PHYSIOCHEMICAL ASSESSMENT OF DRINKING WATER SOURCES IN IMO STATE

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ABSTRACT

Drinking water sources in Imo State, Nigeria were assessed for temperature, appearance, total, suspended solids, total dissolved solids, electrical conducting, PH, total hardness, turbidity and heavy metals content using standard for the examination of water and waste water. The results showed that majority (76.92%) of the properties tested were not within the WHO recommended standard. The properties found to be within the WHO recommended standard were PH, temperature, dissolved oxygen and solids. The presence of impurities in water reduces the quality therefore the need for constant monitoring of drinking water sources cannot be over emphasized.

INTRODUCTION

Background

The concern for water resources containing contaminants such as heavy metals and toxic metalloids that pose a threat to health has increased worldwide (Donahue et al., 1983; White et al., 2005; Bozkurtoglu et al., 2006 and Osunwa, 2011). The increased rate of biochemical reactions that accompanies an increase in temperature, combined with a decrease in the quantity of oxygen present in surface waters, can cause serious depletions in dissolved oxygen concentration (Tchobanologous, 1979). The physical characteristics of water include temperature, colour, taste, odour, solids and conductivity (Jackson, 1990). Temperature is a very important parameter because of its effects on the aquatic life, chemical reactions and reaction rates, and the suitability of water for beneficial uses.

METHODS

Study Area

The area of study is Imo State. The State is named after the Imo river. The geo-political zones in Imo State are Orikwe, Orlu and Owerri. It has Owerri as its capital and largest city. Situated in South Eastern Nigeria, and covering an area of 5,530 square kilometres. Imo State derives its name from Imo River, which takes its course from the Orikwe/Awka upland. It lies within latitudes 4°45’N and 7°15’N, and longitude 6°50’E and 7°25’E. Imo State has many rivers. The main rivers in the state are Imo, Otamiri and Njaba. The major lakes are in Oguta and Abadaha in Obowu Local Government Area.

Sample Collection and Analysis

Water samples used for this study were collected from the different water sources (Rivers, Streams, Lakes, Springs, Rainwater, Tap-water, Boreholes, Storage Tanks, Mosques etc.) available in the selected study areas. Thirty eight Water samples, with an average of 12 water samples per zone were collected.

Water samples were collected in 1–litre sterile bottles and plastic cans and processed according to the standard of Baker (1971), Cruickshank et al (1975), NWRI (1997), Cheesebrough (2004), and transported to the laboratory for analyses. Samples were transported in ice-packs and ice-boxes where delays were envisaged.

For Physico-Chemical Analysis, water samples were analyzed for the following parameters: Temperature (Thermometer), Appearance, Total Suspended Solids (MFT), Total Dissolved Solids (Total Dissolved Solid-meter), Electrical Conductivity (Conductivity Meter), PH (ph meter), Total Hardness (EDTA Manver 2 Hardness Powder Indicator, Hardness Buffer Solution), Turbidity (Spectrophotometer) Heavy Metals Content (Atomic Absorption Spectrophotometer (AAS).
Standard for the examination of water and waste water as described by APHA (2005) was used for the estimation of Temperature, PH and Turbidity, Total Dissolved Solutes, Chlorine and Total Dissolved Calcium and Magnesium hardness was determined using NWRI (1997) stipulations.

RESULTS

The levels for each of the assessed water properties such as the PH, temperature, dissolved oxygen, conductivity, total dissolved solids, colour, turbidity, total hardness, total chlorine, sulphate, BOD and COD in water samples taken from Imo State, Nigeria are presented on Table 1a and 1b, along with the WHO standard for each of the properties. Apparently majority of the properties tested were not within the WHO recommended standard. The properties found within the WHO Standard were PH (WHO level: 6.5–8.5, Imo level: 7.75) and Dissolved Oxygen (WHO: >4mg/L, Imo State Total =5.42mg/L).

All the Total Dissolved Solids (mg/L) readings obtained from drinking water samples analysed were well below the Threshold Limit of the WHO standard for TDS.

**Hydrogen ION Concentration – pH**

The average pH of the different water sources ranged from 5.2 – 9.9. Ezewara Ihube Springwater, Okigwe zone had the highest pH (most basic) reading, whilst Ezelukwu Springwater, Umueze, Okigwe, and the Njaba River at Awo Omamma, Orlu Zone, had the lowest (most acidic) pH values. The highest pH value for Sachet Water samples was 7.99 for Agad Sachet Water, Owerri, and the lowest pH value for sachet water was Prime Mego Sachet Water from Orlu, Orlu zone. Oguta Lake and Obana River water samples had a pH of 6.6 and 7.3 respectively, which fell within the acceptable range of the WHO Standard.

