# INVESTIGATION OF GROUND WATER QUALITY DURING THE DRY SEASON IN RIVERS STATE, NIGERIA: A CASE STUDY OF PORT HARCOURT METROPOLIS

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## ABSTRACT

This research is to investigate the quality of ground water in boreholes and hand-dug wells during the dry season in six locations in Port Harcourt metropolis of Rivers State. The locations are Rumuola, D-line and Trans-Amadi, which use borehole while Elechi Beach, Gbundu and Ozubuko still use hand-dug wells. The parameters analysed were iron, chloride, hardness, and pH. Others were total dissolved solids (TDS), ammonia (free and saline), and E-coli. Results indicated that for iron, all except Ozubuko with a value of 0.32mg/l satisfied WHO's standard. It is not sufficient, however, to reject water containing higher iron content unless a more suitable supply is available. For parameters such as chloride and hardness, the samples from all the locations are within WHO's limit. This is also true for TDS, while for pH, the water samples from all the locations were acidic, falling short of the standard (6.5 – 8.5) specified by WHO although samples from Rumuola with the highest value of 6.66 fall within the WHO range and hence acceptable. Ammonia levels in the water samples from all the locations were within the recommended value by WHO, with the highest value (5.01) coming from Trans-Amadi, which indicates the highest level of biological reductions in this water. Finally and of greater significance too, is the fact that no E-coli was found in all the samples except that from Gbundu waterside with a level of 3 x $10^3$ as against zero recommended by WHO. This therefore makes the hand-dug well water from Gbundu warterside unsuitable for human consumption.

**KEY WORDS**: Ground water, quality, wells, boreholes.

## 1. INTRODUCTION

Water is an indispensable resource outside which human existence will become unbearable. Drinking water should be clear, cool, free from objectionable tastes and odours and from harmful chemicals and microorganisms (Noha, 2007**).** The sources of water in the world include the entire range of natural waters that occur on the earth, which include underground water, surface water and rain water**.** Surface water include rain water collected from structures or prepared catchments, water from rivers, natural lakes, storage reservoirs and oceans. Underground water supplies are a result of surface water percolating through the soil and rock. They include natural springs, shallow wells, deep and artesian wells and horizontal galleries. Rain water is the purest form of natural water because it is formed as a result of the condensation of water vapour in the atmosphere that is, it is a natural form of distilled water. Spring-water contains a considerable amount of mineral salt, but with very little suspended impurities such as dust and bacteria. Water from deep wells or boreholes tends to be free from pollution while water from shallow wells are prone to contain some forms of contaminants.

Improper management of waste especially treatment and disposal of solid and liquid wastes are the major contributors to urban area water pollution (Napacho, 2010). There are various ways groundwater may suffer pollution e.g. land disposal of solid wastes, sewage disposal on land, Agricultural activities, urban runoff and polluted surface water (Jain et al, 1995).

The quality of ground water depends on the quality of water recharging the aquifer and the hydrologic and biogeochemical processes that affect it along flow paths from recharge to discharge areas (Kevin et al., 2004). Problems with drinking water infrastructure, whether public or private, threaten the safety, quality and health values of drinking water for the public (Eftila, 2010). Most water before they reach the

consumer, have been exposed to greater or lesser amount of contamination. Precipitation carries an appreciable amount of materials to the Earth's surface. Windblown spray from seawater is the sources of many salts that are dissolved in rain and they contain chloride (CL, sodium ($Na^+$), magnesium ($Mg^{2+}$), calcium ($Ca^{2+}$) and potassium ($k^+$) irons. Winds pick up small particles and living organisms such as pollen grains, bacteria and the spores of fungi. These air bone particles are trapped by raindrops and are suspended in them as they fall. The amount and types of impurities in precipitation vary with location and the time of the year, and can affect the characteristics of streams, ponds, lakes, reservoirs, oceans and rivers (Bulbul A., 2013).

Other constituents and characteristics that make water less acceptable include total dissolved solid content, colour, turbidity, off taste or odour, phenolic substance carbon chloroform extract, ethyl – benzyl sulfonates, and other wastes not readily degradable. Also products such as detergents, artificial fertilizers, and insecticides become pollutants when they get into water supply (Encylopaedia Britannica, UT – ZW V, 19)

Apart from direct factors some other factors indirectly affect quality of water. In the case of the underground water supply sources, excessive withdrawals may have an adverse effect on the chemical quality of the supply, such as increasing the content of iron or manganese or total dissolved solids (Culp and Culp, 1974).

