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A study on some physical and chemical characteristics of Ona River, Apata, Ibadan South-west, Oyo State, Nigeria

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ABSTRACT

A study of the physico-chemical parameters on surface water of Ona River at Apata, South west, Oyo State, Nigeria was conducted from October, 2010 to March, 2011. Surface water was collected from five different stations along the river. The mean value of surface water temperature was 26.88±0.48°C; water velocity, 0.24±0.07m/s; pH, 7.38±0.09; Total hardness, 109.96±9.06mg/L; Dissolv ed oxygen, 2.80±0.50mg/L; Biochemical oxygen demand, 405.57±59.47mg/L; Alkalinity, 77.5±5.94mg/L; Free c arbondioxide, 63.77±3.19mg/L; Conductivity, 288.76±11.00mg/L; Ammonium-nitrogen, 0.12±0.02mg/L; Total dissolved solids, 554.39±49.9mg/L; Total suspended solid, 1183.65±54.33mg/L. There were sign ificant differences (p<0.05) in the mean values of dissolved oxygen, Biochemical oxygen demand and total dissolved solid with sampling stations. The physico-chemical parameters analysized during the study period showed that Ona river water was not fit for drinking when compared with the acceptable standards of Federal Ministry of Environment, Nigeria.

Key words: Physico-chemical parameters, Pollution, Ona River, Apata, South-west.

INTRODUCTION

Water is essential for the survival of life on earth. It is the most naturally occurring mineral compound and its relevance cannot be overemphasized [1]. It is a very simple chemical compound composed of two atoms of hydrogen and one atom of oxygen, which bond covalently to form one molecule.

In its pure state, water is colourless, odourless, and insipid, freezes at O°C, and has boiling point of 100°C at a pressure of 760mmHg, with a maximum density of 1gcm G3 at 4°C. Chemically, it is a highly realistic substance, which is thermally stable at temperatures as high as 2,700°C [2]. It is neutral to litmus, with a pH of 7 and undergoes a very slight but important reversible self-ionization.

The physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals [3] [4].

Freshwater bodies are important source of water for human activities; they serve as drinking water, water for agricultural use, domestic use (including cooking, washing etc.), transportation, electricity generation, recreation and sometimes, the disposal of waste materials. Freshwater bodies contain diverse habitats within and around which support myriads of both plants and animals. Variations in water quality parameters due to pollution affect the quality of life of resident species and changes are reflected in the biotic community structure with the most vulnerable dying

off leaving behind tolerant species. Some species are eliminated, some are re-enforced for survival, some are proliferated, and some decrease in number [5] [6] [7].

In different parts of Nigeria, rivers are used for disposal of refuse, human sewage, and waste waters from residential areas, abattoirs and industries [8]. Storm water runoffs and discharge of sewage into rivers are two common sources of nutrients in aquatic ecosystem that results in their pollution [9] [10]. Rapid industrialization has direct and indirect adverse effects on our environment [11]. This has led to an increase in generation of industrial effluents which when discharged untreated, would result in water, sediment and soil pollution [12]. Environmental degradation, deterioration and underdevelopment are top public issues both at national and international levels [13].

Therefore, abnormal changes in the water quality can easily be detected and appropriate measures taken before the outbreak of epidemics [12]. Several health stressors significantly deplete the biodiversity of aquatic ecosystems. Biodiversity loss and its effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems [14]. Suspended, precipitated and organic substances in water are capable of adhering pollutant particles by absorption; these are substances of low solubility and low degree of degradability [15[16; 17].

Biological assessment supports physico-chemical water analysis, providing a more robust measure of aquatic conditions. Although physico-chemical parameters represent water quality at the time of sampling, biological assessment determines long-term water quality trends [18]. Several studies have been carried out on physico-chemical parameters as indicators of pollution in Nigerian rivers [19-23].

Few literatures exist on the physico-chemical parameters of Ona River. In response to concern raised regarding water quality of water bodies in Nigeria, several studies have been reported [24-26]. In Ona River such studies is scanty and this research work could be useful for detecting of changes in limnology as a result of accumulation of toxic substance in the environment. Environmental concerns relative to the health and vitality of aquatic ecosystem has become an emerging issue in Nigeria. This paper therefore provides information to fill that gap in Ona River, Apata, Ibadan South-west, Oyo state, Nigeria.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Ona River which is one of the major Rivers in Ibadan south western, Nigeria. Ona River has a length of 55km^2 an area of 81.0km^2 and it flows through the low density western part of Ibadan [27]. The river flows in a north-south direction from its source at Ido Local Government Area) where it is dammed and also flows through Apata Genga (Ibadan south-west Local Government Area) to Oluyole Local Government (Figure.1). Companies located along this river include 7up Nigeria Plc, Zartech, Sumal and Interpac a paper mill industry (not in operation). Channelled effluents from these industries are connected by a network of canals channelled directly into Ona River. Ona River receives allochtonous input of organic matter from the surrounding vegetation, derived through run-offs from the surface of the soil. The water body receives a lot of wastes ranging from industrial, agricultural and domestic sources, which apart from adversely affecting the normal hydrochemistry of the river, also decreases its channel capacity at various points, and this has been largely responsible for flood disasters in the river [27]. The river is often used as a 'latrine' which makes it offensive to sight and smell and therefore not good as a natural resource.

