Assessment of Some Physico-Chemical Parameters of River Ogun (Abeokuta, Ogun State, Southwestern Nigeria) in Comparison With National and International Standards

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Abstract This study assessed the physico-chemical quality of River Ogun, Abeokuta, Ogun state, Southwestern Nigeria. Four locations were chosen spatially along the water course to reflect a consideration of all possible human activities that are capable of changing the quality of river water. The water samples were collected monthly for seven consecutive months (December 2011 – June 2012) at the four sampling stations. pH, air temperature (°C), water temperature (°C), conductivity (µS/cm) and total dissolved solids (mg/L) were conducted in-situ with the use of HANNA Combo pH and EC multi meter Hi 98129 and Mercury-in-glass thermometer while dissolved oxygen (mg/L), nitrate (mg/L), phosphate (mg/L), alkalinity (mg/L) and hardness (mg/L) were determined ex-situ using standard methods. Results showed that dissolved oxygen, hydrogen ion concentration, total hardness and nitrate were above the maximum permissible limit of National Administration for Food, Drugs and Control (NAFDAC), Standard Organization of Nigeria (SON), Federal Environmental Protection Agency (FEPA), United States Environmental Protection Agency (USEPA), European Union (EU) and World Health Organization (WHO) for drinking water during certain months of the study period. Results also showed that water temperature and conductivity were within the permissible limits of all the standards excluding FEPA. However, total dissolved solids and alkalinity were within the permissible limits of all the standards. Adejuwon and Adelakun, (2012) also reported similar findings on Rivers Lala, Yobo and Agodo in Ewekoro local government area of Ogun state, Nigeria. Since most of the parameters measured were above the maximum permissible limits of the national and international standards, it can be concluded that the water is unfit for domestic uses, drinking and aquacultural purposes and therefore needs to be treated if it is to be used at all. The low dissolved oxygen values for the first four months was too low i.e. < 5 mg/L. This is most likely as a result of the amount of effluents discharged into the river. To prevent mass extinction of aquatic organisms due to anoxic conditions, proper regulations should be implemented to reduce the organic load the river receives.

Keywords Physico-chemical; Quality assessment; River Ogun; Water standards; Parameters

Introduction Water is a vital commodity (NBS, 2012) and its sources include rivers, streams, lakes, wells, boreholes, spring etc. Rivers are among the oldest water bodies in the world (Higler, 2012). In most urban-rural communities in the developing countries especially the Sub-Saharan Africa, surface waters (rivers, streams, and lakes among others) have been the most available sources of water used for domestic purposes. The water from these sources is contaminated with domestic, agricultural, and industrial wastes and likely to cause water related diseases (Ojekunle, 2000; Ayeni et al., 2009). The four main sources of aquatic pollution include industrial wastes, municipal wastes, agricultural run-off, and accidental spillage (Walsh, 1980). Nigeria has a surface area of 94 185 000 hectares which extends from latitude 40°16’N to 130°52’N of the equator and longitude 20°49’E and 140°37’E (Ita, 1993). The freshwater resources of Nigeria are within the extensive river systems, lakes, flood plains and reservoirs and constitute about 12.4% of its surface area which is 11 678 940 ha (Olaosebikan and Aminu, 1998). River Ogun is one of them with a total area of 22.4 km² (2 240 ha) and a fairly large flow of about 393 m³ sec⁻¹ during the wet season (Oketola et al., 2006). Since water is of necessity to man, animal and plant there is therefore need to assess its quality so as to proffer guidelines for its sustainable usage and/or make corrective steps to
ensure its quality. This study is therefore aimed at assessing the physico-chemical quality of the river in comparison with national and international standards.