Port Harcourt is a coastal city and the capital of Rivers State, Nigeria. The rural to urban migration resulting in an ever increasing population has put a lot of pressure on existing water facilities. This has further incapacitated the ability of government to meet the water demand of the populace. It is therefore common place to see women and children with buckets and gerri cans roaming the street in search of potable water, especially during the dry season. This development has given rise to the booming sachet water, often called "pure water" business, as numerous outlets are springing up all over the city. As a consequence, residents suffer from water related diseases and in extreme cases deaths. Records in the Rivers State Ministry of Health show that between 2009 and 2012, there were 305 recorded cases of cholera outbreak with 23 deaths. Furthermore, in the year 2012 there were 1,074 recorded cases of typhoid and paratyphoid patient with 12 recorded death cases. There were also 2,856 reported cases of amoebiasis and a total of 128 deaths. The report also indicated that 10 percent of infant mortality was as a result of diarrhea or respiratory infections, while other diseases such as dysentery were also on the increase. To bridge the wide gap between demand and supply, residents have resorted to indiscriminate drilling of boreholes and shallow wells. Most often, the shallow wells are located near sources of pollution and the quality is rather poor (Ajayi A.A., 2008).

The aim of this research, therefore, was to investigate the quality of the most preferred source of water (ground water) during the dry season in six locations in Port Harcourt metropolis.

## 2. MATERIALS AND METHODS

### 2.1 Description of Study Area

Port Harcourt is located in the Niger Delta region, lying along the Bonny river (an eastern distributory of the River Niger), 66km upstream from the Gulf of Guinea. Port Harcourt with latitude$4.75^0$ N and longitude $7^0$ E has a tropical monsoon climate, with average temperature averaging between $25^0$ C - $28^0$ C and rainfall measuring an average of just over 210mm.

The investigation of water quality was performed in six locations in Port Harcourt metropolis. The locations are: Elechi beach, Gbundu water side, D-line, Trans Amadi, Ozuboko Community and Rumuola. The high population density areas of Elechi beach, Ozuboko and Gbundu waterside mainly use water from shallow wells as potable water, while the low population density and industrialised areas of Trans – Amadi, Rumuola and D-Line mainly use boreholes and pipe-borne water. Figs. 1 to 3 show

some of the hand-dug wells in the three high density areas. Samples of water from each location were collected and transported to the laboratory for analysis.

Fig1: Side view of hand-dug well (with protective cover) in Elechi Beach

Fig. 2: Front view of hand-dug well (without protection cover) in Gbundu water side

Fig. 3a: Front view of hand-dug well (without protective cover in Ozubuko

Fig. 3b: Plan view of hand-dug well (without protection cover in Ozubuko

### 2.2 Sample Collection and Test Procedures

The samples were collected in accordance with the procedure recommended in the standard methods for the examination of water and waste water prepared by the American Public Health Association (APHA). The parameters tested were total dissolved solids, pH, iron, chloride, hardness, ammonia test (free and saline) and bacteriological counts.

The total dissolve solid was determined with the gravimetric method (APHA 1995) while the pH was determined with the electronic pH metre. Iron was tested with the ASTM D1068-10 standard method, while chloride was determined with the Argentometric titration method (APHA, 1985). Furthermore, hardness and ammonium-nitrogen were determined by the ASTM D1126-12 standard test method and the phenate method (APHA 1985) respectively, while nitrate measurement was by the Brucine method (APHA, 1979). The bacteriological count was performed with the 9215B pour plate using R2A agar. The turbidity was determined with the ASTM D7726-11 standard method while the dissolved oxygen was measured with the dissolved oxygen meter. Electrical conductivity was measured with the electronic conductivity meter while sulfate and fluoride were measured with the ASTM D516-11 and the ASTM D1179-10 standard methods respectively. Also, magnesium was determined with the ASTM D511-09 standard method while aluminum was tested for with the ASTM D857-12 standard method. Cyanide was determined with the ASTM D2036-09 standard method. Furthermore, taste was determined using flavour threshold test (standard method 2160) while colour was determined with the - ASTM D1209 05 standard method.

## 3. RESULTS AND DISCUSSION

The results of the various test (Physical, Chemical, and Biology) at Trans- Amadi, Gbundu waterside, Elechi beach and Ozuboko) are shown in Table 1.