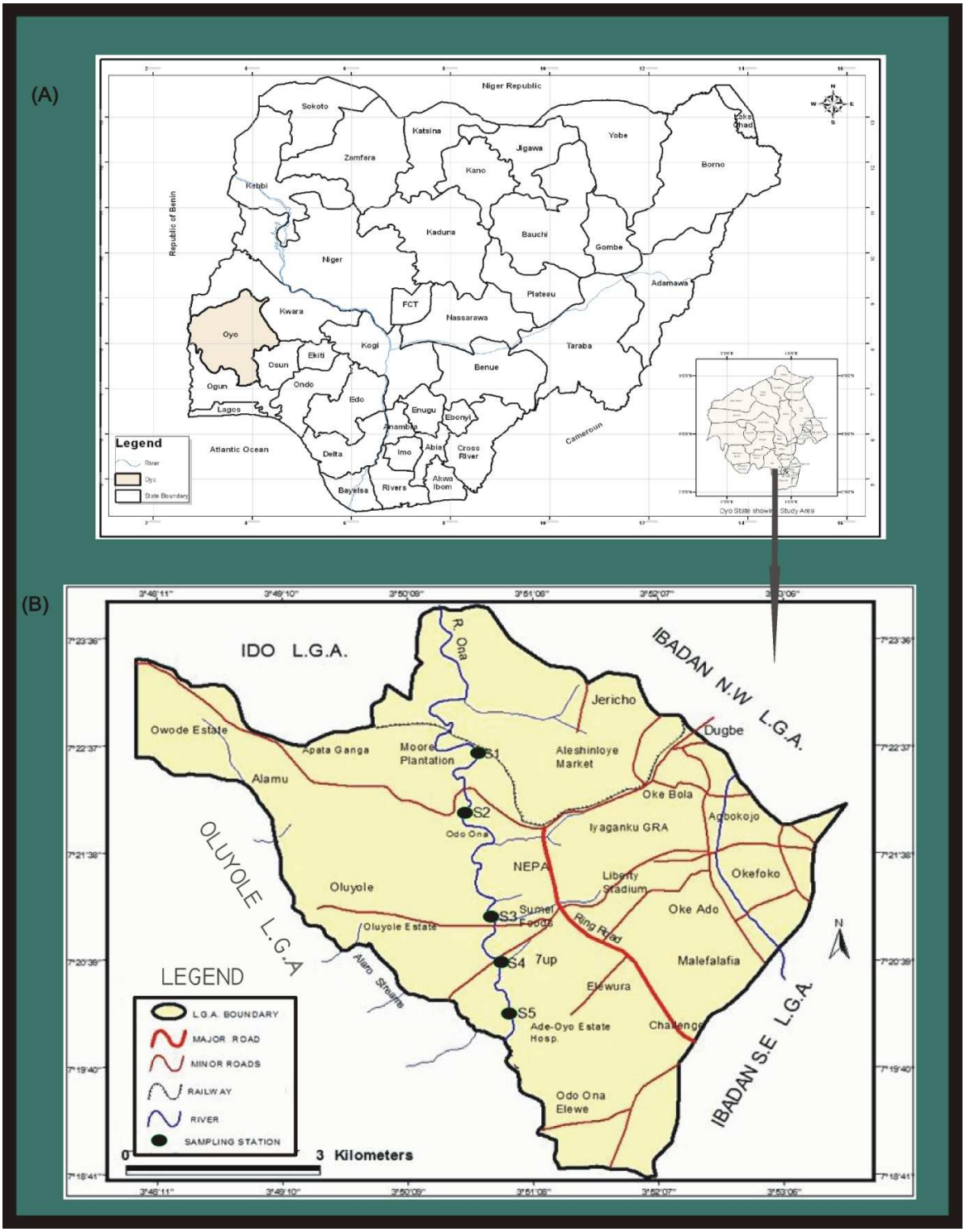

Fig.1. Map of Ibadan South-West Local Government Area Showing Ona River and Sampling Station (1-5), (Map` of Nigeria and Oyo State Inserted).

Sampling stations

Five sampling stations (1-5) were chosen along the river course. The co-ordinates of the sampling stations were taken using Geographic Positioning System (GPS) and approximate distances of the stations were calculated, each station was 1000m apart from the other.