1 Results and Discussion

The results of the physico-chemical parameters of River Ogun are shown in Table 1. Some selected national and international water quality standard guidelines are shown in Table 2. The Comparison of hardness values is shown in Table 3. Water temperature is one of the most important physical characteristics of aquatic systems (Deas and Lowny, 2000). It is one of the most important regulators of life processes in aquatic ecosystems (FOEN, 2011). It has direct and indirect effects on nearly all aspects of stream ecology. Temperature also influences the rate of photosynthesis by algae and aquatic plants. As water temperature rises, the rate of photosynthesis increases thereby providing adequate amounts of nutrients (Boulton, 2012). Water temperature ranged between 26.9±1.1 (June, 2012) and 32.1±0.5 (April, 2012). This was found to be within the permissible limit of the WHO but exceeded the maximum permissible limit of FEPA. This result is similar to Fafioye et al., (2005) who reported a range of 26.5–31.5°C in Omi water body, Ago iwoye, Ogun state, Nigeria. Dissolved oxygen is one of the most important parameters in aquatic systems (Manora online, 2012). When the temperature of water increases, a portion of oxygen converts from the liquid state to a gaseous state. Thus the ability of water to maintain oxygen in dissolved state decreases with increasing temperature. As a result, colder water can potentially contain more dissolved oxygen than warm water (AWQA, 2012). Dissolved oxygen ranged between 2.8±1.95 (January, 2012) and 7.7±0.50 (May, 2012). This value exceeded the maximum permissible limit of the standards. The dissolved oxygen values for the first four months were observed to be critically low. This could be as a result of human activities on the water and low water volume which is characteristic of the dry season. Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current (Manora online, 2012). Conductivity measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content in a solution (Gray, 2005). Conductivity ranged between 99.0±7.84 (February, 2012) and 180.5±6.64 (December, 2011). This value fell within the permissible limit of NAFDAC, SON, NSDW, WHO, EU and USEPA but exceeded the maximum permissible limit of FEPA. Total dissolved solid (TDS) is a measurement of inorganic salts, organic matter and other dissolved materials in water (U.S. Environmental Protection Agency, Office of Water, 1986). TDS concentrations are used to evaluate the quality of freshwater systems (Manora-online, 2012). Total dissolved solids ranged between 48.8±3.68 (February, 2012) and 90.8±3.35 (December, 2011). This value fell within the permissible limit of the standards. Transparency is how easily light can pass through a substance. In other words, when the water is murky or cloudy and contains a lot of particles, the light cannot penetrate as deeply into the water column which hence limits primary productivity. Transparency ranged between 0.2±0.08 (May, 2012) and 0.7±0.07 (December, 2011). The trend in transparency values showed that the first three months was constant after which it began deteriorating gradually and then shoots up again in June, 2012. The reduction in water transparency could be as a result of the human activities around the river such as locust bean processing, ferrying, refuse disposal etc. and run offs from land erosion while the increase could be as a result of more water influx which is characteristic of the wet season. Alkalinity is a measure of the acid-neutralizing capacity of water. In most natural waters, it is due to the presence of carbonate (CO3⁻), bicarbonate (HCO3⁻), and hydroxyl (OH⁻) anions. However, borates, phosphates, silicates, and other bases also contribute to alkalinity if present (Wilson, 2010). Alkalinity ranged between 4.4±0.38 (January, 2012) and 17.8±0.25 (April, 2012). This value fell within the permissible limit of the standards. Hardness is most commonly associated with the ability of water to precipitate soap. As hardness increases, more soap is needed to achieve the same level of cleaning due to the interactions of the hardness ions with the soap. Chemically, hardness is often defined as the sum of polyvalent cation concentrations dissolved in the water (Wilson, 2010). In fresh waters, the principal hardness-causing ions are Calcium and Magnesium; Strontium, Iron, Barium and Manganese ions also contribute (USEPA, 1976). Hardness ranged between 45.5±4.79 (January, 2012) and 105.0±46.74 (April, 2012). This value exceeded the maximum permissible limit of the standards excluding NSDW. The trend in the hardness values showed that River was moderately soft then soft then moderately soft then slightly hard and
finally moderately soft. Hydrogen ion concentration (pH) is the standard measure of how acidic or alkaline a solution is. It is measured on a scale from 0-14. pH of 7 is neutral; pH less than 7 is acidic while pH greater than 7 is basic. The closer pH gets to 1, the more acidic while the closer pH gets to 14, the more basic (Kelly-Addy et al., 2004). The pH scale is logarithmic, which means that a unit decrease in pH equals a tenfold increase in acidity.

