

## QUALITY ASSESSMENT OF SOME WELLS FOR DOMESTIC AND IRRIGATION ACTIVITIES

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### ABSTRACT

*Groundwaters from open wells were investigated to ascertain the current quality status and suitability for irrigation and domestic activities at LAUTECH, Ogbomoso in south-west of Nigeria. The water samples were collected from three wells for physicochemical, biological and microbiological properties and labeled W<sub>1</sub>, W<sub>2</sub> and W<sub>3</sub>. Three soil samples each from the target wells were also taken using a soil auger from a depth of about 0-30 cm. Each sample was placed in a black cellophane paper labeled S<sub>1</sub>, S<sub>2</sub> and S<sub>3</sub> respectively. These were taken to the laboratory for analysis. The water sample of well 2 was slightly basic with pH value of 7.3 and water samples of well 1; well 3 were slightly acidic with pH of 6.9 and 6.7 (which means the two samples are very near to neutral, 7.0). In terms of salinity hazards measured as electrical conductivity (EC) and Total Dissolved Solids (TDS), the water samples had very low salinity (EC for well 1 as 400  $\mu\text{Scm}^{-1}$ , well 2, 380  $\mu\text{Scm}^{-1}$  and well 3, 405  $\mu\text{Scm}^{-1}$ , TDS for well 1 was 200 mg/l, well 2, 220mg/l and well 3, 150mg/l). With respect to sodicity hazards, the sodium absorption ratio (SAR) values obtained for the three samples were 3.46 for well 1, 4.57 for well 2 and 6.53 for well 3. This indicates a low risk of sodium build up in the soils. However, irrigation water of very low salinity (<200  $\mu\text{Scm}^{-1}$ ) and low SAR can lead to problems of water infiltration into the soils. The nitrate concentration in the samples was quite low with values of 0.07 mg/l for well 1; 0.11 mg/l for well 2 and 0.03 mg/l for well 3, possibly because of no application of nitrogen fertilizers in the farm site near the wells.*

**Keywords:** quality assessment, wells, domestic, irrigation Ogbomoso

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## 1. INTRODUCTION

**W**ater quality is defined in terms of the chemical, physical and biological characteristics of water (Glenn, 1993). There is no single measure that constitutes good water quality (Glenn, 1993). For instance, according to the same author, water suitable for drinking can be used for irrigation but water used for irrigation may not meet drinking water guidelines. As stated by El-Ashry (1993), a few aspects of irrigation water quality have a direct impact on plants. water analysis is aimed to determine the effect of the water on the soil, with ultimate residual impact on plant grown on it. Thus, the interpretation of the water analysis is based on a prediction of the consequences on the soil and some plant species. Production systems may have much different requirements or tolerances (El-Ashry, 1993). All irrigation water contains essential plant nutrients, and these nutrients are free bonuses from a crop production standpoint, but some can be present in amounts toxic or damaging to crop growth (Michael, 1998). He reported that irrigation water quality can affect crop, fruit and vegetable production. All ground and surface waters contain dissolved mineral salts of various kinds and quantities. A laboratory analysis will however provide unbiased information on irrigation water quality. Most irrigation water analyses will include: sodium adsorption ration (SAR); total dissolved solids as measured by electrical conductivity of the water (E<sub>cw</sub>); concentration of specific anions, especially bicarbonate, chloride and sulphate; concentration of specific cations such as sodium, magnesium and calcium, and pH value. The most common irrigation water quality problems are caused by excessive amounts of salt (salinity), and sodium (alkali). Besides being toxic to crop growth, excess salt can restrict the capability to extract sufficient water from the soil. Excessive amount of sodium can cause soil particles to disperse, thereby destroying soil structure and restricting the movement of water and air through the soil. Some water may contain sufficient chloride and bicarbonate to cause damage to certain crops when applied through sprinkler systems. Often when these hazards exist, problems are avoided by developing appropriate management practices. The plant nutrient content of irrigation water can be an economic factor in the soil fertility management plan. Irrigation water should be tested prior to application on the field. (Graham, 2004). Ground water also contains iron.