Station 1

This was the upstream station used as the control point because it was assumed to be unpolluted since waste/effluent was not discharge into the station. It is located at Moore plantation, Apata, Ibadan (Lat: $N7^0$ 22' 4.81"; Lon: $E3^0$ 50'

09.84"). In this station, there is no emergent vegetation. Bank side vegetation is predominantly melina tree (*Commelina nodiflora*). This river bed is basically coarse sand, granite and fast flowing, it appears undisturbed, unaltered and clean.

Station 2
Station 2 is the discharge point, located at Odo-Ona (Lat: $N7^0$ 22' 4.85"; Lon: $E3^0$ 50' 09.88"). It receives effluents from human household and wastes disposal. This is the station, in which the river at this point flows along a concrete channelled of about 5m wide and through some residential area. The river here is dirty brown and fast moving, speed was not uniform because of midstream eddies and side water friction with debris and land.

Station 3
Station 3 receives effluents from Sumal Food Company, that produces biscuit and sweet and it is located along Ring Road between Ibadan northwest and southwest L.G.A (Lat: $N7^0$ 21' 4.89"; Lon: $E3^0$ 51' 09.92"). The river at this station is also insensitively used for disposal of domestic waste. The river is also very dirty, contaminated with heavily disposed domestic, solid wastes and other activities are like washing of cars, clothes, bathing and human defecation.

Station 4
Station 4 receives effluents from 7up Bottling Company and also some industrial wastes around. It is located at 7up Road, Ring Road, Ibadan (Lat: $N7^0$ 20' 4.92"; Lon: $E3^0$ 51' 09.96"). This station; is probably turbid due to the effect of discharged effluents. The vegetation is composed mainly of trees which form a partial shade over this station, with *Panicum maximum* (Guinea grass) and some banana cover. The substratum is muddy.

Station 5
Station 5 receives effluents from Adeoyo State Hospital and also some industrial wastes around. It is located at Elewura area towards Fodasis Hospital, Ring Road, Ibadan (Lat: $N7^0$ 19' 4.96"; Lon: $E3^0$ 51' 09.99"). In this station, the vegetation is composed mainly of trees which form a shade over this station and the substratum is also muddy.

Physical and Chemical Parameters Analysis
Samples were collected monthly from the October, 2010 to March, 2011 at five different stations usually between 7:00am and 10:00am. The physico-chemical parameters investigated in each case were surface water temperature(^{o}C), pH, water velocity (m/s), dissolved oxygen (mg/L), biochemical oxygen demand (mg/L), total hardness (mg/L), Conductivity (mg/L), Free carbondioxide (mg/L), Ammonia-Nitrogen (mg/L), total dissolved solids (mg/L), total suspended solids (mg/L). The methods used were described by [28-33]. Data collected for the environmental parameters were subjected to statistical analysis using Analysis of variance (ANOVA) to test for differences between the means of the physico-chemical parameters of the five sampling stations [34]. Pearson correlation coefficient (r) was used to correlate physico-chemical parameters.

RESULTS

The range and mean values of physico-chemical parameters of surface water for all the sample stations during the study period are shown in Table 1.

Surface water temperature during the period of study ranged between 26.17-27.50°C with a mean value of 26.80±0.48^{o}C. Highest mean surface water temperature value was recorded in Station 2 (27.50±1.05^{o}C) while lowest mean value was recorded in Station 4 (26.17±2.23^{o}C). There was no significant difference ($p < 0.05$) in mean value of surface water temperature with stations (Table 2). Surface water temperature was significantly and negatively correlated to dissolved oxygen ($p<0.05$) (Table 3). Water velocity ranged between 0.14-0.31m/s with the mean value of 0.24±0.07m/s. Highest mean water velocity value was recorded in Station 2 and 4 (0.31±0.15 and 0.31±0.10m/s) while lowest mean value was recorded in station 1 (0.20±0.07m/s). There was no significant difference ($p<0.05$) in mean value of water velocity with stations (Table 2). pH ranged between 7.27-7.47 with the mean value of 7.38±0.09. Highest mean pH value was recorded in Station 3 (7.47±0.84) while the lowest mean value was recorded in Station 5 (7.27±0.53). There was no significant difference ($p<0.05$) in mean value of pH with stations (Table 2). pH was significantly and positive correlated to free carbondioxide ($p<0.05$) (Table 3). Dissolved oxygen ranged between 2.24-3.46mg/L with a mean value of 2.80±0.50mg/L. Highest mean dissolve oxygen value was recorded in station 4 (3.46±0.80mg/L) while lowest mean value was recorded in station 2 (2.24±1.00mg/L). There was significant difference ($p < 0.05$) in mean value of dissolved oxygen in Station 3 (2.41±0.96mg/L) and Station 4 (3.46±0.80mg/L) (Table 2). Biochemical oxygen demand ranged between 322.25-485.44mg/L with a mean value of 405.57±59.47mg/L. Highest mean biochemical oxygen demand value was recorded in Station 3

