Case Study

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# Comparative quality analysis between surface water and groundwater: a case study of Otamiri river and water boreholes in owerri west, Imo State Nigeria

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## Abstract
***Disease vectors are prevalent and thrive well in water and this makes it inevitable to investigate the pathogenic state of every water source before it is applied for any purpose of usage. This research investigated the quality status of Otamiri River and water boreholes located in Owerri west, Imo State Nigeria. Water samples collected from the river and the selected boreholes were subjected to bacteriological, physical and chemical analyses in a laboratory sited within the locality. The results obtained indicated that the surface water is heavily adulterated, polluted and unsafe for drinking without treatment while the water from boreholes are safe for drinking without any further treatment.***

## Keywords
***Surface water, Groundwater, Quality, Pollution.***

## 1.Introduction
Apart from water existing in the troposphere, water on the earth can be bifurcated into two broad categories of surface water and ground water. Groundwater and surface water are found in localities, communities and cities. Both groundwater and surface water are sources of water supply to communities and most communities use them for domestic, industrial, recreational and cultural purposes. While groundwater is accessed through the construction of boreholes, surface water occur as rivers, streams, springs, lakes, ponds, etc. and are open and can easily be reached by its host communities and towns.

Since these two categories of water are used by communities, it becomes imperative to know their comparative quality standards. The comparative quality analysis will help the communities and other users to be properly guided in their usage of the water for their various needs and purposes. This research was conceived due to the fact that Otamiri River and Water Boreholes are the major sources of water supply to the inhabitants of Owerri west local government area. The intention is to bring to limelight the quality status of these sources of water through the method of comparative analysis.

### 1.1Surface water
Surface water is an area in hydrology that encompasses all water on the surface of the earth which includes overland flows, rivers, lakes, wetlands, estuaries, oceans etc. It is a subset of the hydrologic cycle that excludes atmospheric and ground water. This includes the field measurement of flow discharge, the statistical variability at each setting: floods, drought susceptibility and the development of levels of risk. Comprehensive analysis of surface water components in the hydrologic cycle include hydrometeorology, evapotranspiration, rainfall, runoff characteristics, open channel flow, flood, and statistical and probabilistic methods in hydrology [1,2]

#### 1.1.1Rivers
A river is a natural flowing water course, usually freshwater, flowing towards an ocean, sea, lake or another river. Small rivers are called streams, creeks, brook, rivulet and rill. Rivers are important components of the hydrologic cycle. Rainfall and precipitation empties into the river from a drainage basin and through surface runoff. At times, there are flows from one aquifer to another and this is called watershed leakage. At any place where the water table intersects the ground surface, a seepage surface or spring (river) is formed. The study of rivers is called potamology and the study in land waters in general is called limnology. Natural channels are used to convey the flow of water through rivers. Channels may indicate past rivers, specifically out

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flow channels on Mars. Rivers are theorized to exist on planets and moons in habitable zones of stars [3].

The beginning of a river is called its source and follows a path and ends up in a mouth. The river flow is confined to a channel. The channel has a floor called bed and it normally lies between valleys called the bank. Rivers can flow between mountains, through valleys or depressions and create gorges. The river channel contains a single stream of water but some rivers flow as several interconnecting streams of water and produce a braided river.

The controlling of rivers to make them more useful, or less disruptive and destructive to human activity is called river engineering. Engineering structures such as levees, dams, weirs, canals and barrages are structural elements employed in river engineering. River engineering is continuous activities as the river on its own alters the modifications of engineering. For instance, dredged river builds its sediments to return to its former condition. Surface water has high degree and concentration of solids as it has no natural filtration facility like groundwater [4].

### 1.2Groundwater
Groundwater is water located under the surface of the earth. It is replenish able through the rainfall and run off on the earth surface. The water from rainfall enters into the earth surface through pores and accumulates within the aquifers to form groundwater. Groundwater is relatively free from pollution and can easily be developed at a least possible cost. Groundwater occurs in two zones of saturation and accretion. The zone of accretion has water existing in it through molecular attraction the water at this zone is not under hydrostatic pressure. The zone is unsaturated as it contains both water and air. The soil water zone is immediately below the ground surface and the roots of crops take water from the zone for its transpiration [5].