**Table 1a** The Levels for Physico-Chemical Properties of Water Samples in Imo State

<table>
<thead>
<tr>
<th>Properties</th>
<th>OWERRI Average</th>
<th>OWERRI Std. Dev</th>
<th>OLRU Average</th>
<th>OLRU Std. Dev</th>
<th>TOTAL Average</th>
<th>TOTAL Std. Dev</th>
<th>Sig. p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>6.55</td>
<td>0.864</td>
<td>6.643</td>
<td>1.246</td>
<td>6.948</td>
<td>0.910</td>
<td>6.753</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28.127</td>
<td>0.918</td>
<td>27.407</td>
<td>0.980</td>
<td>27.707</td>
<td>0.786</td>
<td>27.711</td>
</tr>
<tr>
<td>Dissolved Oxygen, mg/L</td>
<td>4.854</td>
<td>1.395</td>
<td>5.786</td>
<td>1.461</td>
<td>5.429</td>
<td>1.085</td>
<td>5.416</td>
</tr>
<tr>
<td>Conductivity µScm/hr</td>
<td>100</td>
<td>45.714</td>
<td>38.844</td>
<td>26.429</td>
<td>35.003</td>
<td>41.868</td>
<td>40.125</td>
</tr>
<tr>
<td>Total dissolved solids, mg/L</td>
<td>34.923</td>
<td>29.047</td>
<td>29.714</td>
<td>25.248</td>
<td>17.179</td>
<td>22.752</td>
<td>27.214</td>
</tr>
<tr>
<td>Colour</td>
<td>0.0</td>
<td>0.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Turbidity</td>
<td>0.0</td>
<td>0.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Total hardness, mg/L</td>
<td>0.0</td>
<td>0.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Table 1b** The Levels for Physico-Chemical Properties of Water Samples in Imo State

<table>
<thead>
<tr>
<th>Properties</th>
<th>OWERRI Average</th>
<th>OWERRI Std. Dev</th>
<th>OLRU Average</th>
<th>OLRU Std. Dev</th>
<th>TOTAL Average</th>
<th>TOTAL Std. Dev</th>
<th>Sig. p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total chloride, mg/L</td>
<td>189.755</td>
<td>81.696</td>
<td>505.812</td>
<td>213.357</td>
<td>387.212</td>
<td>287.936</td>
<td>467.402</td>
</tr>
<tr>
<td>Sulphate, mg/L</td>
<td>444.59</td>
<td>300.403</td>
<td>473.75</td>
<td>77.287</td>
<td>203.077</td>
<td>177.435</td>
<td>0.055</td>
</tr>
<tr>
<td>Total suspended solids, mg/L</td>
<td>172.082</td>
<td>159.18</td>
<td>61.762</td>
<td>23.715</td>
<td>148.14</td>
<td>85.330</td>
<td>167.355</td>
</tr>
<tr>
<td>BOD</td>
<td>1.3</td>
<td>0.950</td>
<td>2.029</td>
<td>1.082</td>
<td>1.75</td>
<td>2.207</td>
<td>1.800</td>
</tr>
</tbody>
</table>

**Total Dissolved Solids (TDS)**

The average Total Dissolved Solids found in Imo State for the water samples is 27.21mg/L at a standard deviation (st.dev) of 26.08mg/L. Clearly the average total dissolved solids on Imo water samples fall within the acceptable WHO recommended limit as it is below the 250mg/L WHO benchmark. For the three zones in the state, the average value of total dissolved solids were found to be 34.92 mg/L (st.dev=29.05 mg/L) in Owerri zone, 29.71 mg/L (st.dev=25.25 mg/L) in Okigwe zone and 17.18 mg/L (st.dev =22.75 mg/L) in Orlu zone.

The highest TDS values recorded were 87.75mg/L, 98.8mg/L and 91.65mg/L for Iyiogwu Springwater (Okigwe), Borohole Sample, Egbu (Owerri), and Prime Mego Sachet Water (Orlu) respectively. The lowest TDS value recorded was 4.55mg/L for both the Borohole Sample, Okporo (Orlu) and Timotex Sachet Water (Orlu) respectively, raising the possibility of the Sachet water being drawn directly from this Borohole Water Source.

**COLOUR (PCU or Platinum Cobalt Units)**

With the exceptions of Iyiogwu Springwater, Okigwe (11.00pcu), Iwo River, Umuna Okigwe (730.0 pcu), Obana River, Oguta, Orlu Zone (21.00pcu), Njaba River, Awo Omamma, Orlu Zone, all the other drinking water samples analysed had the same value of 0.00 pcu. Colour is one of the important indices used to assess quality of drinking water. The highest value for colour (pcu) was from Iwo River, Umuna Okigwe.