(485.44±105.78mg/L) while lowest mean value was recorded in Station 5 (322.25±106.75mg/L).There was significant difference ($p < 0.05$) in mean value of biochemical oxygen demand in Station 1 (471.89±141.58mg/L) and Station 4 (387.09±80.62mg/L) (Table 2). Biochemical oxygen demand was significantly and negatively correlated to free carbondioxide ($p<0.05$) (Table 3).). Alkalinity ranged between 67.76-82.64mg/L with the mean value of 77.05±5.94mg/L. Highest mean alkalinity value was recorded in Station 5 (82.64±26.45mg/L) while the lowest mean value was recorded in Station 4 (67.76±23.86). There was no significant difference ($p<0.05$) in mean value of alkalinity with stations (Table 2). Alkalinity was significantly and positive correlated to Ammonium-Nitrogen ($p<0.05$) (Table 3). Total dissolved solid ranged between 459.88-625.42mg/L with a mean value of 554.39±49.9mg/L. Highest mean total dissolved solid was recorded in Station 2 (625.42±121.90mg/L) while the lowest mean value was recorded in Station 1 (459.88±128.83mg/L). There was significant difference ($p<0.05$) in mean value of total dissolved solid in Station 4 (484.76±118.48mg/L) (Table 2). A steady trend of spatial variation in physico-chemical parameters was observed (Fig. 2).

Table.1. Physico-chemical parameters of Ona River during the study period from October, 2010 to March, 2011.

Physico-chemical Parameters	Range	Mean values ± Std Deviation	
Surface water temperature (°C)	26.17-27.50	26.88±0.48	
Water velocity (m/s)	014-0.31	0.24±0.07	
pH	7.27-7.47	7.38±0.09	
Total hardness (mg/L)	99.38-122.64	109.96±9.06	
Dissolved oxygen (mg/L)	2.24-3.46	2.80±0.50	
Biochemical oxygen demand (mg/L)	322.25-485.44	405.57±59.47	
Alkalinity (mg/L)	67.76-82.64	77.05±5.94	
Free carbondioxide (mg/L)	59.38-68.18	63.77±3.19	
Conductivity (µS/Cm)	270.35-297.56	288.76±11.00	
Ammonium-nitrogen (mg/L)	0.11-0.15	0.12±0.02	
Total dissolved solids (mg/L)	484.76-625.42	554.39±49.9	
Total suspended solid (mg/L)	1092.89-1237.01	1183.65±54.33	

Table.2. Mean variation of physico-chemical parameters measured at the five stations along Ona River, Apata, Ibadan South-west, Oyo state, Nigeria

Physico-chemical Parameters	Sampling Stations 1 Moore plantation	2 Odo-ona Area	3 Sumal Food Company	4 7up Bottling Company	5 Adeoyo state Hospital
Surface water temperature (°C)	26.5±1.87^a (24-29)	27.5±1.05^a (26-29)	27.0±1.26^a (25-28)	26.17±2.23^a (23-29)	26.83±1.47^a (25-29)
Water velocity (m/s)	0.20±0.07^a (0.12-0.30)	0.31±0.15^a (0.17-0.55)	0.14±0.09^a (0.02-0.22)	0.31±0.10^a (0.22-0.5)	0.21±0.16^a (0.05-0.40)
pH	7.44±0.64^a (6.70-8.20)	7.32±0.68^a (6.50-8.10)	7.47±0.84^a (6.30-8.30)	7.45±0.65^a (6.5-8.10)	7.27±0.53^a (6.50-7.80)
Total hardness (mg/L)	121.74±20.06^a (90.3-145.0)	114.07±23.83^a (87.25-150)	103.74±18.97^a (85.0-130.0)	99.38±14.12^a (80.3-120)	122.64±41.54^a (80.03-170)
Dissolved Oxygen(mg/L)	2.89±1.34^a (1.05-4.11)	2.24±1.00^a (4.11-1.09)	2.41±0.96^b (1.04-3.60)	3.46±0.80^b (2.03-4.09)	3.09±0.59^a (2.45-4.12)
Biochemical Oxygen Demand(mg/L)	471.89±141.58^b (345.11-687.05)	427.52±187.25^a (59.78-598.7)	485.44±105.78^a (301.92-592.47)	387.09±80.62^b (308.49-491.48)	322.25±106.75^a (175.43-413.1)
Alkalinity(mg/L)	76.81±25.40^a (50.0-120.35)	76.01±20.65^a (55.0-110.32)	81.79±19.71^a (60.0-115.01)	67.76±23.86^a (40.0-95.3)	82.64±26.45^a (53.43-13.40)
Carbon dioxide (mg/L)	60.27±14.37^a (41.9-80.5)	64.79±13.25^a (51.70-80.20)	59.38±13.78^a (45.0-80.5)	62.75±14.72^a (40.25-80.39)	68.18±8.70^a (58.02-80.0)
Conductivity (µS/cm)	291.28±77.85^a (216.7-411.32)	270.35±96.20^a (180.0-420.31)	290.25±59.18^a (240.0-390.31)	297.56±104.67^a (201.12-430.51)	296.88±89.52^a (225.0-450.35)
Ammonium-Nitrogen (mg/L)	0.12±0.05^a (0.08-0.20)	0.13±0.09^a (0.01-0.22)	0.15±0.10^a (0.07-0.30)	0.11±0.04^a (0.08-0.17)	0.14±0.14^a (0.01-0.32)
Total Dissolved Solids(mg/L)	459.88±128.83^a (346.10-700.4)	625.42±121.90^a (419.5-779.32)	548.08±142.87^a (335.37-757.04)	484.76±118.48^{ab} (349.29-629.8)	559.31±137.36^a (397.90-760.18)
Total Suspended Solids(mg/L)	1390.16±441.41^a (912.9-1853.2)	1205.09±251.94^a (866.9-1491.02)	1198.82±251.03^a (889.47-1492.96)	1092.89±215.96^a (823.01-1410.2)	1237.01±172.83^a (1052.16-1490.08)

