, cholera, typhoid, hepatitis and giardiasis through drinking water is one of the primary concerns for safe drinking water. According to [6], more than 3.4 million people die each year from water borne diseases, most of whom are young children and 80% of ill health especially in developing countries stems from lack of safe drinking water. This makes infections contracted from contaminated water supply a leading cause of illness and death worldwide and helps to explain why the provision of safe drinking water is such a high priority for Governments, Allied Agencies and well-meaning individuals. [7] reported *Staphylococcus, Streptococcus, Proteus, Escherichia coli, Clostridium, Acetobacter, Salmonella, Pseudomonas, Micrococcus* from Udu River in Warri.

Ujiogba is a rural agrarian community and its river serves communities such as Uhi, Ugieghudu Obazagbon, Ogwa, Ebelle, Okalo and a host of others. Unfortunately, water is one of the most scarce basic amenities of life in Ujiogba and the entire Esan land, Edo Central Senatorial District of Edo State due to its being situated on a high altitude. Water from Ujiogba River is basically used for domestic purposes like cooking, bathing and drinking. The river plays host to human activities such as cattle grazing by herdsmen, indiscriminate release of faecal wastes, contamination from surface runoffs, crude oil discharge, washing of clothes and automobiles and lots more. These activities tend to have adverse effects on the water quality with or without the awareness of the consumers. The aim of this study was to determine the effect of human activities on the physicochemical and bacteriological qualities of Ujiogba River in Edo State, Nigeria.

2. MATERIALS AND METHODS

2.1 Characteristics of the Study Area

Ujiogba River is located at latitude 6°32'N and longitude 6°10'E and flows from Ugbegun through Ujiogba to Ugun. It's a freshwater, free-flowing during the rainy season and slow-moving

during the dry season. It is surrounded by economic trees and acts as the natural boundary separating Ujiogba and Obazagbon communities in Esan West and Uhunmwode Local Government Areas of Edo State, respectively. The region is primarily agrarian and plays host to all forms of human activities but not limited to laundry, drinking, washing of cars, bathing and watering of crops [1].

2.2 Sampling and Samples Collection

Water samples for physicochemical and bacteriological analyses were collected in eight triplicates directly from three different sampling stations 1, 2, 3 along the course of the river with sterile screw capped plastic containers in the early hours of the morning. The samples were immediately transported to the laboratory for physicochemical and bacteriological analyses within 2hrs of collection.

2.2.1 Station 1

It is the upstream and uninhabited with very few human activities. The vegetation around this station is composed mainly of economic trees with branches extending and creating shades around the immediate bank of the river. The station is calm and cool.

2.2.2 Station 2

It is the midstream, 3 Km from the upstream and is located just by the Ujiogba river bridge. The water is polluted with high human activities like washing of cars, bikes and clothes, swimming, defecation, surface runoff making the water highly turbid. Nomadic activities are very high at this station and consequently there are always litters of cattle faecal matter in the water body. Water is mainly drawn from this station for consumption.

2.2.3 Station 3

It is the downstream, 3 Km from the midstream with moderate flow rate and less human activities. The water is less turbid than the midstream but more than the upstream.

2.3 Determination of Physicochemical Parameters

The physicochemical parameters were analysed according to the methods of [8,9]. The pH and Electrical conductivity (EC) were measured in-situ using the potentiometric method with pH/Conductivity metre (HACH pH meter sense ion 2 Model). The colour was determined using HACH UV/VIS Spectrophotometer (model DR/2000). Turbidity was measured in the laboratory using a HACH Turbidimeter Model 2100p. Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined using Winkler's method. Samples for DO were fixed in the field using 1.0 ml each of Winkler's solution A and B and determined titrimetrically in the laboratory using the Azide modification techniques of the Winkler's method. Chemical oxygen (COD) demand was measured in the laboratory. Nitrate was determined following the Cadmium Reduction method and optical density read at 410nm in a Spectrophotometer (HACH UV/VIS Model DR 2000). Phosphate was determined using the ascorbic acid method and optical density read at 890 nm in a Spectrophotometer (Model DR 2000) and Sulphate was determined following the turbidimetric method and reading the optical density at 450 nm in a Spectrophotometer (DR/2000). The heavy metals were determined using the modified method of [10]. The concentration of the metals was determined with atomic absorption spectrophotometer, model PG 550 attached to a graphic printer PR-4 after the calibration of the equipment.

2.4 Determination of Total Viable Bacterial Counts

The pour plate method as described by [11] was used. Ten-fold serial dilution of each water sample was prepared aseptically in distilled water up to 10^{-10}. Aliquot 1ml of appropriate ten-fold serial dilution (10^{-3}, 10^{-6} and 10^{-9}) were plated into Petri dishes. Nutrient agar containing fulcin was added and rocked gently for a uniform mixture. All incubations were carried out at 37°C for 24 hrs under aerobic conditions and the colonies were enumerated using colony counter and expressed as colony forming units per mililitre (cfu/ml) of the water sample.