However, iron in water is not available to plants, but the nutrients in irrigation water are just as available to the crops as those applied in commercial fertilizers (Graham, 2004). The quality of water affects the quality of life because the aim of analyzing is for human health, as the crops produced from irrigation are consumed, and can have negative or positive effect on our body systems (Suresh, 1997). Although irrigation is used for sustaining/increasing agricultural production, it is imperative that good quality water be used (Singh, 2000). Regardless of its source, soluble salts are always dissolved in irrigation water, which could affect the physical and chemical properties of soils. Hence, there is necessity to analyze the water present in LAUTECH because toxic substances and high populations of certain microorganisms can present a health hazard for both irrigation and domestic purposes. The aim of this study, therefore, is to assess the open wells in LAUTECH for their potential use for irrigation and domestic purposes.

## **2. METHODOLOGY**

### **2.1 Study Area**

The area of this study lies approximately within longitude 3°E and 5°E, and latitude of 7°N to 8°N. It lies in the humid-tropical zone climate, having two seasons which are wet season and dry season. The annual rainfall is between 1200 mm – 1300 mm. Average annual temperature is 32°C and relative humidity is 70% (Dorling, 1997).

### **2.2 Ground Water (wells) Sampling Methods**

Three wells in LAUTECH are identified as targets for experimentation, located at the following places:

- i. Agricultural Engineering Research Field (Well 1)
- ii. LAUTECH Nursery/Primary School (Well 2).
- iii. Department of Pure and Applied Mathematics (Well 3)

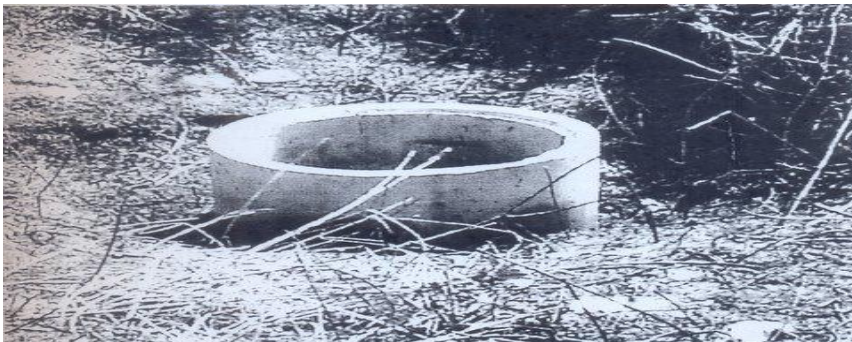


Figure 1: Agricultural Engineering Research Field (Well 1).

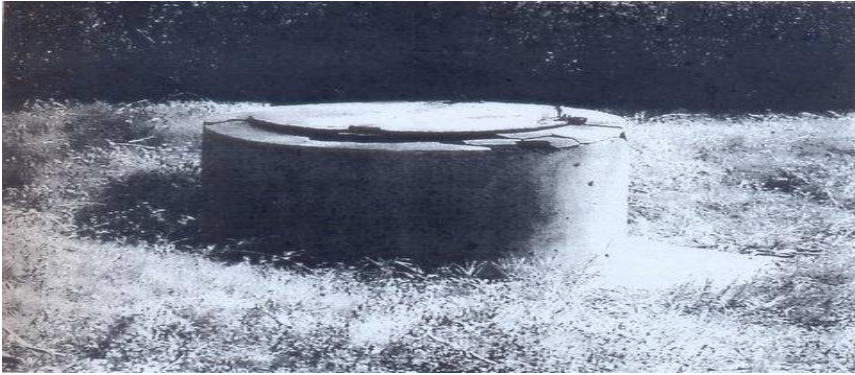


Figure 2: LAUTECH Nursery/Primary School (Well 2).