Values are mean ±S.D (Minimum – Maximum values in parenthesis) Different superscript letters in a row show significant difference ($p < 0.05$)

Table 3: Correlation coefficient (r) values between physico-chemical parameters of Ona River, Apata, Ibadan south-west, Oyo state, Nigeria

Physico-chemical Parameter	Surface water temperature (°C)	Water velocity (m/s)	pH	Total hardness (mg/L)	Dissolved Oxygen (mg/L)	Biochemical Oxygen Demand (mg/L)	Alkalinity (mg/L)	Free Carbondioxide (mg/L)	Conductivity (µΩ/Cm)	Ammonium Nitrogen (mg/L)	Total Dissolved Solid (mg/L)	Total Suspended Solid (mg/L)
Surface water temperature (°C)	1.00											
Water velocity (m/s)	-0.04	1.00										
pH	-0.50	0.38	1.00									
Total hardness (mg/L)	0.24	-0.51	-0.63	1.00								
Dissolved Oxygen (mg/L)	-0.90*	-0.08	0.10	-0.11	1.00							
Biochemical Oxygen Demand (mg/L)	0.15	0.35	0.72	-0.23	-0.57	1.00						
Alkalinity (mg/L)	0.53	-0.83	-0.37	0.53	-0.49	0.03	1.00					
Free Carbondioxide (mg/L)	0.23	-0.33	-0.94*	0.44	0.21	-0.91*	0.15	1.00				
Conductivity (µΩ/Cm)	-0.84	-0.48	0.28	-0.11	0.82	-0.34	-0.04	-0.04	1.00			
Ammonium Nitrogen (mg/L)	0.62	-0.66	-0.23	0.15	-0.60	0.11	0.90*	0.05	-0.13	1.00		
Total Dissolved Solid (mg/L)	0.92	-0.03	-0.64	0.09	-0.68	-0.18	0.38	0.49	-0.72	0.55	1.00	
Total Suspended Solid (mg/L)	0.07	-0.32	-0.05	0.80	-0.22	0.35	0.45	-0.19	-0.07	0.09	-0.27	1.00