2.5 Determination of Total Coliform and Faecal Coliform (*E. coli*) Counts

The modified multiple tube dilution method as described by [12] was used to determine the total coliform and faecal coliform counts in the water samples. This was carried out in three stages outlined below;

2.5.1 Presumptive stage

Ten mililitres (10 ml) of double strength medium was dispensed into 10 tubes and 10 ml of single strength medium was dispensed into 5 tubes and Durham tube was placed in an inverted position. One tube of single strength (50 ml) and 5 tubes of double strength (10 ml) for each water sample were tested. Using a sterile pipette, 50 ml of water sample was added to the tubes containing 50ml single strength medium. Similarly, 10ml was of water was added to 5 tubes containing 10 ml double strength medium. The tubes were incubated at 37°C for 24 hrs to 48 hrs and observed for tubes that appeared positive. Reference was made to MPN statistical tables to ascertain the total coliform and faecal coliform count in 100 ml of the respective water samples.

2.5.2 Confirmatory stage

This was carried out by measuring one millilitre (1ml) aliquot from the positive presumptive test tube and transferred into freshly prepared tubes containing 9 mls of single strength lactose broth and inverted Durham tubes to detect gas production. The tubes were incubated at 30°C for 48 hrs for total coliforms and 44°C for 24hrs for *Escherichia coli.*

2.5.3 Completed stage

This was carried out by streaking a loopful of broth from a positive tube onto Eosine Methylene Blue (EMB) agar. The plates were incubated at 37°C for 24 – 48hrs. The colonies that grew on the EMB agar were further identified as coliforms or faecal coliforms. Discrete dark centered nucleated colonies with or without metallic sheen were regarded as a positive test. Colonies were picked from EMB agar plate and transferred to nutrient agar slants for morphological examination of all gram negative, short rods or cocci to be identified. The MPN per 100ml of water was calculated using the completed test.

2.6 Identification of Bacterial Isolates

This was carried out according to the method described by [13].

2.7 Antibiotics Susceptibility Test

The method of [14] was used. The antibiotics disk used contained the following antibiotics: augumentin (30 µg), gentamicin (30 µg), perfloxacin (30 µg), ofloxacin (30 µg), streptomycin (30 µg), cotrimoxazole (30 µg), chloramphenicol (30 µg), sparfloxacin (10 µg), ciprofloxacin (10 µg) and amoxicillin (30 µg). The zones of inhibition were measured and interpreted according to the criteria of [15].

2.8 Statistical Analysis

Conventional statistical methods were used to calculate means and standard deviation. Data were statistically tested for one-way analysis of variance (ANOVA) and Duncan's multiple range test was applied for comparing means at ($P<0.05$) according to the method of [16].

3. RESULTS

The mean values for the various physiochemical parameters analysed are shown in Table 1. The pH values ranged from 5.43 ± 0.11 cfu/ml to 5.73 ± 0.14 at midstream and downstream respectively while electrical conductivity values ranged from 10.75 ± 3.19 Us/cm to 17.5 ± 4.30 Us/cm at upstream and midstream respectively. The mean values for dissolved oxygen ranged from 5.30 ± 0.57 mg/l at midstream to 5.59 ± 0.60 mg/l at downstream and also the midstream had the least, 2.17 ± 0.38 mg/l while the downstream had the highest, 2.29 ± 0.39 mg/l for biological oxygen demand. Midstream had the highest for sulphate (0.88 ± 2.15 mg/l), nitrate (0.19 +2.27 mg/l) and phosphate (0.56 ± 0.45 mg/l) while upstream had the least for sulphate (0.80 ± 0.51 mg/l) and phosphate (0.40 ± 0.45 mg/l). Lead and Manganese had the least concentration, 0.001 ± 0.01 mg/l at the tree sampled locations while Iron had the highest of all heavy metals analysed in the three sampled points; upstream (0.11 ± 1.21 mg/l), midstream (0.12 ± 1.37 mg/l) and downstream (0.11 ± 1.40). Table 2 revealed the total heterotrophic bacterial, total coliform and faecal coliform counts of water samples. Water samples from the midstream had the highest total bacterial and coliform counts of 6.33 ± 0.40 cfu/ml and 4.28 ± 0.52 respectively while the least, 5.36 ± 0.50 cfu/ml and 1.51 ± 0.72 was recorded in the upstream for total bacterial and coliform counts respectively. Table 3 showed the percentage frequency of occurrence of bacterial isolates in water samples. *Escherichia coli* and *Klebsiella* sp. had the highest frequency of occurrence (12.68%) followed by *Salmonella* sp. (11.27%), *Pseudomonas* sp. (11.27%), *Shigella* sp. (11.27%) and *Staphylococcus* sp. (11.27%) while *Enterobacter* sp. had the least (9.68%). Antibiotics resistance profile (Table 4) revealed

that the highest rate of resistance, 75% was recorded against Strepyomycin for all isolates except *Salmonella, Enterococcus* and *E. coli* which had 50%. All the isolates displayed 25% resistance against Augumentin and Gentamycin.