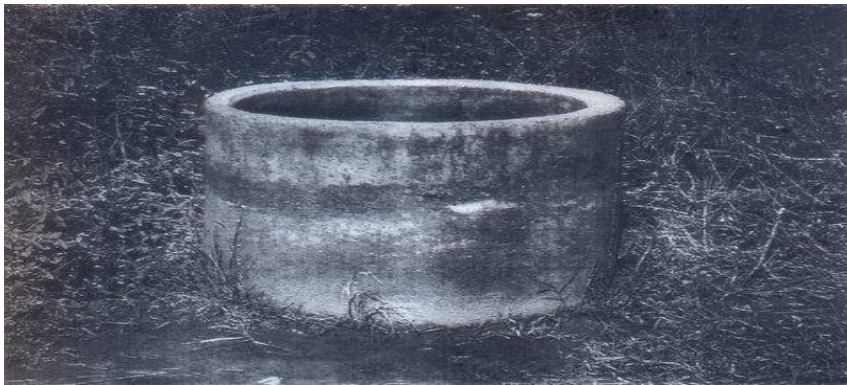


Figure 3: Department of Pure and Applied Mathematics (Well 3).

**2.3 Analytical methods**

**2.3.1 Sampling requirements**

- Effective depth ‘h’ of the wells in meter was measured using a meter rule.
- Depth of the well ‘H’ was measured using a meter rule, attached to a long bamboo stick.
- Diameter ‘D’ of the well was measured using a meter rule.
- Volume of the water was calculated using equation:

$$Volume = Area (A) * depth = \frac{\pi D^2}{4} \times (H - h) \dots\dots\dots (i)$$

The wells are of the same diameter which means that they are of the same area.

$$Diameter = 1m. Area = \pi(1)/4 = 0.79m^2$$

For well 1,  $H = 5m, h = 4m$

$$Volume = 0.79 \times (5 - 4) = 0.79m^3$$

For well 2,  $H = 11m, h = 6m$

$$Volume = 0.79 \times (11 - 6) = 3.95m^3$$

For well 3,  $H = 10m, h = 6m$

$$Volume = 0.79 \times (10 - 5) = 3.16m^3$$

- Water temperature was monitored thrice daily using standard thermometer.
- Water samples were collected from the three wells for physicochemical, biological and microbiological properties.
- Two liters of water from each well was used as sample specimen with analyses conducted within 24 hours of sampling. Clean plastic bottles rinsed with distilled water were used.
- Three soil samples each from the target wells were taken using a soil auger from a depth of about 0 – 30cm and each samples was placed in a black cellophane paper labeled S<sub>1</sub>, S<sub>2</sub> and S<sub>3</sub> respectively. These were taken to the laboratory for analysis.

### 2.3.2 Irrigation – water analysis

The various sample analyses were conducted at three different laboratories.

- (i) EL-ALPHA MEGA SERVICES, Ibadan carried out the pH, Total Alkalinity, Carbonate ( $CO_3^-$ ), Hydrocarbonate ( $HCO_3^-$ ), Nitrate ( $NO_3^-$ ), Sulphate ( $SO_4^{2-}$ ) and Phosphate for the water samples.
- (ii) Rotas Soilab Limited, Ibadan carried out the Sodium ( $Na^+$ ), Phosphate ( $P$ ), Potassium ( $K^+$ ), Nitrate, Calcium ( $Ca^{2+}$ ), Magnesium ( $Mg^{2+}$ ), and Sulphate ( $SO_4^{2-}$ ).
- (iii) Other pollution parameters were determined at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria.

Table 1: Classification of surface water quality based on the BOD\* value

Degree of pollution	BODS (mg/l)
Very clean	<1.0
Clean	1.1 – 1.9
Moderately polluted	2.0 – 2.9
Polluted	3.0 – 3.9
Very polluted	4.0 – 10.0
Extremely polluted	>100

\* Biological Oxygen Demand

**pH**

The pH of both soils and water samples were determined following the method of (Miroslav, 1999).

**Total alkalinity**

The total alkalinity, which is the amount of strong acid needed to neutralize the alkalinity of the water samples, was measured by titrimetric method using 0.02M HCl with methyl orange indicator (Miroslav, 1999).

**Carbonates and bicarbonates**

Samples were also analyzed for both carbonates and bicarbonates using the method of titrimetry (Miroslav, 1999).