**Correlation is significant at $p < 0.05$*

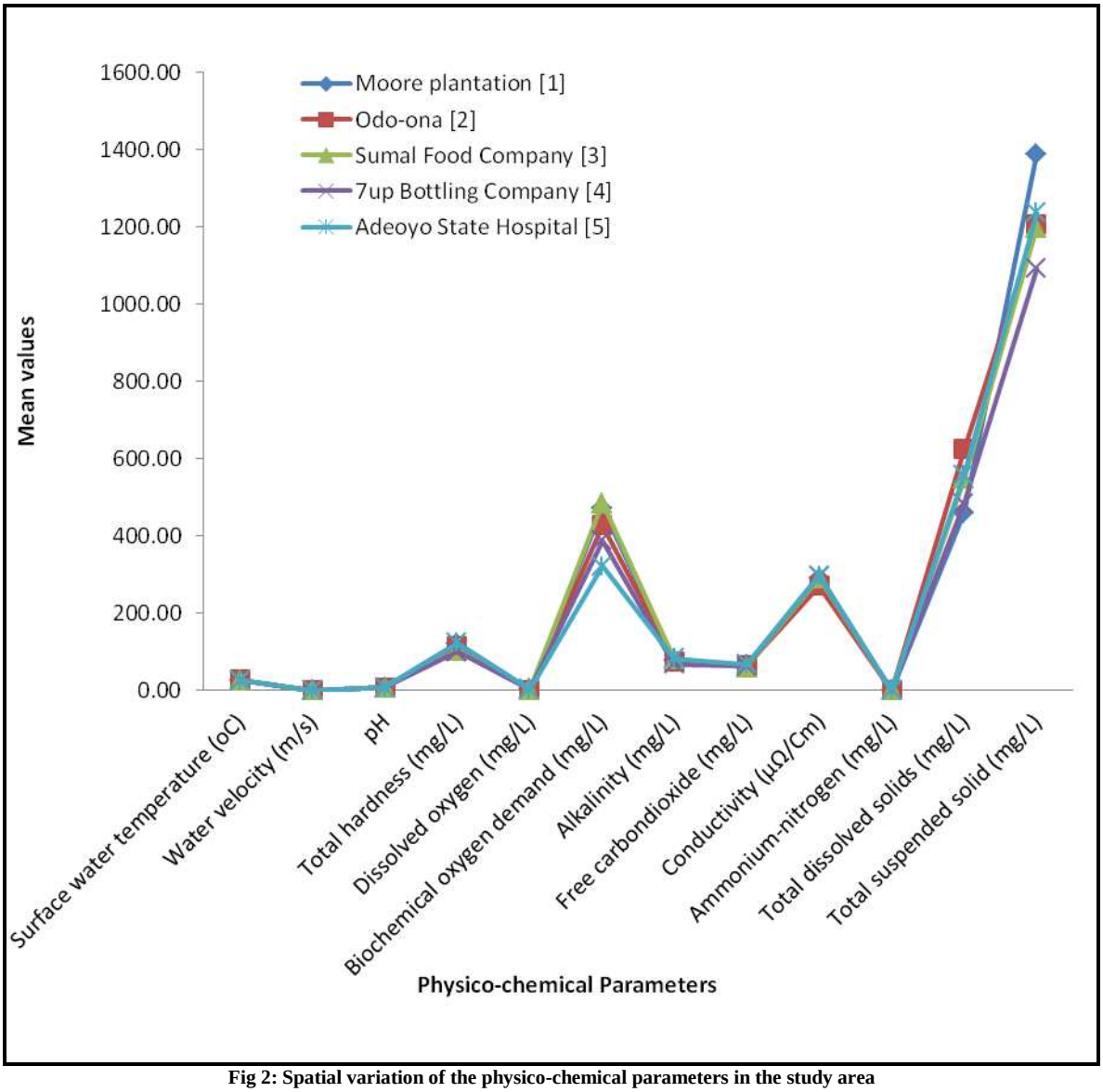

Fig 2: Spatial variation of the physico-chemical parameters in the study area

DISCUSSION

Physico-chemical parameters of Ona River during the period of study showed that all sampling stations were polluted, except for the upstream station which was assumed to be unpolluted since waste/effluent was not discharge into this station. This means that the introduction of effluent impacted the water quality. The mean of surface water temperature recorded in this study fall within the normal temperature range 20-30 ^{o} C stipulated for aquatic life in the tropical region [35]. The mean of pH obtained in this study in all sampling stations falls within the recommended range 6.5- 9 reported as suitable for aquatic life by Federal Ministry of Environment [36]. The mean pH between stations during the study showed no significant difference and this could suggests that the water body was homogeneous in terms of pH, indicative of stability at all stations as reported by [37].

Alkalinity is the buffering (alkaline) capacity of water. The range of alkalinity observed is characteristic of estuarine environment. Water with high alkalinity is undesirable because of the associated excessive Hardness. The reported alkalinity in this present study is within the acceptable range for natural surface water. [38] recommended acceptable range of 30-500mg/L for natural waters. For the aquatic environment to be protected, guidelines stipulate that alkalinity must be maintained at natural background level [39]. This could suggest that the water of Ona River is desirable for aquatic life and industrial uses as it has alkalinity above 30mg/L.

Dissolved oxygen is probably the most universal applied water quality criterion. The observed dissolved oxygen concentrations during the study period were lower than Federal Ministry of Environment permissible range of 5.0mg/L. [40] recommended that dissolved oxygen concentration above 4mg/L is good while below 4mg/L is

detrimental to the aquatic life. This was not surprising considering the high levels of total suspended solids contents of the effluent from Sumal Food industry station. The depletion of dissolved oxygen at this station could also be due to enormous amount of organic loads which required high levels of oxygen for chemical oxidation, decomposition or break down. Similar findings were reported by [41] in River Ase, Niger Delta.

