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Full Length Research Paper

Physiochemical and bacteriological analysis of surface water in Ewekoro Local Government Area of Ogun State, Nigeria: Case study of Lala, Yobo and Agodo Rivers

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This study examined the physiochemical and bacteriological analysis of surface water in Ewekoro Local Government Area of Ogun State, Nigeria - a case study of Lala, Yobo and Agodo Rivers. Water samples were collected from the rivers in October and December 2008. The samples were analyzed for pH, TDS, TH, electrical conductivity, chloride, calcium, nitrate and fecal coli form. Result indicated that total alkalinity, total hardness, calcium, nitrate and calcium carbonate were above maximum permissible limit of National Administration for Food, Drugs and Control (NAFDAC), Standard Organization of Nigeria (SON), United States Environmental Protection Agency (USEPA), European Union (EU) and World Health Organization (WHO) for drinking water in some sections of the rivers during certain period of the year. The rest of the parameters measured fall within these limits. The bacteriological analysis showed that *Escherichia coli* were present in all the rivers in October while only Lala River is free from *E. coli* in December. All the samples showed no growth of salmonella under the period of investigation. The implication of these results is that the rivers pose a health risk to the rural communities who rely primarily on them as the only source of domestic water supply.

Key words: Surface water, rivers, water samples, Ewekoro Local Government.

INTRODUCTION

Water is one of the important natural resources useful for developmental purposes in both urban and rural areas. Despite this, most of the rural communities in the developing countries, especially Nigeria, lack access to portable water supply. They rely commonly on rivers, streams, wells, and ponds for daily water needs (Nevondo and Cloete, 1991). However, World Health Organization (WHO, 1993) maintained that water from most of these sources was contaminated, yet they are used directly by the inhabitants.

Agricultural wastes such as pesticides, fungicides and fertilizers, human and animal feces, seepage from pit latrines and septic tanks, refuse dump, industrial, domestic and municipal wastes released into water bodies are often responsible for surface water contamination. Bremen et al. (2001) observed that most surface water resources accessible to household in rural areas are subjected to chemical and biological contaminations which may come from animals, septic tanks, storms water run off.

Contaminated water is associated with health risks. It leads to the spread of diseases such as dysentery, cholera, typhoid, diarrhea and so on. According to Grabow (1996), the diseases associated with most surface water supplies include Campbacteriosis, Shigellosis, Salmollosis, Cholera and a varieties of other bacteria as well as fungi, viral, and parasitic infection.