**Nitrate**

The quantity of nitrate present was analyzed using Phenoldisulphonic acid colorimetric method (Miroslav, 1999).

**Sulphate**

The sulphate was analyzed using Barium Gelatin turbidimetric colorimetric method. Total phosphorus present was analyzed using vanadomolybdate colorimetric method (Miroslav, 1999).

**Total Solids**

The Total Solids present in the samples were analyzed using gravimetric method by evaporation and weighing (Miroslav, 1999).

**Total Dissolved Solids**

The Total Dissolved Solids was analyzed using gravimetric method by filtration, evaporation, and weighing (Miroslav, 1999).

**Electrical Conductivity**

Conductivity meter was used for the analysis (Miroslav, 1999).

**Dissolved Oxygen**

Dissolved Oxygen was analyzed by modified Winkler's method using alkaline-iodide azide reagent (Miroslav, 1999).

**BOD (Biological Oxygen Demand)**

The Biological Oxygen Demand was determined using the method described in ALPHA (1985). This method involved measuring the DO of each water sample initially and then incubate diluted water sample for period of five days at temperature of 20°C. The BOD is the difference between the initial dissolved oxygen and the final dissolved oxygen (Miroslav, 1999).

By calculation,

$BOD (mg/l) = (DO_o - DO_d) \times \text{volume of BOD bottle} / \text{volume of sample used.}$

where  $DO_o$  = dissolved oxygen in the sample on initial day.

$DO_d$  = dissolved oxygen in the diluted sample after titration on 5th day.

### **Chlorophyll**

Chlorophyll was analyzed using colorimetric method (Miroslav, 1999).

### **Calcium and Magnesium**

They were analyzed from the samples using Atomic Absorption Spectrophotometry, (Miroslav, 1999).

### **Potassium and Sodium**

The analysis of potassium and sodium were done using flame photometry by flame photometer (Miroslav, 1999).

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

For well 1,  $Na^+ = 10.53mg/l$

$$\text{Milliequivalent} = \frac{10.53}{23} = 0.46 \text{ eq./l}$$

$$Ca^{2+} = 14.0mg/l$$

$$\text{Milliequivalent} = \frac{14.0}{40} = 0.35 \text{ eq./l}$$

$$Mg^{2+} = 4.5mg/l$$

$$\text{Milliequivalent} = \frac{4.5}{24} = 0.19 \text{ eq./l}$$

$$SAR = \frac{0.4}{\sqrt{(0.35 + 0.19)/2}} = 0.89$$

For well 2,  $Na^+ = 16.20mg/l$

$$\text{Milliequivalent} = \frac{16.20}{23} = 0.70 \text{ eq./l}$$

$$Ca^{2+} = 17.75mg/l$$

$$\text{Milliequivalent} = \frac{17.75}{40} = 0.44 \text{ eq./l}$$

$$Mg^{2+} = 5.5mg/l$$

$$\text{Milliequivalent} = \frac{5.5}{24} = 0.23 \text{ eq./l}$$

$$\text{SAR} = \frac{0.70}{\sqrt{(0.44 + 0.23)/2}} = 1.21$$

For well 3,  $\text{Na}^+ = 19.44 \text{ mg/l}$

$$\text{Milliequivalent} = \frac{19.44}{23} = 0.85 \text{ eq./l}$$

$$\text{Ca}^+ = 12.0 \text{ mg/l}$$

$$\text{Milliequivalent} = \frac{12.0}{40} = 0.30 \text{ eq./l}$$

$$\text{Mg}^+ = 5.73 \text{ mg/l}$$

$$\text{Milliequivalent} = \frac{5.73}{24} = 0.24 \text{ eq./l}$$

$$\text{SAR} = \frac{0.85}{\sqrt{(0.30 + 0.24)/2}} = 1.64$$

The three samples were below 10 in SAR value, which means that they can be used for all crops except those which are slightly sensitive to sodium. Sodium salts are generally present in irrigation waters but if in a high proportion, they may be absorbed on the soil particles resulting in impeding the movement of water and air when the soil is wet and formation of hard clods when the soil is dry (Sharma et al., 1992).