The biochemical oxygen demand was very high during this study. Water with biochemical oxygen demand less than 4 mg/L are termed reasonably clean and unpolluted, while water with level greater than 10mg/L are considered polluted since they contain large amount of degradable organic materials [42]. The mean range of biochemical oxygen demand obtained in this study 404.63- 486.56mg/L, indicates that Ona River was under high organic pollution which make it bad for drinking and water quality. High biochemical oxygen demand has been reported to be a good indication of organic pollution [43]. High biochemical oxygen demand recorded in this study could explain slightly low dissolved oxygen also recorded in this study, this was also observed by [42] in studies of the Warri River. The water of Ona River was therefore not suitable for drinking.

The conductivity of Ona River water during the study period fell within the medium level 50-600µS/cm reported by [37]. [29] affirmed that natural water normally has conductivity ranges from 20-1500µS/cm. [44] observed a range of 31- 13µS/cm in upper Ogun River. Higher conductivity observed in this study could be due to increase in amount of organic material of the river. High conductivity recorded in this study also could explain high biochemical oxygen demand also recorded in this study, this was also observed by [45] in Ogunpa River.

The range of total dissolved solids and total suspended solids obtained in this study were high and beyond standards range for drinking water and survival of aquatic life as reported by [46]. High levels total dissolved solids and total suspended solids observed in this study could be as a result of regular discharge of effluents from industries such as Sumal Food Industry, 7up bottling Company and dumping of solid wastes around the river. The continuous deposition of these wastes/effluents around the river could lead to the reduction in the volume of the water and also impede the free flowing of the river. Long term deposition of materials in the river could also result in flooding, particularly during heavy rain fall which could have both economic and ecological implications.

Surface water temperature and biochemical oxygen demand concentration correlate negatively with dissolved oxygen concentration and free carbondioxide while pH and Alkalinity correlate positively with free carbondioxide and Ammonium-Nitrogen, these mean that there is detectable negative and positive relationship between these parameters and also suggests functional similarity between the parameters. Similar finding were reported by [47] in lower Bonny River of Niger Delta.

The spatial distribution of physico-chemical parameter in this study showed gradual increase in the mean values from the upstream stations to downstream stations along the river. This trend could be attributed to effluent water discharges from industrial, agricultural and domestic activities that are prevalent along the stations of Ona River.

CONCLUSIONS

I. The physico-chemical parameters like biochemical oxygen demand, alkalinity and ammonia nitrogen, conductivity, TDS, TSS, total hardness, lead, chromium, iron and copper of Ona River water were not within suitable range for aquatic organisms and drinking water.
II. Physico-chemical parameters influenced the water quality of Ona River, Apata, Ibadan south-west, Oyo state, Nigeria.
III. It could be concluded that Ona River water is under pollutional stress due to the disruption of abiotic and biotic factors.