**Temperature**

The Temperature range was from 25.8°C to 29.3°C, and the average temperature was 27.7°C. The highest temperature recorded was from the Borohole source in Amawom, Owerri Central, and the lowest temperature reading was from Iwo River, Umuna, Okigwe. The average Borohole Water Temperature value was 27.9°C and the average temperature reading for Spring water Sources was 27.8°C. Iyiechu Stream, Okigwe, recorded a temperature reading of 26.5°C.
temperatures for Borehole Water, Spring Water and River Water were 27.9°C, 27.5°C and 27.8°C respectively. All the temperature readings from the different drinking water sources fell within the acceptable range of the WHO Standard and Threshold Limits.

**Total Suspended Solids (TSS)**

The Total Suspended Solids were found as an average total of 167.36mg/L in Imo State. It was highest in Okigwe zone with a sample average value of 172.08mg/L, while it was lowest in the Okigwe zone with an average value of 61.76mg/L. The average total suspended solids value found in Orlu zone is 48.1mg/L. The bar chart below shows the average total suspended solids as well as those found in each of the three zones of Imo state. All the TSS values obtained from the drinking water samples studied far exceeded the threshold limit of the WHO Standard value, with the exception of Otamiri River Water Sample, which had a value of 54.7mg/L which was just slightly above the recommended WHO Standard limit (50mg/L). This value was the lowest by far, followed by the value obtained for the sample from Oguta Lake (Orlu zone).

The highest TSS value recorded was for Iyiebi Springwater, Amuzi (Okigwe), followed by Holy Family Sachet Water, Egbeada (Owerri).

**Conductivity Values of Water Sources**

The Conductivity values of water sources in Imo State were found to be well below the WHO Standard. While the WHO recommended a water conductivity level of 100µS/cm, the average conductivity level found in Imo State is only 40.13µS/cm (53.73 in Owerri zone, 45.71 in Okigwe zone and 26.43 in Orlu zone). The conductivity value of the water sources recommended by WHO is far high in a line graph compared to what was recorded in Imo State. Variations in conductivity value of the water sources are observable in each of the three zones of the state.

The highest readings recorded were 135µS/cm, 141µS/cm and 152µS/cm, which were the values for Iyiogwugwu Springwater (Okigwe), Prime Mego Sachet Water (Orlu), and Borehole Water, Egbu (Owerri) respectively. The lowest conductivity value was 7µS/cm which was recorded for Timotex Sachet Water, Okporo (Orlu) and Borehole, Okporo (Orlu). All the Conductivity values recorded were well below the threshold value of the WHO Standard.

**Total Hardness Values**

The Total Hardness values of the water samples in Imo state were all found to be within acceptable limits when compared with the WHO recommended standard. The recommended level by WHO is 200mg/L, but the average total hardness found in Imo State was 1.25mg/L, for which it was found as 1.218mg/L in Owerri zone, 1.414mg/L in Okigwe zone and 0.95 mg/L in Orlu. These are clearly represented in a Bar Chart. Otamiri River Water Sample (Owerri zone) recorded the highest TH value of 7.20mg/L, followed by Prime Mego Sachet Water (Orlu) with a value of 3.70mg/L. The lowest TH values recorded in the study were from the Njaba River, awo Omamma (Orlu zone), Borehole Amakohia (Owerri), Borehole, Umuororonjo (Owerri) and Timotex Sachet Water, Okporo (Orlu). All the drinking water samples analyzed for Total Hardness (TH) had values well within and way below the WHO Standard Threshold Limit.

**Turbidity**

Clearly the water turbidity level in Imo state is much higher than the WHO benchmark of 5NTU. The average turbidity level for drinking water samples sourced in Imo State was found to be 45.37. It was found to be highest in Owerri zone at 152.8, followed by Okigwe zone at 2.21 and then Orlu zone at 0.86 NTU.

**Total Chloride Level**

The WHO standard for total chloride level is zero, but the samples in Imo state, contained a total average of 467.47 mg/L. Going by the zones in the state, the highest found chloride level was observed in Okigwe zone (total chloride = 189.76 mg/L) followed by Owerri zone (387.21mg/L) and the lowest average value found in Owerri zone (189.75mg/L).

**Biological Oxygen Demand (BOD)**

The water samples studied gave the average total BOD level to be 1.8mg/L in Imo State. On average, the BOD level on the water samples were found to be 1.3mg/L in water samples from Owerri zone, 2.03mg/L in water samples from Okigwe zone and 1.75mg/L in water samples from Orlu zone. The bar chart shows the average BOD level for each of the zones. The figure also shows that BOD level found in Imo State drinking water samples tested were not above the WHO benchmark and thus within the acceptable limits. The highest BOD value recorded was for Oguta Lake (Orlu), 7.70mg/L, and the lowest value recorded in the study was 0.2mg/L for Timotex Sachet Water (Orlu), Masyco Sachet Water (Orlu), and Agad Sachet Water (Owerri zone) respectively.