ESP (Exchangeable Sodium Percentage)

$$= \frac{100(0.01475 \text{ SAR} - 0.0126)}{1 + (0.01475 \text{ SAR} - 0.0126)}$$

ESP for well 1

$$= \frac{100(0.01475 \times 0.89 - 0.0126)}{1 + (0.01475 \times 0.89 - 0.0126)} = 0.053$$

ESP for well 2

$$= \frac{100(0.01475 \times 1.21 - 0.0126)}{1 + (0.01475 \times 1.21 - 0.0126)} = 0.522$$

ESP for well 3

$$= \frac{100(0.01475 \times 1.64 - 0.0126)}{1 + (0.01475 \times 1.64 - 0.0126)} = 1.146$$



### **Soil samples**

The soil samples were digested using concentrated nitric acid for total determination of phosphate, potassium, sodium, calcium, magnesium and sulphate in the samples and read on Atomic Absorption Spectrophotometer for calcium and magnesium while potassium and sodium were determined by flame photometer while phosphate and sulphate were determined by colorimetric method (Sharma et al., 1992). Meanwhile generated data were analyzed, interpreted and recommended accordingly.

## **3. RESULTS AND DISCUSSION**

### **3.1 Well Temperature**

The average temperature of well 1 at 10.00am was 26.4°C, at 2.00pm was 27.2 °C and at 4.00pm was 28.6 °C. The average temperature for well 2 at 10.00am was 26.5°C, at 2.00pm was 26.8 °C and at 4.00pm was 28.4 °C. The average temperature for well 3 at 10.00am was 26.6°C, at 2.00pm was 27.1 °C and at 4.00pm was 28.4 °C. These temperatures were found to be within the range of ambient air temperature which is optimum for the survival of aquatic lives (Fiocco et al., 1991). Temperature is very vital to these ecosystems (wells) because it governs to a large extent the biological species present and their rate of activities.

### **3.2 pH values**

The pH of the water samples was found to be 6.9 for well 1, and 7.3 for well 2, and 6.7 for well 3. The pH values for the well 1 and well 3 fell in the threshold range (0 – 7) while well 2 fell in the alkalinity range (7 – 14). Studies have shown that pH has profound effect on water quality. It affects metal solubility, alkalinity, hardness of water and microbial degradation activities. These make aquatic animals' life sensitive to pH variation, because most of their metabolic activities are pH dependent (Haines, 1981). Biodegradation of organic matter releases nutrient elements that are essential to the growth and reproduction of aquatic plants and animals which depend on surrounding water to provide these nutrients.

### **3.3 Total Alkalinity**

The total alkalinity for the three water samples was 160 for well 1, 208 for well 2 and 216 for well 3. However, in large quantities, alkalinity impacts a bitter taste to water and reactions with various cations.

Resultant can foul pipes and other water system accessories. For drinking water, WHO set 200 mg/l for total alkalinity which means that the well 2 and 3 have to be treated before use.

### **3.4 Dissolved Oxygen (DO)**

Dissolved oxygen values for the water samples were 5.0 mg/l for well 1, 4.5 mg/l for well 2, and 5.0 mg/l for well 3. According to Miroslav (1999), most countries do not set DO for drinking water with the exception of Russia that has a Maximum Allowable Concentration (MAC) of 4.0 mg/l for drinking, fisheries and aquatic lives. The following DO standard in mg/l has been adopted, EU (5.0 – 9.0), Canada (5.0 – 9.5), and Russia (4.0 – 6.0) corresponding values of DO measure from the samples are high. However, the presence of DO in water or waste is desirable because it prevents the formation of noxious odours. Very high values of DO are to be avoided in domestic and water supplies to minimize corrosion of iron and steel pipes in the distribution system.