Table 1. Physicochemical concentrations of water samples from Ujiogba River

Parameters	Upstream ×±SD	Midstream ×±SD	Downstream ×±SD	SON limit	FEPA (1991) effluent limit
pH	5.58 ± 0.04^a	5.43 ± 0.11^a	5.73 ± 0.14^a	6.5 - 8.5	6 – 9
EC (Us/cm)	10.75 ± 3.19^a	17.5 ± 4.30^b	11.75 ± 8.29^a	778	1000
Colour	0.03 ± 0.03^a	0.07 ± 0.04^a	0.04 ± 0.04^a	NI	NI
Turbidity(mg/l)	0.32 ± 0.24^a	2.60 ± 0.24^b	0.12 ± 0.26^a	4.5	5
COD (mg/l)	2.68 ± 1.75^a	2.75 ± 1.66^a	2.96 ± 1.88^a	NI	40
DO (mg/l)	5.45 ± 0.59^a	5.30 ± 0.57^a	5.59 ± 0.60^a	6.5 - 8.5	40
BOD (mg/l)	2.23 ± 0.65^a	2.17 ± 0.38^a	2.29 ± 0.39^a	6.5 - 8.5	10
SO_4^{2-} (mg/l)	0.80 ± 0.51^a	0.88 ± 2.15^a	0.85 ± 0.52^a	150	50
NO_3^- (mg/l)	0.18 ± 2.82^a	0.19 ± 2.27^a	0.17 ± 0.57^a	0.91	1.0
PO_4^{2-} (mg/l)	0.40 ± 0.45^a	0.56 ± 0.45^a	0.40 ± 0.49^a	150	5.0
Fe^{2+} (mg/l)	0.11 ± 1.21^a	0.12 ± 1.37^a	0.11 ± 1.40^a	0.3	20
Zn^{2+} (mg/l)	0.06 ± 0.71^b	0.06 ± 0.70^b	0.006 ± 0.77^a	3.0	1.0
Cr^{6+} (mg/l)	0.009 ± 0.11^a	0.009 ± 0.20^a	0.008 ± 0.10^a	0.05	0.5
Pb^{2+} (mg/l)	0.001 ± 0.01^a	0.001 ± 0.01^a	0.001 ± 0.01^a	0.01	0.5
Cu^{2+} (mg/l)	0.016 ± 0.20^a	0.016 ± 0.20^a	0.017 ± 0.01^a	1.0	1.5
Mn^{2+} (mg/l)	0.001 ± 0.01^a	0.001 ± 0.01^a	0.001 ± 0.01^a	0.2	NI

Legend: values are in mean ± standard deviation of 24 samples
NOTE: Mean with different superscript on the same row are significantly different (P<0.05).
EC = Electrical Conductivity, COD = Carbon Oxygen Demand, BOD = Biological Oxygen Demand, DO = Dissolved Oxygen, NI: Not indicated, SON: Standard Organization of Nigeria; FEPA: Federal Environmental Protection Agency

Table 2. Total heterotrophic bacterial count (cfu/ml), total coliform count (MPN/100 ml) and faecal coliform count (MPN/100 ml)

Source of samples	Total heterotrophic bacterial count (cfu/ml)	Total coliform count (MPN/100 ml)	Faecal coliform count (MPN/100 ml)
Upstream	5.36 ± 0.50^a	1.51 ± 0.72^a	1.51 ± 0.02^a
Midstream	6.33 ± 0.40^a	4.28 ± 0.52^b	1.11 ± 0.72^a
Downstream	5.42 ± 0.10^a	1.52 ± 0.54^a	1.51 ± 0.72^a

values are in mean ± standard deviation of 24 samples
NOTE: Mean with different superscript on the same column are significantly different (P<0.05).

Table 3. Percentage Frequency of the bacterial isolates

Bacterial isolate	Frequency of occurrence (%)
Salmonella sp.	11.27
Pseudomonas sp.	11.27
Bacillus sp.	9.86
Micrococcus sp.	9.86
Shigella sp.	11.27
Klebsiella sp.	12.68
Enterobacter sp.	9.68
Staphylococcus sp.	11.27
Escherichia coli	12.68
Total	100.00

4. DISCUSSION

All the physical and chemical characteristics of the surface water samples from Ujiogba river, Ujiogba, Edo State, Nigeria, had their concentration values within the set limits of Standard Organisation of Nigeria (SON) and Federal Environmental Protection Agency (FEPA), except for pH which was slightly acidic. This deviation from standard level may be as a result of the fluctuation in bicarbonate equilibrium. The electrical conductivity had the highest value at midstream which decreased along the sampled stations, probably due to the effect of dilution and removal of soluble salts by biological utilisation.