These diseases are caused by microscopic organisms

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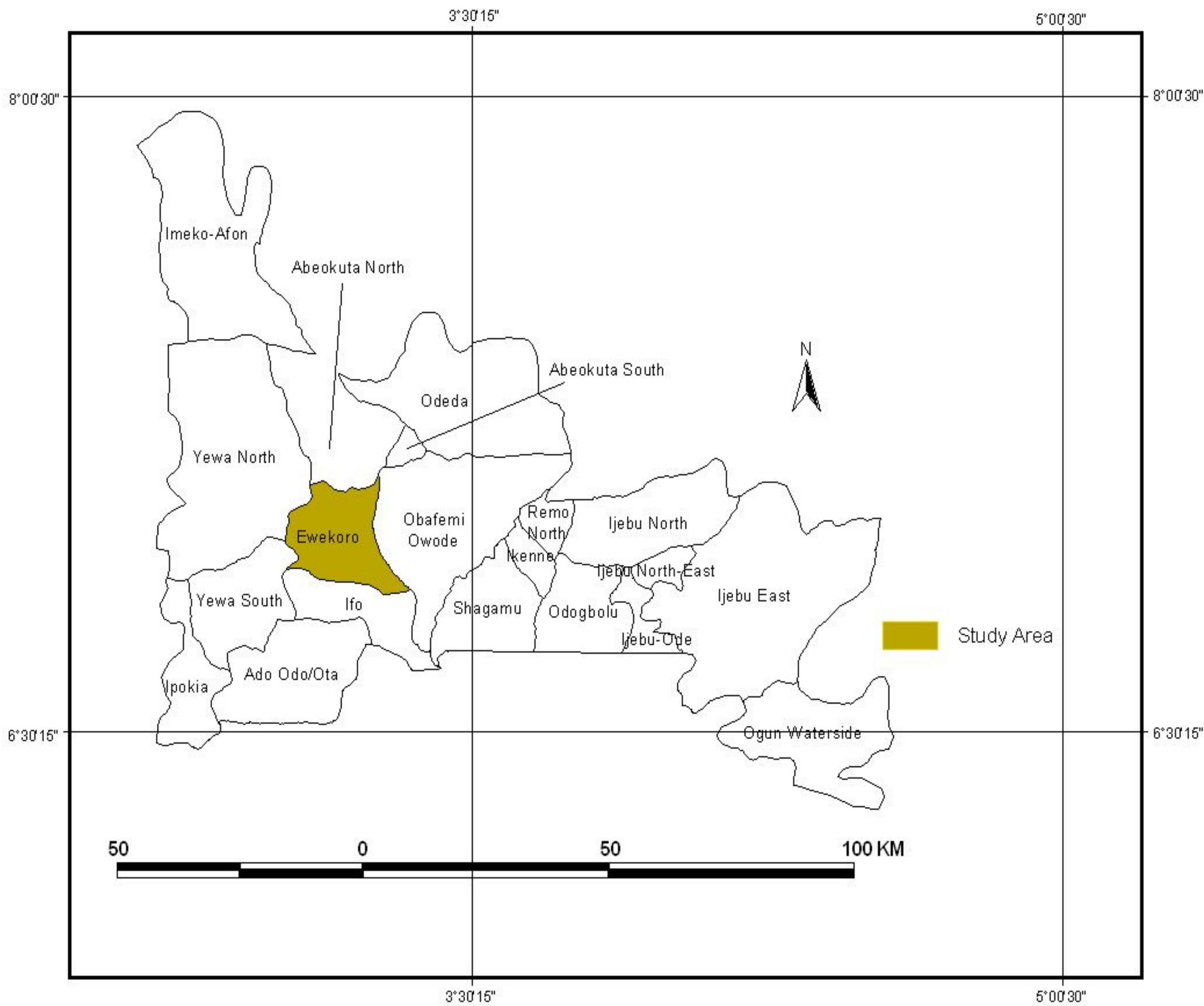

Figure 1. Map of Ogun State showing Ewekoro Local Government.

including bacteria, virus, fungi, and single celled protozoan. They eventually results in crippling, devastating and debilitating effect on rural residence and further exacerbate the already strained health burden and facilities in the country.

However, there is no doubt that governments at local, state and federal have attempted in ensuring water supply in some rural areas, but these have been grossly inadequate. Nevondo and Cloete (1991) observed that in areas where portable water supply are provided, the supplies are unreliable and insufficient, forcing residence to reverse to traditional contaminated water sources. It is therefore imperative to monitor the physico-chemical and microbial quality of water supply in rural areas in other to highlight the quality of water supply and to provide the impetus for sustained government intervention.

This study intends to carry out the physical, chemical and bacteriological analysis of selected rivers in Ewekoro Local Government Area of Ogun State, Nigeria. The objectives of this study are to: assess the physical chemical component of Lala, Yobo and Agodo rivers in the study area; examine the seasonal variation of the physiochemical and bacteriological components of the rivers; identify some of the diseases prevalent in the rivers in the study area; and compared the quality of the water in the rivers with both national and international portable water standards.

Study area

Ewekoro is one of the twenty local governments in Ogun State (Figure 1). It is bounded in the north by Abeokuta North and Abeokuta South Local Governments, in the

Table 1. The result of physico-chemical analysis of Yobo, Agodo and Lala Rivers in Ewekoro Local Government in October.

River	Sample	pH	E.C. (us/mc)	TDS	Dissolved oxygen (mg/L)	Alkalinity (mg/L)	Total hardness (mg/L)	Chloride (mg/L)	Carbonate mg/L	Calcium (mg/L)	Nitrate (mg/L)
Yobo	Up-stream	6.25	540	45	5.52	89	35	83	67.4	20.65	40.50
	Downstream	6.65	525	60	5.84	150	40	78	67.3	22.25	37.00
Agodo	Upstream	6.25	535	130	5.77	181	39	78	130.0	23.50	43.51
	Downstream	6.55	535	125	5.72	62	44	81	104.2	21.50	47.01
Lala	Upstream	6.50	535	65	5.77	150	38	83	128.1	20.30	51.50
	Downstream	6.45	525	35	5.74	72	43	78	103.4	20.90	47.41