The saturation zone is heavily water-saturated and it is often called the groundwater zone. It is the final destination of the groundwater recharge which comes as rainfall and passes through the pores and accumulates in the aquifers.

#### 1.2.1Water boreholes
Generally, groundwater exploitation is achieved through the digging of holes vertically into the aquifer and these holes which are dug to extract water from the aquifer is called water boreholes. The water is normally extracted through pumping. Water boreholes can be described as shallow or deep. When the depth of the water borehole is less that 6m, it is said that shallow but when the depth is more than 6 metres, it is described as being deep [6].

**Contamination of Groundwater**
Groundwater is an important source of drinking water. Historically, groundwater was considered to be so safe that it has been consumed directly from water wells without any challenge of treatment. In underdeveloped countries, practically all villages rely on groundwater from shallow dug wells. Immediately, a groundwater is contaminated, it is difficult to restore it to a safe state. There are several ways through which an aquifer can be contaminated, through a legally or an illegally constructed hazardous landfill or a nearby septic/soakaway pit or illegally located waste dumpsite. The control of groundwater pollution may include physical containment and extraction of contaminated water for subsequent treatment. The physical containment method involves literally stopping the plumeof an advancing pollution by a barrier [7].

#### 1.2.2Borehole drilling operation
Modern technology has provided tools which increase and facilitate the success of drilling operations. The tools are cable or percussion tools, hydraulic rotary tool, and reverse rotary tool. The cable or percussion tool drills the hole by striking the force of the drilling bit of the lower end cable. The drilling bit is automatically lifted and dropped in the descending borehole to break the formation.

The hydraulic rotary tool is the fastest tool that can be used in drilling boreholes and it is best used in unconsolidated formations. The tool uses the force provided by the continuous rotating of the hollow pit, through which a mixture of clay and water or mud is formed. The bit cuttings are carried up in the hole by the rising mud. No casing is required during drilling because the mud itself makes a lining on the walls of the holes, preventing it from caving. The reverse rotary tool is a modified form of the hydraulic rotary method. It used for making large wells of 1.2m diameter in unconsolidated formations [8].

### 1.3Natural quality differences between groundwater and surface water
Naturally, there are obvious differences between surface and ground waters. Every source of water has a peculiar set of contaminants; groundwater stores pesticides chemicals and nitrate while surface water contains mostly bacteria and other microorganisms. Surface water can be affected by numerous physical variables such as topography, land cover, soil

conditions, mineralogy. Both groundwater and surface water may be affected by geologic conditions. Surface water is more susceptible to contamination than groundwater. The filtration through the soil profile down to the aquifers purifies and cleans the groundwater. Inspite of this groundwater is often contaminated due to human activities.

### 1.4Water quality

Quality is basically defined as fit for use and it is a measure of a resource or product fitness for use for the intended purpose. Water quality parameters are assessed based on the source of its pollution. Sources of water pollution are grouped into three namely physical pollutant, bacteriological pollutant and chemical pollutant. Physical pollutants occur both in surface and ground water. Physical pollutants may occur in groundwater due to sediments arising from soil erosion [3].

Turbidity is a physical pollutant which occurs as a result off suspended materials such as clay and silt. High concentration of detergent may cause formability in ground water.

Bacteriological pollutant occurs when the presence of Escherichia coli form (E-coli) is noticed in water. E-colis on the its own is harmless but its presence signifies the occurrence of bacterial contamination, Chemical pollutant occurs when any chemical element or compound considered to be inimical to health is observed in water [2].

#### 1.4.1Water quality legislation

Water quality legislation laws govern the release of pollutants into water resources including surface water, ground water and stored drinking water. Water quality laws such as drinking water regulations may be designed solely with reference to human health. Many others, including restrictions on the alteration of the chemical, physical, radiological and biological characteristics of water resources, may also reflect efforts to protect aquatic ecosystems more broadly. Regulating efforts may include identification and categorization of water pollutants, determination of acceptable pollutant concentrations in water resources and limiting pollutants discharges from effluent sources.

Regulatory areas include sewage treatment and disposal, industrial and agricultural waste, water management and control of surface water runoff from construction sites and urban environment [3].