**Chemical Oxygen Demand (COD)**

In similarity to the result found on BOD, the COD level on the water samples in Imo State were well within the range and threshold limits recommended by WHO. The COD level was found to be on average total of 4.1mg/L in Imo State, with an average of 1.9mg/L in water samples from Owerri zone, 3.25mg/L in the water samples from Okigwe zone and 6.19mg/L in water samples from Orlu zone. Again, the highest COD value recorded from the drinking water samples was for Oguta Lake (12.32mg/L), whilst the lowest COD readings obtained were for Timotex Sachet Water (Orlu), Masyco Sachet Water (Orlu), and Agad Sachet Water (Owerri), which all had a value of 0.2mg/L.

**DISCUSSION**

Hydrogen ion concentration (pH) is determined by the content of dissolved substances discharged into it through natural and anthropogenic activities. Extreme acidic and alkaline levels of pH subjects aquatic micro and macro-organisms to high risk (Alan, 1995). Oguta Lake had pH levels within acceptable limits. The pH levels found in Otamiri and Nworie rivers could be due to constant pollution by industrial, domestic and agricultural wastes (Aririatu, 1999; Chikwendu, 2008).

**Conductivity -** Jackson (1990) established that there is a positive correlation between Dissolved solids and Conductivity, which is a measure of ionized solids dissolved in the water.
water. Results obtained agreed with this assertion. Conductivity and Dissolved solids were well below Threshold Limit of WHO Standard. The average TDS in Imo State was 27.21mg/DL, and Conductivity was 40.13µs/cm. The highest value for conductivity was 152µs/cm from Borehole water in Egba, Owerri zone, while the lowest values recorded were from Timotex Sachet Water, Okporo and Borehole Water from Okporo. Both samples which were from the same location (Okporo) could mean the Sachet water was being collected from the Borehole Source.

**Total Hardness:** Hardness in natural waters is as a result of multivalent cations especially magnesium and calcium ions. Studies carried out in Southeastern Nigeria (Obiekezie et al (2006), Okereke et al (2006), and Nwaugo et al (2006) show that water in these area, which includes the study area, tend to be soft. Water sources studied had Total Hardness values within WHO acceptable Limits. The average hardness found was 1.25mg/L. Otamiri River had the highest value at 7.20mg/L followed by Prime Mego Sachet Water with 3.70mg/L. The lowest values recorded were from Njaba River at Awo-Oromma and the two Boreholes from Owerri.

**Turbidity:** Tchobanoglous (1979) described Turbidity as the interference of light passage through water as a result of particles, dust, soil, organics, microorganisms and other materials which impede passage of light through water by scattering and absorbing the rays. There was a high average turbidity in Owerri zone (152.8 NTU), and a very low average of 0.86 NTU at Okigwe zone. This low level in Okigwe zone could be due to the preponderance of Springwater sources in the zone.

**Total Chloride:** Substantial amounts of Chloride in water normally impacts salty taste. In natural waters chlorides can occur as a result of leaching of chloride-containing rocks in rain (Jackson, 1990; Coombes, 2003). The WHO Standard for total chloride level is zero. The samples collected contained an average of 467.47mg/L. The highest chloride levels found were from Okigwe zone, and the lowest values were from Owerri zone. The high chloride levels could be as a result of the geological formations (soil nature) and the hilly and rocky topography characteristic of Okigwe zone.

**Sulphates:** Sulphates are often present in natural waters as Calcium Sulphate. Humans can tolerate high concentrations of sulphate in drinking water. With the exception of Timotex sachet water (Orlu) and Paddies Sachet water (Okigwe), all the water samples analysed fell within the WHO permissible limit of 400mg/L. Sulphates are corrosive to concretes, and in sewage, it is the precursor of a major corrosion problem (Okereke, 2009). In such cases, possible remedies could include the use of plastic pipes or epoxy linings inside concrete (Jackson, 1990). Earlier studies on Sulphate levels revealed values similar to what was obtained in this study. Ana et al (2004), Coombes et al (2003) and Khalequzzaman (2000) recorded low values of sulphate in underground water. The values of sulphate in sachet water by Ifeanyi et al (2006) and Okereke (2009) were similar to results obtained in this study.

**References**


National Water Resources Institute (NWR) (1997): Training Guidelines for Water Quality Testing and Control, Outreach Department, Mando Road, Kaduna 8-62


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