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REFERENCES

[1] MR Harrison, Pollution, causes, effects and control. Royal Society of Chemistry, Chemistry, London, **1992**; pp. 393.
[2] EM Wilson, Engineering Hydrology Macmillan Press Ltd Houndmills, Basingstoke Hampshire, RG216XS and London, **1990**; pp. 348.
[3] HS Swingle, Methods of analysis for waters, organic matter and pond bottom soils used in fisheries research. Auburn University, Auburn, Alabama, **1969**; pp. 119.
[4] BS Moses, Introduction to Tropical Fisheries. University Press, Ibadan, **1983**; pp. 105.
[5] R Victor and O.Onomivibori, S.P.B Academic Publishes. Amsterdam, Netherlands, **1996**, pp. 223-238.
[6] MT Barbour, J. L. Paltkin, K. D. Porter, S. K. Gross and R. M. Hughes, Environmental Protection Agency, **1989**, 440, 89-001.
[7] J Tyokumbur, TG Okorie and OA Ugwumba, *the Zoologist*, **2002**, 1, 59-69.
[8] SO Fagade, A A Adebisi and O. A. Ugwumba, *National Resources Conservation Council*, **1993**, pp. 176 -182.
[9] HS Sudhira and V. S. Kumar, Centre for Ecological Sciences, Indian Institute of Science, **2000**, pp. 1-10.
[10] OK Adeyemo, the Environmentalist, **2003**, 23**,** 297-306.
[11] RN Nasrullah, B. Hamida., I. Mudassar and I. M. Durrani, *Journal of agricultural and biological science*, **2006**, 1, 18-24.
[12] RJ Wakawa, A Uzairu and JA Kagbu, *African journal of pure and applied chemistry*, **200**8, 2, 6-13.
[13] I Ekweozor and IE Agbozu, *the environmentalist*, **2001**, 23**,** 297-306.
[14] OE Sala, IS Chapin, JJ Armesto, E Berlow, J Bloomfield, R Dirzo, E Huber-Sanwald, LF Huenneke, RB Jackson, A Kinzig, R Leemans, DM Lodge, HA Mooney, M Oesterheld., NL Poff, MT Sykes, BH Walker, M Walker and DH Wall, *Science*, **2000**, 287, 1770–1774.
[15] C Biney, AT Amazu, D Calamari, N Kaba, IL Mbome, PBO Ochumba, O. Osibanjo, V Radegonde and M A Saad, Review of heavy metals in the African aquatic environment, ecotoxicology and environmental safety, **1994**, 31, 134-159.
[16] MT Barbour, J Gerritsen, BD Snyder and JB Stribling, US Environmental Protection Agency, **1998**, 841, 98-010.
[17] MT Barbour, J Gerritsen, BD Snyder and JB Stribling, US Environmental Protection Agency, **1999**, 841, 99-002.
[18] DM Rosenberg and VII Resh, Fresh water biomonitoring and benthic macro invertebrates. New York, Chapman and Hall, **1998**; pp. 488.
[19] DP Monda, DL Galat and SE Finger, *Archives of environmental contamination and toxicology*, **1995**, 28, 378-38.
[20] SR Matagi, *Archiv fur hydrobiologie*, **1996**, 137, 537-549.
[21] CA Edopkayi and EC Osimen, *African journal of science and technology*, **2001**, 12, 72-81.
[22] LO Chukwu and DI Nwankwo, Diffuse Pollution Conference Dublin. ECSA4: Persistent pollutants, **2003** ; pp. 65.
[23] EA Ajao and SO Fagade, *Chemical pollution*, **1991**, 7, 85 -105.
[24] TV Akpata and JA Ekundayo, *Journals of science*, **1978**, 12, (1and 2).
[25] SO Ajayi and SA Adeleye, *Bulletin chemical society of Nigeria*, **1977**, 8**,** 77-99.
[26] EP Akpan, UI Ekpe and UJ Ibok, *Environmental geology*, **2002**, 42, 47-51.
[27] AG Akin-Oriola, *Review biological tropica*, **2003**, 51, 7 pp.
[28] RA Parker, International conference on mining and the environment III, Sudbury, Ontario, Canada, **1972**; pp. 11.
[29] CE Boyd, Water Quality in warm water fish ponds. Craftmaster and Printers Inc. Auburn, Alabama, **1979**; pp. 359.
[30] D Kumar, FAO Fisheries Technical paper, **1992**, 325, 239.
[31] ND Gordon, TA Mc Mahon and BL Finlayson, Stream hydrology, an introduction for ecologist. New York, John Wiley and Sons, 1994; pp. 526.
[32] APHA, Washington DC, **1985**, pp. 1244.
[33] APHA-AWWA and WEF, Washington DC, **1995**, pp. 1132-1145.
[34] AE Ogbeibu, Biostatistics: A practical approach to research Data handling. Mindex Publishing Company Ltd. Nigeria, **2005**; pp. 153 -162.
[35] M Horsfall and AI Spiff, Environmental pollution with biological, chemical and physical emphasis. Metro print Ltd. Port Harcourt, Nigeria, **2001**; pp. 1-11, 138-232.
[36] FMENV, Federal Ministry of Environment Decree 58 of 1988, **1999**, pp. 238.
[37] AA Sowunmi, *Nigeria trends in applied science research*, **2001** (in press).
[38] DNHW, Department of Natural Health and Welfare. First edition. Washington D.C.: McGraw-Hill, **1969**.
[39] ESB, Environmental Studies Board, Washington, D.C, **1973**, EPA R3-73-033.

[40] IJC, International Joint Commission Volume 11. Great Lakes Water Quality Board Report, **1977**.
[41] FO Arimoro, RB Ikomi and E Efemuna, *Journal of fisheries and aquatic science*, **2007**, 2, 337-34.
[42] EI Ohimain, OT Imoobe and DS Dorcas, *World journal of agricultural sciences*, **2008**, 4, 752-758.
[43] OE Chukwu, ES Ajisegiri, KR Onifade and OD Jimoh, *Journal of environmental resources*, **2007**, 2, 339-342.
[44] AA Adebisi, *Hydrobiologia*, **1981**, 79, 157-165.
[45] OE Atobatele, OA Morenikeji and OA Ugwumba, *the Zoologist*, **2005**, 3, 58-67.
[46] FEPA, Federal Environmental Protection Agency, Lagos, Nigeria, **1991**, pp. 15.
[47] AC Chindah and U Nduaguibe, *J. Nigerian Environ. Soci*, **2003**, 1, 206-222.