### **3.5 Biological Oxygen Demand (BOD)**

The BOD for wells 1, 2, and 3 were 9, 6 and 5.8 mg/l. On the basis of BOD values, the degrees of pollution may be estimated (Table 1). All the BOD values recorded from the wells were within extremely polluted well. Maximum allowable BOD of 2.9 mg/l was adjudged optimum for most water standard of 3 – 6 mg/l and Russia has 3 mg/l.

### **3.6 Anionic concentrations**

The anionic concentrations from literature (in mg/l) are 5 for nitrate ( $\text{NO}_3^-$ ), 0.192 for sulphate ( $\text{SO}_4^{2-}$ ), 4 for chloride ( $\text{Cl}^-$ ), 3 for carbonate ( $\text{CO}_3^{2-}$ ), and hydrocarbon ( $\text{HCO}_3^-$ ) are considered safe. The mean values for all the samples fell within the safe limit (for nitrate, well 1 has 0.07 mg/l, well 2 has 0.11 mg/l, well 2 has 0.03 mg/l; for sulphate, well 1 has 7.11 mg/l, well 2 has 7.73 mg/l, well 3 has 2.24mg/l; while it was 0.0 mg/l of carbonate in all the three wells). But for drinking purpose, the standard set by WHO for nitrate is 40 mg/l, sulphate 200 mg/l.

### **3.7 Cationic concentrations**

Respective values for sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ), calcium ( $\text{Ca}^{2+}$ ), and magnesium ( $\text{Mg}^{2+}$ ) in mg/l were 10.53, 3.90, 14.0 and 4.50 for Calcium and magnesium as predominant cations. The ratio of  $\text{Ca}^{2+}$ ;  $\text{Mg}^{2+}$  is greater than 1, which means that all the samples indicated a calcium dominated water. It also means that the potential effect of sodium may

not be slightly increased unlike magnesium dominated water (Ayers and Westcot, 1985). Research findings show that at a given SAR of the applied water, a higher soil ESP (Exchange Sodium Percentage) than normal will result when using water with a Ca:Mg ratio less than 1 (Jamie and Richard, 1996), but the three samples will not show any high ESP than normal, since Ca:Mg ratio is greater than 1.

EC and TDS did not show wide variation. However, the salinity levels were generally low (ECw 400, 380 and 405 in  $\mu\text{Scm}^{-1}$  and TDS 200, 110 and 150 mg/l for the three wells respectively. Although, EC (of 0-1000 $\mu\text{Scm}^{-1}$ ) is the optimum for irrigation and domestic use. Thus some water bodies are considered unsuitable for irrigation and domestic use. Low - salinity water leaches surface soil free of soluble minerals and salts, thus reducing their stabilizing influence on soil aggregates and soil structure. Low salinity water of 200 $\mu\text{Scm}^{-1}$  results in water infiltration problems (Ayers and Westcot, 1994).

#### **4. CONCLUSION**

Generally, analysis of the groundwater (well) samples showed that they were slightly acidic, except the samples from LAUTECH Nursery and Primary School (pH of 7.3) which slightly deviate from the normal, and appear not to have salinity and sodicity hazards (EC 400, 380 and 405 $\mu\text{Scm}^{-1}$ ; and SAR 4.90, 6.72 and 9.21 for the three samples). The Ca:Mg ratio was generally greater than 1 and continued use of such water for irrigation would not lead to nutrient imbalances in the soils. This may also be the cause of the rather low ESP (Exchangeable Sodium Percentage) levels of the soils. In case of high ESP, applications of organic matter and gypsum and deep tillage may ameliorate the effects of high soil ESP. Furthermore, the waters sampled showed rather low nitrate contents. Such water can be used for domestic use if treated to meet the WHO water guidelines for drinking quality. However, for irrigation purpose, nitrogen fertilizer has to be used by the farmers for proper farm management. Repeated sampling of water from the three wells should be carried out every season, because there are always fluctuations in the mineral constituents of groundwater during the rainy season. The wells should be properly managed and maintained. The wells should always be covered, so that they do not get contaminated and precipitation does not fall directly in the wells by acidic rain, since

they are needed for domestic use. When the wells are needed for large scale farming, alternative sources of water are necessary, because their water can easily dry up, especially during the dry season.

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