### 1.5Interaction between surface water and groundwater

When a river and an aquifer are in direct hydraulic contact, an interchange of surface water and groundwater occurs. If the water table stands higher than the river stage, groundwater may enter the river as a base flow. Normally, the groundwater discharge can make up most of the stream flow during dry months. On the other hand, a substantial percentage of total recharge to groundwater in some arid and semiarid areas can be from the leakage of water through the streambed.

Many perennial streams recharge the subsurface formation in some portion upstream of their reach, while groundwater discharge appears in the rivers further downstream. Gaining and losing reaches can be influenced by human activities. Similarly, any factor which can alter the river stage or water table could change the rate of the base flow. For instance, it has been observed in irrigation areas bordering a river, that part of the irrigation water which percolates below the root zone discharges into the river as irrigation return flow. When artificial recharge activities are conducted near a river, part of the recharge water may find its way into the river [6]. In the upper reaches of a watershed, subsurface contributions to stream flow aid in the build-up of the flood wave in a river. While in the lower reaches, a different type of groundwater–stream flow interaction known as bank storage occurs and this often moderates the flood wave.

## 2.Methodology

The research employed the method of laboratory analysis of the samples of the Otamiri River and the selected water boreholes.

### 2.1Sample collection

The Otamiri River was divided five reaches and samples of water were collected from these reaches. The water boreholes were selected from the study area in a manner that gives geographical spread which can be considered as a true representative of the study area. Water samples were collected from these boreholes and labelled accordingly.

### 2.2Laboratory analysis

The water samples were taken to the laboratory for an analytical process. The samples were tested for the various water quality parameters and recorded accordingly.

### 2.3Description of study area

The study area involved in this research is the Owerri West Local Government Area of Imo State, Nigeria. The local government area was carved out of the old Owerri Division. Its political and administrative headquarters is situated at Umunguma and its communities include Obinze, Eziobodo, Irete, Ihiagwa, Oforola, Okuku, Avu, and Ogbaku, Otamiri River transverses the area and has Eziobodo, Ihiagwa and Obinze as its vipararian communities. The local government area houses the industrial estate of Imo State and it is located at Irete. The river is a perennial river that serves its host communities for industrial, domestic, agricultural, fishing and recreational purposes.

## 3.Result presentation and discussion

The comparative results of the bacteriological, chemical and physical characteristics of the water quality of the surface water and groundwater are shown on *Tables 1, 2 and 3* respectively.

**Table 1** Comparative results of bacteriological analysis

| Parameter | Groundwater SW | | | Surface water (Otamiri River) SW | | |
|---|---|---|---|---|---|---|
| | Obinze | Avu | Oforola | Upstream Reach | Middle Reach | Downstream Reach |
| BOD (mg/L) | 4.3 | 4.2 | 4.2 | 4.3 | 4.5 | 4.8 |
| COD | 6.7 | 6.8 | 5.0 | 7.2 | 6.8 | 6.80 |
| Total coli form | 268 | 279 | 302 | 393 | 393 | 394 |
| Total Bacterial Count | - | - | - | 233 | 234 | 233 |
| E-Coli | - | - | - | 141 | 143 | 144 |

**Table 2** Comparative result of physical parameter analyses

| Parameter | Groundwater GW | | | Surface water (Otamiri River) SW | | |
|---|---|---|---|---|---|---|
| | Obinze | Avu | Oforola | Upstream Reach | Middle Reach | Downstream Reach |
| Appearance | Clear | Clear | Clear | Clear | Clear | Clear |
| Taste | Tasteless | Tasteless | Tasteless | Tasty | Tasty | Tasty |
| Colour (TCU) | 5.00 | 5.00 | 5.00 | 9.00 | 10.00 | 12.00 |
| Odour | Odourless | Odourless | Odourless | Bad | Bad | Bad |
| TSS(mg/L) | 1.05 | 1.45 | 2.07 | 20 | 22.00 | 24.00 |
| Temperature ($^0$C) | 27.00 | 26.0 | 28.00 | 28.00 | 27.5 | 29.0 |
| Turbidity (NTU) | 1.30 | 1.00 | 1.00 | 30.00 | 1.00 | 48.00 |