south by Ifo Local Government, in the east by Yewa North and Yewa South Local Governments, and in the west by Obafemi Owode Local Government. Ewekoro local government lies between Latitude 6.2 and 7.8°N and Longitude 3.0 and 5.0°E. Ewekoro Local Government is characterized by tropical climate with distinct wet and dry seasons. Between March and October (wet season), the climate is dominated by the tropical maritime air mass from the Atlantic Ocean while November and February (dry season), is under the influence of the dry continental air mass from Sahara desert. The little dry season in the mid-wet season of July/August months is dominant in the area (Adedokun, 1978; Adekoya, 1979; Ilesanmi, 1981; Omotosho, 1988; Gbuyiro et al., 2005; Adejuwon and Odekunle, 2006). The study area has a mean annual temperature of 27^0C, relative humidity of 71.09% and means annual rainfall of 1194.33 mm (Oguntoyinbo, 1978; Emielu, 2000).

METHOD OF STUDY

Water samples were collected from the rivers on October and December 2008. Systematic random sampling technique was adopted for the collection of the samples at a fixed distance.

The most important step in trace analysis is the sample collection. All possible sources of contamination from sampling device were taken into consideration while performing the analysis. As part of the precautionary measure, residue of previous sample needs to be removed from the container to eliminate or minimize error. The plastic bottles used for sample collection were washed using detergent. Afterward, the bottles were rinsed properly with de-ionized distilled water. A total of twelve plastic sample bottles of two litres capacity each was used to collect water sample from the field. Six (6) plastic bottles, with 2 for each river were used in the wet and dry season respectively. The samples were then put in a cool environment immediately after collection. Each bottle is tagged with different code, to differentiate them from each other.

The samples were collected at the up-stream and the down-stream sections of the rivers. The samples collected were transported to the University of Agriculture, Abeokuta where they were analyzed. The analysis for physico-chemical parameters were carried out at the Water Laboratory in the Department of Water Resources Management and Agricultural Meteorology (WMA) while the bacteriological analysis was carried out in the Microbiology Laboratory of the Department of Biology. The samples were analyzed for bacteriological analysis in not more than 24 h after collection. The samples for physico-chemical analysis were left capped and cello taped and kept in a refrigerator to avoid contamination and gas dissolution. This is because all the analyses were not performed the same day. A duplicate measurement was made in order to ensure accuracy of the measurement.

The physico-chemical parameters analyzed include, pH, total dissolved solid (TDS), dissolved oxygen (D.O), electrical conductivity (E.C) total hardness (TH), alkalinity, chloride (Cl^-), nitrate ($N0_3^-$), calcium (Ca_2^+), and carbonate. The pH, conductivity and TDS were measured through the use of electrode. Total hardness, total alkalinity and chloride were analyzed by titrimetric method while nitrate analysis was carried out by spectrophotometer method. The quality control measure of Batley and Gardner were adhered to during the sampling and analysis.

Coliform and Salmonella/shigella tests were the bacteriological analysis performed for this study. The Mac Conkey Agar without salt was used in the detection of the enterobacteriae and Coli gram positive. The standard analysis was divided into presumptive, confirmed and completed tests. This principle is that except for many coliforms only a few bacteria will ferment lactose with the simulation production of acid and gas. The ultimate aim is to narrow down the identification of the coliforms to *E. Coli* or to rule it out.

A fresh pipette was used for each dilution and non-dilution and 0.5 ml of each of the dilution and undiluted water sample was placed into a separate and properly labeled stente Petri-dishes. Forty-nine (49 g/l) grams of Mac Conkey Agar was dissolved in water in a water bath, sterilization was at 121°C for 15 bv minutes in an autoclave. Sixty grams of S.S. Agar (60 g/l) was dissolved

Table 2. The result of physico-chemical analysis of Yobo, Agodo and Lala Rivers in Ewekoro Local Government in December.

River	Sample	pH	E.C. (us/mc)	TDS (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L)	Total hardness (mg/L)	Chloride (mg/L)	Carbonate (mg/L)	Calcium (mg/L)	Nitrate (mg/L)
Yobo	Up-stream	5.95	125	75	6.65	150	58	78	67.20	20.60	26.00
	Downstream	6.35	305	115	6.35	105	168	78	54.00	21.90	34.50
Agodo	Upstream	6.45	138	78	6.45	100	79	78	50.25	22.50	42.50
	Downstream	6.95	354	85	5.95	150	157	81	73.15	20.90	39.00
Lala	Upstream	5.48	355	115	5.48	150	77	83	63.25	20.80	51.50
	Downstream	6.25	593	110	6.25	104	157	78	46.50	21.72	48.50

in water for Salmonell/shigella.