Hydrogen ion concentration ranged between 7.7±0.15 (March, 2012) and 9.1±0.13 (December, 2011). This value exceeded the maximum permissible limit of the standards. Phosphate (PO4\(^{3-}\)) can be found as a free ion in water systems and as a salt in terrestrial environments used in detergents as water softeners (Turner Designs, 2012). Phosphates can be in organic form (organically-bound phosphates) or inorganic form (including orthophosphates and polyphosphates). Phosphates ranged between 0.0±0.01 (February, 2012) and 0.7±0.09 (March, 2012).

Air temperature is a measure of how hot or cold the air is. It is the most commonly measured weather parameter. More specifically, temperature describes the kinetic energy, or energy of motion, of the gases that make up air. As gas molecules move more quickly, air temperature increases. Air temperature ranged between 26.3±1.31 (December, 2011) and 35.3±0.48 (January, 2012). Results of the Duncan’s Multiple Range Test showed that there was significant difference in all the parameters excluding nitrates throughout the study period.

### Table 1: Mean values of physico-chemical parameters of River Ogun, Abeokuta, Ogun state, Nigeria

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WT</td>
<td>27.0±0.41a</td>
<td>30.0±0.58ab</td>
<td>30.3±0.04b</td>
<td>30.0±0.10b</td>
<td>32.1±0.50b</td>
<td>31.7±2.54b</td>
<td>26.9±1.15b</td>
</tr>
<tr>
<td>DO</td>
<td>2.9±0.40a</td>
<td>2.8±1.95a</td>
<td>3.3±0.77a</td>
<td>4.2±0.64a</td>
<td>6.6±0.36b</td>
<td>7.7±0.50b</td>
<td>6.6±1.21b</td>
</tr>
<tr>
<td>COND</td>
<td>180.5±6.64c</td>
<td>131.3±14.42ab</td>
<td>99.0±7.84a</td>
<td>99.0±8.44a</td>
<td>119.5±8.74a</td>
<td>131.8±8.19b</td>
<td>177.8±33.25bc</td>
</tr>
<tr>
<td>TDS</td>
<td>90.8±3.35c</td>
<td>64.8±7.47a</td>
<td>48.8±3.68a</td>
<td>49.8±3.42a</td>
<td>59.5±4.29a</td>
<td>66.5±4.91c</td>
<td>88.8±16.67c</td>
</tr>
<tr>
<td>TRANS</td>
<td>0.7±0.07c</td>
<td>0.7±0.09bc</td>
<td>0.7±0.08bc</td>
<td>0.6±0.15bc</td>
<td>0.4±0.08bc</td>
<td>0.2±0.08b</td>
<td>0.6±0.02b</td>
</tr>
<tr>
<td>ALK</td>
<td>5.0±1.35a</td>
<td>4.4±0.38a</td>
<td>4.8±0.75a</td>
<td>5.0±0.58a</td>
<td>17.8±0.25b</td>
<td>5.3±1.03a</td>
<td>5.5±2.99a</td>
</tr>
<tr>
<td>HARD</td>
<td>55.0±1.91c</td>
<td>45.5±4.79a</td>
<td>47.5±7.80a</td>
<td>82.0±37.62a</td>
<td>105.0±46.74a</td>
<td>56.0±4.76c</td>
<td>67.0±13.13c</td>
</tr>
<tr>
<td>pH</td>
<td>9.1±0.13c</td>
<td>7.8±3.00a</td>
<td>8.0±3.33a</td>
<td>7.7±0.15c</td>
<td>8.2±0.28ab</td>
<td>8.1±1.11bc</td>
<td>8.7±0.08bc</td>
</tr>
<tr>
<td>NITR</td>
<td>0.6±0.14a</td>
<td>2.2±0.92a</td>
<td>2.6±0.85a</td>
<td>58.0±4.89a</td>
<td>26.1±5.91a</td>
<td>43.4±7.95a</td>
<td>113.4±8.88a</td>
</tr>
<tr>
<td>PHO</td>
<td>0.1±0.02ab</td>
<td>0.1±0.03ab</td>
<td>0.0±0.01a</td>
<td>0.7±0.09a</td>
<td>0.2±0.05b</td>
<td>0.1±0.02ab</td>
<td>0.4±0.02c</td>
</tr>
<tr>
<td>AIRTEMP</td>
<td>26.3±1.31a</td>
<td>35.3±0.48a</td>
<td>31.8±0.85a</td>
<td>31.0±0.41a</td>
<td>33.3±0.85bc</td>
<td>31.0±0.41b</td>
<td>28.0±0.58b</td>
</tr>
</tbody>
</table>