Table 4. Antibiotics resistance profile of bacterial isolates (n=4)

Bacterial isolates	AUG	GTN	PEF	TAR	SPT	SPN	CHL	SPA	CRP	AMX
Salmonella	25%	25%	50%	50%	50%	75%	75%	75%	25%	25%
Pseudomonas	25%	25%	25%	50%	75%	75%	50%	50%	50%	50%
Bacillus	25%	25%	50%	50%	75%	75%	50%	25%	25%	50%
Micrococcus	25%	25%	25%	50%	75%	50%	50%	25%	25%	50%
Shigella sp.	25%	25%	50%	50%	75%	75%	50%	50%	50%	50%
Klebsiella sp.	25%	25%	50%	50%	75%	75%	50%	50%	75%	50%
Enterococcus	25%	25%	50%	50%	50%	50%	25%	25%	50%	50%
Staphylococcus	25%	25%	50%	50%	75%	50%	50%	50%	50%	50%
E. coli	25%	25%	50%	50%	50%	50%	50%	50%	50%	50%

AUG = Augumentin, GTN = Gentamycin, PEF = Perfloxacin, TAR = Ofloxacin, SPT = Streptomycin, SPN = Cotrimoxazole CHL = Chloramphenicol, SPA = Sparfloxacin, CRP = Ciprofloxacin, AMX = Amoxicillin

Similar results had been reported by [17]. The midstream had the highest turbidity values of 2.60 ± 0.26 mg/l, probably because this station plays host to lots of human activities. The electrical conductivity and turbidity were significantly different (P<0.05).The upstream had the highest dissolved oxygen value which reduced along the other stations of the river. This could be due to reduced nutrients which invariably meant low biodegradative activities. However, downstream had the highest value for biological oxygen demand and chemical oxygen demand. The Nutrient concentration levels (nitrate, sulphate and phosphate) recorded were extremely low which suggested that Ujiogba River was less polluted by organic matter. Ground water contains some iron concentration because it is common in many aquifers. The minimum and maximum concentration of iron in the three stations ranged from 0.11 mg/l to 0.12 mgl. The maximum permissible limit by [18] is 0.3 mg/l for drinking water. The low concentration of iron could be attributed to the low anthropogenic activities in the studied river. Generally, the concentration recorded for most heavy metals were below the SON/FEPA desirable level in drinking water.

The midstream had the highest heterotrophic bacterial and coliform counts. This is an indication of high human activities like contamination through surface run off during rains; indiscriminate faeces and urine disposal, washing of cars, bathing and washing of clothes which take place at this point.

The bacterial load in this study was significantly higher than the 100 cfu/ml limit set by [19] for heterotrophic bacterial count. Also [20] stated that coliform should not be present in portable water supplies but counts were recorded in water samples from Ujiogba river. Thus, water from Ujiogba river is a far cry from the universally accepted minimum standard. The nine bacterial isolates identified in this study are similar to those reported by [21,22] on water samples from rivers. In this study, *Escherichia coli* and *Klebsiella* sp. had the highest occurrence (12.68%) which corroborates with earlier findings of [1] where *E. coli* was reported as the most prevalent bacterial isolate from the same river. Most of the bacterial reported in this study are capable of causing water borne diseases such as typhoid fever, acute gastroenteritis and urinary tract infections. Also *S. aureus* is a major cause of food poisoning and suppresses the host immune system as reported by [23].

The resistance rate of most bacterial isolates against Septrin, Streptomycin. Chloramphenicol was high. The highest resistance rate (75%) observed in this study against streptomycin agreed with the 94.1% recorded by [24]. This high resistance rate against streptomycin antibiotics could probably due to its abuse since it is readily available across the counter in tablet form. The observed 25% resistance rate of isolates against gentamacin and augumentin corroborates with the 23% reported by [24]. This low resistance rate may be due to the obvious that this drug is available in ampules and can only be administered intravenously making intake not as palatable as oral antibiotics. In all, the antibiotics resistance profile revealed multiple resistance pattern which could have resulted from high indiscriminate intake across the counter without physician's prescription.

5. CONCLUSION AND RECOMMENDATION

The result of this study revealed that bacteriologically, the water quality of the Ujiogba river was compromised. This makes the water

not suitable for direct drinking as it contained bacterial and coliform counts above WHO set limit. The bacteria identified are capable of compromising human health due to a host of diseases they could cause as the presence of *Escherichia coli* indicated that the river had recently received faecal pollutants. These unwholesome practices should be highly discouraged. It is recommended that the water from Ujiogba river be treated by at least boiling before drinking.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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