RESULT AND DISCUSSION

Tables 1 and 2 showed the analysis of water quality of Yobo, Agodo and Lala rivers in Ewekoro Local Government of Ogun state, Nigeria in October (wet season) and December (dry season). Conductivity is the measurement of the ability of a solution to carry electric current. The determination of electrical conductivity helps in estimating the concentration of electrolytes. Its ability is dependent upon the presence of ions in solution and its measurement is an excellent indicator of the total dissolved solid in matter. The result of electrical conductivity analyzed was higher in the wet season than in the dry season. The value ranged from 525 to 540 (us / cm^{-1}) in October but ranged between 125 and 595 (us / cm^{-1}) in December. It has been established that the conductance of water solution increase as temperature rises (Twort and Dickson, 1994). The low conductivity value in December was due to low temperature. This period marked the prevalence of harmattan, characterized by very cold temperatures (Iloeje, 1977). The value was only above 500 (us / cm^{-1}) in upstream section of Lala river in December. It falls within the permissible limit of 1000 (us / cm^{-1}) for National Administration for Food, Drugs and Control (NAFDAC) and Standard Organization of Nigeria (SON), and 1200 (us / cm^{-1}) for World Health Organization (WHO).

Total dissolved solids (TDS) show the general nature of water quality or salinity (Olajire and Imeokperia, 2001). The TDS in river Yobo, Agodo and Lala was very low. It ranged from 35 mg/L in the downstream section of river Lala to 130 mg/L in the upstream section of river Agodo in the wet season (Table 1). The TDS also ranged from 75 mg/L in the upstream section of River Yobo to 115 mg/L in the downstream section of Yobo and upstream section of Lala in the dry season. These values were found to be within the permissible limit for drinking water standards (Table 1). The maximum permissible limit of TDS ranges from 500 to1000 mg^{-1}, the desirable limit is 500 $mgdm^{-3}$ (United States Environmental Protection Agency (USEPA), 1974; WHO, 1983, 2007; NAFDAC, 2007; SON, 2007). 500 mg dm^{-3} is considered desirable for domestic uses. Weathering of rocks and soil beneath the ground always contribute to the level of TDS in water. However, its contribution to these rivers was very low.

The pH value of hydrogen ion concentration is a measurement of the acidity or alkalinity (basicity) of water. The pH value of Agodo, Yobo and Lala rivers ranged from 6.25 to 6.65 in the wet season and 6.25 to 6.95 in the dry season (Tables 1 and 2). The three rivers with the exception of downstream section of River Agodo and Yobo, and the upstream section of River Lala were acidic in the wet season. In the dry season, only the downstream section of Agodo River was not acidic. The value of pH of the rivers at this periods were lower than 6.5 required for portable water standards of NAFDAC, SON, USEPA, European Union (EU) and WHO. The lower pH value could be as a result of contamination by acidic substance, which is responsible for imparting taste to water (Crowley and Twort, 1994)

The least value for total alkalinity in all the three rivers during the period of study is 60 mg/l while the highest is 182 mg^{-1}. The maximum permissible limit for total alkalinity is 100 mg/l (Table 3). During the wet season in October, the concentration of alkalinity in the upstream section of River Yobo and the downstream section of

Table 3. Selected national and international water quality standard guidelines.

S/N	Parameter	Maximum allowances limits in water mg/L				
		NAFDAC, 2007	SON, 2007	WHO, 1983; 2007	EU, 1998	USEPA, 1974
1	Conductivity (us/cm-1)	1000	1000	-	-	-
2	Total dissolved solids (mg/L)	500	500	1000	-	500
3	PH	6.5-8.5	6.5-8.5	6.8	6.5-9.5	6.5-8.5
4	Total hardness (mg/L)	100	100	100-	-	-
5	Total alkalinity (mg/L)	100	100	100-	-	-
6	Chloride (mg/L)	100	100	250	250	250
7	Nitrate (mg/L)	10	10	50	50	10
8	Carbonate	-	-	-	-	-
9	Calcium	75	75	--	--	-
10	Biochemical oxygen demand	-	-	-	-	-

Table 4. Comparism of hardness level (adapted from Twort and Dickson, 1994) l.