Note: Variables with the same superscript across the column are not statistically significant (P > 0.05). Where: WT – Water Temperature, DO – Dissolved Oxygen, COND – Conductivity, TDS – Total Dissolved Solids, TRANS – Transparency, ALK – Alkalinity, HARD – Hardness, pH – Hydrogen ion concentration, NITR – Nitrates, PHO – Phosphates, AIRTEMP – Air Temperature.

### Table 2: Selected national and international water quality standard guidelines

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameter</th>
<th>NAFDAC</th>
<th>SON</th>
<th>FEPA</th>
<th>NSDW</th>
<th>WHO</th>
<th>EU</th>
<th>USEPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conductivity</td>
<td>1000</td>
<td>1000</td>
<td>70</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>Total dissolved solids</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>–</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>Hydrogen ion concentration</td>
<td>6.5–8.5</td>
<td>6.5–8.5</td>
<td>6.0–9.0</td>
<td>6.5–8.5</td>
<td>6.8</td>
<td>6.5–9.5</td>
<td>6.5–8.5</td>
</tr>
<tr>
<td>4</td>
<td>Total hardness</td>
<td>100</td>
<td>100</td>
<td>–</td>
<td>150</td>
<td>100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>Total alkalinity</td>
<td>100</td>
<td>100</td>
<td>–</td>
<td>–</td>
<td>100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>Nitrate</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Water temperature</td>
<td>–</td>
<td>–</td>
<td>26</td>
<td>–</td>
<td>40</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>Dissolved oxygen</td>
<td>–</td>
<td>–</td>
<td>&gt; 4</td>
<td>–</td>
<td>&gt; 6</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 3 Comparison of hardness level (adapted from Twort and Dickson, 1994)

<table>
<thead>
<tr>
<th>Hardness level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>Soft</td>
</tr>
<tr>
<td>50 to 100</td>
<td>Moderately soft</td>
</tr>
<tr>
<td>100 – 150</td>
<td>Slightly hard</td>
</tr>
<tr>
<td>150 – 200</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>Over 299</td>
<td>Hard</td>
</tr>
<tr>
<td>Over 300</td>
<td>Very hard</td>
</tr>
</tbody>
</table>

Note: Source: Adejuwon and Adelakun, 2012

2 Conclusion

Since most of the parameters measured were above the maximum permissible limits of the national and international standards, it can be concluded that the water is unfit for domestic uses, drinking and aquacultural purposes and therefore needs to be treated if it is to be used at all. The low dissolved oxygen values for the first four months was too low i.e. < 5 mg/L. This is most likely as a result of the amount of effluents discharged into the river. To prevent mass extinction of aquatic organisms due to anoxic conditions, proper regulations should be implemented to reduce the organic load the river receives.