**Table 3** Comparative result of chemical parameter analysis

| Parameter | Groundwater GW | | | Surface Water (Otamiri River) SW | | |
|---|---|---|---|---|---|---|
| | Obinze | Avu | Oforola | Upstream Reach | Middle Reach | Downstream Reach |
| $C0_2$(mg/L | 23.0 | 18.5 | 20.0 | 4.0 | 23.2 | 2.4 |
| Chromium(mg/L | - | - | - | - | - | - |
| Hardness (mg/L) | 0.45 | 0.30 | 0.20 | 0.00 | 0.01 | 0.00 |
| Zinc (mg/L) | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.03 |
| DO (mg/L) | 3.5 | 7.0 | 4.5 | 20.7 | 23.5 | 19.8 |
| Alkalinity | 6.8 | 6.7 | 6.9 | 6.2 | 5.9 | 6.8 |
| $C0_3$(mg/L) | 29.8 | 28.5 | 27.0 | 21.5 | 22.0 | 20.5 |
| Phosphorus | 0.5 | 0.7 | 0.5 | 0.4 | 0.3 | 0.3 |
| Nacl | - | - | - | - | - | - |
| $PO_4$(mg/L | 0.6 | 0.7 | 0.5 | 1.3 | 1.1 | 0.7 |
| $SO_4$(mg/L | 0.0 | 0.1 | 0.00 | 1.8 | 3.8 | 5.8 |
| $NO_3$(mg/L) | 0.0 | 0.0 | 0.00 | 2.8 | 10 | 14 |

### 3.1Discussion of results

The comparative results in *Table 1, 2and 3* exposed the bacteriological, physical and chemical characteristics of groundwater vis a vis the surface water. This means that groundwater needs the treatment process of aeration more than the surface water. From *Table 2*, it was discovered that there was zero presence of Escherichia coliform (E-coli) groundwater while there was a heavy amounts of the presence of e-coli to the tune of 141, 143, and 144. This shows that the groundwater in the study is pathogenic free. The heavy defecation around the banks of the Otamiri River by inhabitants must have been responsible for this high presence of Escherichia coliform (e-coli) in the river. The presence of the e-coli is above the recommended limit by the World Health Organization and therefore the water should be properly treated through chlorination or any other method of sterilization,. Comparatively, the turbidity in the surface water (i.e. 30 NTU 41 NTU and 48 NTU) is very high as against the negligible amounts of 2.3, 1.0 and 1.0 NTU seen in the groundwater. The surface should be treated through the process of coagulation to reduce the turbidity. It was observed that the groundwater and surface water did not contain the heavy metals in excess of the recommended limit.

There is a higher concentration of nitrate in the surface water as compared with the quantity in the groundwater. This may be as a result of washing away of fertilizer remnants from the farming, activities carried out in the river banks by runoff and overland into the river.

From *Table 3*, it was observed that the dissolved oxygen of 3.50mg/L, 7.0mg/L, and 4.5mg/L seen in groundwater is lower than the quantities of 20.7mg/L, 23.5mg/L and 19.8mg/L indicated in surface water.

## 4.Conclusion and recommendation

### 4.1Conclusion

Surface water is more susceptible to pollution than the groundwater. This is due to the case with the surface water is exposed to human activities unlike the groundwater which is naturally confined. Apart from the threat of proximity to septic tanks and landfills the groundwater has less susceptibility to pollution than surface water. The natural filtration process provided by the geological formation gives the groundwater a strong defence and protection against pollution-laden overland flow and runoff which serves as recharge to the groundwater aquifers. Industrial and hospital wastes are most often discharged directly into our rivers as effluents.

Empirically, it has been established that there is a wide gap between the quality of groundwater and surface water. This suggests that generally groundwater is safer for usage than rivers. Surface water such as rivers, ponds, seas, lakes etc. should be subjected to full scale treatment processes before usage.

### 4.2Recommendations

With the results of this research, it is recommended that;

1) Surface waters such as rivers, seas, ponds and lakes should be subjected to full scale treatment processes before usage.
2) Apart from the threats of proximity to septic tanks and dumpsite, groundwater in the study area is considered safe.
3) Boreholes constructed in the area should be located at a safe distance from the septic tanks, landfills, and dump sites to strengthen its immunity against pollution.

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### Conflicts of interest

The author has no conflicts of interest to declare.

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