Range (mg/L)	Hardness level
0.05.	Soft
50 to 100	Moderately soft
100 to 150	Slightly hard
150 to 200	Moderately hard
Over 299	Hard
Over 300	Very hard

Agodo and Lala (Table 1) were within the maximum permissible limit of NAFDAC, SON and WHO. The values were above these standards in the upstream section of Agodo and Lala, and the lower section of Yobo Rivers. In the dry season in December, the values were above permissible limits in all sections of the rivers except in upstream of Agodo River (Table 2). The reason for these concentrations of alkalinity in Agodo and Lala stream could possibly resulted from some materials being washed on the different sections of the rivers or the river water has been diluted by less alkaline tributaries, especially at the lower section of the rivers.

Hardness is a measure of how much calcium and magnesium is present in water (Olajire and Imeokparia, 2001). In other word, the Total hardness is dependent upon the amount of calcium or magnesium salts or both. The value of hardness ranged from 35 to 40 mg^{-1} in Yobo, 39 to 44 mg/L in Agodo and 38 to 43 mg/L in Lala in the wet season (Table 1). The total hardness also ranged from 58 to 168 mg/L in River Yobo, 78 to 157 mg/L in River Agodo amd 77 to 157 mg/L in River Lala in the dry season. The water in the rivers is above the maximum permissible limit of both National and International drinking water standard during the dry season (Tables 2 and 3). The amount of total hardness was only higher than the permissible limit of drinkable water standards in the downstream section of these rivers in the dry season. Hardness, whether it is caused predominantly by calcium, manganese or both is usually reported as the equivalent of the total concentration of calcium carbonate ($CaCO_3$). Water with a $CaCO_3$ equivalent of concentration greater than 120 gm^{-3} is considered hard (Table 4).

The total hardness consists of carbonate or temporal hardness and non-carbonate or permanent hardness. Carbonate hardness for example, 250 mg/L expressed as $CaCO_3$ result from solution of calcium and magnesium carbonate by carbon oxide which is formed in soils by the oxidation of organic matter. Carbonate was 67.4, 130 and 128.1 mg/L in the upstream section and 67.3, 104.2 and 103.2 mg/L in the downstream section of River Yobo, Agodo and Lala in the wet season. The value of carbonate for these rivers was 67.20, 50.25 and 63.25 mg/L in the upstream section and 54, 73.15 and 46.50 mg/L in the downstream section during the dry season respectively. The value of carbonate was higher than 100 mg/L during the wet season especially in river Agodo and Lala.

Calcium is usually present in water as the carbonate, bicarbonate and sulphate, although in water of high salinity, calcium, chloride or nitrate can also be found. In igneous and metamorphic rocks, weathering also releases calcium from such minerals as apatite, fluoride and various members of the feldspar, amphibole and pyroxene groups. Calcium contributes to the hardness of water within the bicarbonate, forming temporal carbonate hardness and sulphate, chloride and nitrate forming permanent or non-carbonate hardness (Twort and Dickson, 1994). In the wet season, the amount of calcium in Yobo, Agodo and Lala rivers are 20.65, 23.50 and 20.30 mg/L in the upstream sections, and 22.25, 21.50 and 20.90 mg/L in the downstream sections respectively (Table 1). However, in the dry season, the values are 20.60, 22.50 and 20.80 mg/L in the upstream section and

Table 5. The result of bacteriological analysis of Yobo, Agodo and Lala Rivers in Ewekoro Local Government during the wet season.

Media used	Coliform (*E. Coli)* Mc Conkey Agar	Salmonella/Shigella count S.S Agar
Quantity	49 gl	60 gl
Lala River - Upstream	1.4×10^3 cfu/ml	Ng
' ' - Downstream	1.36×10^4 cfu/ml	Ng
Agodo River - Upstream	2.85×10^3 cfu/ml	Ng
' ' - Downstream	2.67×10^4 cfu/ml	Ng
Yobo River - Upstream	1.3×10^3 cfu/ml	Ng
' ' - Downstream	1.2×10^4 cfu/ml	Ng

Ng – No growth cfu/ml – Colony forming per ml.

Table 6. The result of bacteriological analysis of Yobo, Agodo and Lala Rivers in Ewekoro Local Government during the dry season.