3 Materials and Methods

3.1 The Study Area

Ogun State is a state in South-western Nigeria. It borders Lagos State to the South, Oyo and Osun states to the North, Ondo State to the east and the republic of Benin to the west. Abeokuta is the capital and largest city in the state (NBS, 2012).

3.2 Geography of River Ogun

It (Figure 1) is one of the main rivers in the southwestern part of Nigeria with a total area of 22.4 km² and a fairly large flow of about 393 m³ sec⁻¹ during the wet season. It has coordinates of 3°28'E and 8°41'N from its source in Oyo state to 3°25'E and 6°35'N in Lagos where it enters the Lagos lagoon (Ayoade et al., 2004; Oketola et al., 2006). Two seasons are distinguishable in Ogun river basin, a dry season from November to March and a wet season between April and October. Mean annual rainfall ranges from 900 mm in the north to 2 000 mm towards the south. The estimates of total annual

Figure 1 Map of River Ogun showing the Sampling Stations
Note: Source: Google maps, (2012)
potential evapotranspiration have been put between 1 600 and 1 900 mm (Bhattacharya and Bolaji, 2010). The water is used for agriculture, transportation, human consumption, various industrial activities and domestic purposes. Along its course, it constantly receives effluents from breweries, slaughterhouses, dyeing industries, tanneries and domestic wastewater before finally discharging to Lagos lagoon (Ayoade et al., 2004; Oketola et al., 2006). A 100 square km area around River Ogun has an approximate population of 3 637 013 (0.03637 persons per square meter) and an average elevation of 336 meters above the sea (Travel Journals, 2012).

3.3 Collection of Water Samples
Four sampling stations were established along the length of the river. Their description based on personal visual observations is given below:

3.3.1 Station 1 (Iberekodo)
It is located just downwards the Ogun State Water Works Corporation at Arakanga in Iberekodo. The water is cured by the corporation and dispensed through underground pipes to respective homes. The river here is characterized by a dam/spillway and high concrete dykes. The water is generally very clear and has good aesthetic quality. The water is turbid in the rainy months and clear in the dry months. The activities here are majorly fishing, bathing, dam maintenance and fishing gear mending. No farmland was observed at this station.

3.3.2 Station 2 (Agodo)
It is located close to the FADAMA III supported ferry for transportation to Lafenwa. The vegetation around the banks is very dense. The activities here includes: locust bean processing, bathing, washing of clothes, refuse dumping and transportation by ferry. The water is turbid in the rainy months and clear in the dry months. The activities of the ferry men could lead to siltation of the water body causing high turbidity conditions. No farmland was observed at this station.

3.3.3 Station 3 (Enu gada)
It is located some few steps after the bridge connecting to Lafenwa. It is characterized by less dense vegetation and slow flowing water. The water is turbid in the rainy months and clear in the dry months. Activities carried out here includes: washing of clothes, farming; indiscriminate dumping of refuse and human excreta.

3.3.4 Station 4 (Off Pepsi bus stop)
It is characterized by rocky outcrops with fast flowing water. The vegetation consists of terrestrial vegetation which is less dense. The water is clear and has good aesthetic quality. Activities carried out here includes: bathing, washing of clothes and drying of fishing gear on the rocks. No farmland was observed at this station.

3.4 Experimentation
Water samples for physico-chemical analyses were collected monthly for seven consecutive months (December 2011 – June 2012) at the four sampling stations. pH, air temperature (°C), water temperature (°C), conductivity (µs/cm) and total dissolved solids (mg/L) were conducted in-situ with the use of HANNA Combo pH and EC multi meter Hi 98129 and Mercury-in-glass thermometer while Dissolved Oxygen (mg/L), Nitrate (mg/L), Phosphate (mg/L), Alkalinity (mg/L) and Hardness (mg/L) were determined ex-situ using standard methods for examination of water.

3.5 Statistical analysis
The data was subjected to One way Anova Analysis using SPSS for the various parameters. Further test such as Duncan’s multiple range tests was carried out to ascertain whether there is significant difference among the parameters.

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