Table 1: Result of Parameters Tested

| Parameters | Rumuola (bore hole) | D-Line (bore hole) | Trans-Amadi (bore hole) | Gbundu (shallow well) | Elechi beech (shallow well) | Ozuboko (shallow well) | WHO |
|---|---|---|---|---|---|---|---|
| Iron | 0.06 | 0.08 | 0.27 | 0.19 | 0.16 | 0.32 | 0-0.30 |
| Chloride | 3.34 | 4.84 | 19.06 | 17.20 | 7.80 | 18.92 | 250 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Taste | no | no | no | no | no | no | INOFFENSIVE |
| Colour | clear | clear | clear | clear | clear | clear | Clear |
| Hardness | 4.40 | 5.10 | 23.51 | 30.91 | 18.44 | 35.50 | 1000 |
| pH | 6.66 | 6.30 | 5.78 | 5.50 | 5.48 | 5.31 | 6.5-8.5 |
| TDS | 171.8 | 198.2 | 223.7 | 154.3 | 151.9 | 138.1 | 500 |
| TURBIDITY (NTU) | 0.00 | 0.00 | 0.00 | 0.24 | 0.10 | 0.00 | 1.00 |
| Nitrate (mg/l) | 0.01 | 0.04 | 0.01 | 0.10 | 0.06 | 0.02 | 50 |
| DISSOLVED OXYGEN (mg/l) | 6.4 | 6.9 | 6.7 | 7.9 | 7.8 | 6.8 | - |
| ELECTRICAL CONDUCTIVITY (µs/cm) | 180 | 192 | 165 | 210 | 200 | 190 | 250 |
| SULFATES AS $SO_4$(mg/l) | 1.8 | 1.6 | 2.0 | 5.8 | 5.2 | 2.8 | 400 |
| Fluoride (F-) (mg/l) | 0.2 | 0.1 | 0.5 | 0.8 | 0.6 | 0.2 | 1.5 |
| Magnesium (Mg+2) (mg/l) | 2.4 | 1.8 | 2.1 | 3.9 | 4.2 | 1.2 | 50 |
| Aluminum (Al) (mg/l) | 0.02 | 0.01 | 0.04 | 0.01 | 0.03 | 0.01 | Nil |
| Cyanide (CN-) ( µg/l) | 0.3 | 0.1 | 0.2 | 0.3 | 0.1 | 0.1 | 50 |
| Ammonia (mg/l) | 1.21 | 1.26 | 5.07 | 2.88 | 1.95 | 2.01 | 10 |
| E-coli | 0.00 | 0.00 | 0.00 | 3 x 103 | 0.00 | 0.00 | Nil |

For borehole water in respect of iron, all the values are within the range recommended by WHO, while those from well water (except Ozubuko) are also within the WHO range. Although iron can produce taste and colour in water, there is no basis for the rejection of water containing iron in quantities above the WHO standard especially when other more suitable supplies are not available (Fair et al; 1981). The chloride levels in all the water supplies, both from the boreholes and wells are within the specified WHO limit. The results further indicates that there was neither taste nor colour problem in all the water samples. Turbidity and nitrate were also below the recommended value by WHO, thus making water from all the location potable with respect to these parameters.

There is no guideline by WHO on dissolved oxygen (Okechukwu et al, 2013) but water sample from Gbundu shallow well recorded the highest value of 7.9mg/l. Conductivity is the measure of the activity of all dissolved ionized solids in water. From the WHO standard, the conductivity values of all the water samples are below the maximum allowable. Sulfate and the fluoride of all the water samples were also below the recommended values by WHO. Also, magnesium and cyanide of all the water samples were below the range recommended by WHO. Though there is no standard value for aluminum in water analysis by WHO, the values obtained from the water sample showed that the values are very minimal and can be accepted as potable.

All the values obtained, in terms of hardness, are also far below WHO'S limit. For pH, all the data obtained were below the range specified by WHO except Rumuola, thus indicating acidity of all the water including Rumuola. This may be attributable, in part, to the high volume of industrial activities in these locations especially gas-flaring which results in acid-rain.

Ammonia (free and saline) is said to occur in natural water supply as a result of micro-biological reduction and can also indicate pollution by sewage (Nelson and Nelson, 1973). It therefore implies that

the higher the amount of ammonia, the greater the level of microbiological reduction and/or sewage pollution. From the analyzed samples the levels of ammonia range from 1.21mg/L to 5.07mg/L. One can therefore say that the water sample from Trans-Amadi with the highest ammonia level of 5.07mg/l is where more biological reductions took place. Also there was no trace of E-coli in all the samples tested except for Gbundu. This indicates that all the water sources are suitable for human consumption except Gbundu well water.

## 4. CONCLUSIONS AND RECOMMENDATIONS

Parameters whose values in all the locations were within the limit set by WHO are chloride, taste, colour, hardness, total dissolved solids, and turbidity. Others include nitrate, electrical conductivity, sulphates, fluorides, magnesium, cyanide, and ammonia. However, for iron, all locations except Ozuboko satisfied WHO standards while for pH, only water from Rumuola fell within the limit set by WHO. Since there was no standard set by WHO for dissolved oxygen and aluminum, it is safe to assume that the results obtained from the water sample pose no threat to health. E-coli level in Gbundu well water is high, thereby rendering it unsuitable for drinking. On the whole, these results indicates that boreholes are better sources of potable water than shallow wells in Port Harcourt metropolis.

It is recommended that the indiscriminate drilling of boreholes by individuals and institutions without co-ordination from an organized body needs to be properly checked. Reliable and efficient contractors should be engaged in the construction of boreholes. Hand-dug wells for water supply should be accompanied with provision for adequate sanitary facilities. The low levels of chloride and fluoride suggest the necessity for some forms of treatment such as chlorination and fluoridation in the boreholes and wells in Port Harcourt metropolis.

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