Media used	Coliform (*E. Coli*) Mc Conkey Agar	Salmonella/Shigella count S.S Agar
Quantity	49 gl	60 gl
Lala River - Upstream	Ng	N g
' ' - Downstream	Ng	Ng
Agodo River - Upstream	2.38×10^4 cfu/ml	Ng
' ' - Downstream	2.48×10^3 cfu/ml	Ng
Yobo River - Upstream	1.76×10^5 cfu/ml	Ng
' ' - Downstream	1.38×10^3 cfu/ml	Ng

Ng – No growth cfu/ml – Colony forming per ml.

21.90, 21.90 and 21.72 mg/L in the dry season (Table 2). Chloride in Yobo, Agodo and Lala rivers ranged from 72 to 84 mg^{-1} variation in the value of chloride during the two periods were minima. The values were within the standard limit of both National and International drinking water standards (Table 3). Chlorides are present in all natural water and are major anions in water and sewage. Sources of chloride include sedimentary rocks, particularly the evaporated salt seeps, oil feed drainage, domestic and industrial contaminators and to some degree, air-borne matter resulting from ocean spray.

Apart from some of these sources, precipitation contributed to increase of chloride in these rivers. According to Vitosek (1977), most of the chlorine in steams comes from precipitation. Juang and Johnson (1967), noted that chlorine is deposited in particulate form during the summer and washed away by autumn rains. The salty taste produced by chloride concentration is variable and dependent on the chemical composition of the water, seawater or other saline water (Martins, 1990). High chloride in both surface water and ground water are often due to contamination from ocean water and many brackish supplies (Lennon and Ashley, 1970).

Nitrate ranged from 37 to 51.50 mg/L during the wet season and from 24 to 51.50 mg/L during the dry season. These values are above the maximum allowable limit of national drinking water standards. However, the water is within the maximum permissible limit of 50 mg/L in the rivers, except in the upstream section of river Lala in both seasons. There was reduction of this ion in the dry season in all the sections of the rivers except the upstream section of River Lala where the value remains the same. The high concentration of nitrate during the wet season was probably as a result of high dissolved oxygen concentration in the streams. This facilitates oxidation of ammonia (NH_4) to $N0_3$ (Feller and Kimmins, 1979). The enrichment of nitrate could also be attributed to human and animal sewage, intense use of fertilizer, seasonal influence of biomass burning and harmattan dust during the dry season (Vomocil, 1987; Cashier and Durcret, 1991; Dillion, 1997). These are washed into water bodies by rainfall.

In the upstream and the lower sections of river Yobo, Agodo and Lala, the dissolved oxygen (DO) were 5.52, 5.77, 5.77 and 5.84, 5.72 and 5.74 mg/L during the wet season. In like manner, the values were 6.65, 6.45, 5.48 and 6.35, 5.95 and 6.25 mg/L in both the upstream and the downstream sections of the rivers during the dry season. The D.O was generally higher during the dry season.

Tables 5 and 6 showed the result of bacteriological analysis of the rivers in the wet season and dry seasons respectively. The rivers with the exception of River Lala, have *Escherichea coli* (*E. coli)* in the dry season. The presence of *E. coli* bacteria is an indication that the water is contaminated by fecal waste, hence, not fit for drinking. Khazael et al. (2004) maintained that during rainfall, *E. coli* may be washed into creeks, rivers, steams, lakes or groundwater. WHO (1985) established that for untreated and non chlorinated supplies, such as surface water or shallow or deep well water, the detection of fecal coliform alone can generally serve as an adequate guide for determining whether pathogenic organisms are present in the water. However, there is no presence of Salmonelle/ Sheigella that causes dysentery in any of the rivers.

Conclusion

This study has examined the physical, chemical and bacteriological analysis of Lala, Yobo and Agodo Rivers in Ewekoro Local Government Area of Ogun State, The result obtained showed that the rivers were contaminated with fecal coliform during the wet season. However, only river Lala is free from contamination by both *E. coli* and Salmonelle/Sheigella during the dry seasons respect-tively. The usage of the water without treatment could be hazardous to human health.

RECOMMENDATIONS

We hereby recommend that: (1) water from rivers should be treated before supplying to the public (2) water from the rivers should be boiled before drinking. (3) the provision of public water should be supplied by government to the villages. (4) if boreholes are to be provided, there should be proper geological survey before sitting the borehole. (5) dissemination of information for public awareness on environmental safety including increased use of agro-chemicals/pesticides, heavy metal contamination by industrial affluent, indiscriminate use of agro-chemicals, domestic refuse dump sites which are washed to the rivers during the wet season.

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