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# Bacterio-Chemical Assessment of Hand-Dug Wells in New Haven, Enugu State Nigeria

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**Abstract**

The focus of the study was a bacterio-chemical analysis of hand-dug wells in New Haven, Enugu State Nigeria. Three wells, W1, W2, and W3 were randomly selected for the study. The method adopted for the selection of the wells was a simple random sampling. A total of 180 water samples from the wells were analyzed for metals and enteric bacteria. The enteric bacteria were identified using Gram reaction, lactose fermentation, indole, and catalase, oxidase, Voges-Proskauer procedures. The metal concentrations were determined by using atomic absorption spectrophotometer. The result of the study showed that the average concentrations of iron, zinc, calcium, magnesium, and lead were within the permitted limits stipulated by WHO and The Federal Republic of Nigeria. Bacteria identified were *Escherichia coli* (*E. coli*) and *Salmonella*. It was concluded that water from the wells in New Haven, Enugu State Nigeria should be treated before they can be used for drinking and other domestic uses.

***Keywords:*** Assessment; bacterio-chemical; *Escherichia coli*; *Salmonella*; hand-dug well.

## 1. Introduction

Drinking water includes all water in its original state or after treatment, intended for drinking, cooking, food preservation or other domestic purposes, regardless of its origin and whether it is supplied from a drinking water system, or a tanker, or taken from a private well [1].

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Safe drinking water is very essential to maintain a healthy living. In most cities in developing countries of the world, such as Nigeria, valuable time was spent on seeking and fetching water, often of doubtful quality. Water is sourced from either springs, wells, streams, rivers, lakes or reservoirs. In most Nigerian communities, such as New Haven, the problem of acute water shortage resulted in a rapid increase of hand-dug wells from were households fetch water for drinking, cooking, and washing. A well is a term used to describe a man-made excavation that was constructed to drain water from the groundwater [2]. In most rural, as well as urban communities in Nigeria, wells are usually dug by hand, using shovels, hoes, and diggers, and other implements, and they are relatively shallow. These hand-dug wells tap water from groundwater, and most households in Nigeria depend on this untreated groundwater for their supplies. The groundwater system, from which well-water is drawn, is composed of both chemical and biological substances. Naturally, the chemical composition of groundwater relies on certain factors such as the chemical and physical properties of the soil and rock, and biological processes [3]. As rain falls, it penetrates and pass through the soil and rock and dissolves the soil and rock materials, and minerals are added to the groundwater flowing through them [3]. However, the chemical composition of groundwater varies from place to place; it depends on the type of rock formation locally present. Trace metals are usually linked to igneous and metamorphic rocks [3]. Chemicals naturally found in groundwater include calcium, magnesium, sodium, bicarbonate, silica, iron, manganese, and lead among others [1,3]. High concentrations of trace metals in groundwater may render water unfit for drinking and other domestic uses.

Few naturally-occurring micro-organisms are found in groundwater, usually the chemolithotrophic bacteria [3]. Most micro-organisms grow and coat the solid surfaces of the particles of soil or aquifer; they attach themselves to the particles of soil or aquifers, forming a protective biofilm which can be difficult to remove, even though transport in the flowing groundwater is possible [4]. Micro-organisms use dissolved materials and suspended solids in the water and solid matter in the aquifer in their metabolism and then release the metabolites back into water [4]. Micro-organisms usually cause water-borne diseases. Nevertheless, chemicals and micro-organisms may be introduced into groundwater by human activities such as agriculture, mining, industries, and by the introduction of human and animal wastes. In general terms, the physical, chemical, and biological characteristics (quality) of groundwater, and as such, well-water is important to public health. A great risk is taken when water containing pathogenic micro-organisms and elevated concentrations of chemicals is consumed. However, there is no evidence available to the researchers that a study like the current one has been carried in New haven, hence the need to carry out the study.

## 2. Materials and Methods

### *2.1 Study area*

New Haven is located in the rainforest region of South East Nigeria. The topography is gently undulating sandy plains. Dwellings are compacted together. Dwellers are mainly Civil Servants and traders that buy and sell goods. However, due to lack of physical planning wastes are not properly disposed of; refuse and human wastes are dumped indiscriminately along the roads, streets, in open places and inside drainage systems.

### *2.2 Sample and sampling techniques*

Wells, W1, W2, and W3 in three streets were randomly selected for the study. Simple random sampling was used to select the streets, as well as the wells. A total of one hundred and eighty (180) water samples were collected from the wells for analysis to determine the metals of interest and analysis for enteric bacteria.

### *2.3 Collection of samples*

A hard plastic and 1000ml volumetric flasks were used to collect water samples from the wells. The hard plastic and volumetric flasks were thoroughly washed with clean water and soap and afterwards sterilized by autoclaving at a temperature of $121^0$C for 15minutes to eliminate chemical and microbial contaminants. The hard plastic was used to collect water samples from wells W1, W2 and W3, and aseptically transferred into the volumetric flasks until they were filled up. Thirty (30) water samples were collected from each of the wells and acidified with trioxonitrate (V) acid. Another set of thirty (30) samples were taken from the wells, and acid was not added. Samples were then transported to the laboratory in an ice-filled jar for analysis and stored in the refrigerator at $4^o$C to prevent any chemical or biological changes. The water samples were collected at different times until the final set was collected. The water samples were collected during the rainy season, between April and August 2017.

### *2.4 Analysis of water samples*

The water samples from the wells were analyzed at the laboratory to determine their bacteriological and chemical characteristics. The chemical components of the samples considered were the metals: magnesium (Mg), iron (Fe), zinc (Zn), lead (Pb), and calcium (Ca). The bacteriological characteristics of the water samples determined were the presence of enteric bacteria that are important in drinking water.

#### *2.4.1 Determination of enteric bacterial species in the well-water samples*

A diluent comprising of Mac-Conkey broth and distilled water was prepared and put in different test tubes. The diluent was autoclaved at $121^0$C for 15 minutes. After autoclaving, one millilitre of each of the water samples was added to the diluents contained in different test tubes. Aseptically, 0.1ml of each was taken and plated in nutrient agar plates. The nutrient agar plates were incubated at $37^0$C for 24hours. After incubation bacterial colonies were identified by their characteristics in catalase test, oxidase test, Gram staining, lactose fermentation test, Voges-Proskauer test, and indole test [5]

#### *2.4.2 Determination of metallic components in the well-water samples*

The water samples from the wells were not muddy; therefore, they were not digested before analysis. According to [8], aqueous samples can be generally introduced for analysis without mineral acid digestion. An atomic absorption spectrometer was used to determine the concentrations of zinc, calcium, lead, magnesium, and iron in the water samples. According to [9], atomic absorption spectrometry is a technique for determining the quantity of chemical elements in samples by measuring the absorbed radiation of the chemical element of interest. It is a technique suitable for the determination of metals in samples [10].

## 3. Results

**Table 1:** Enteric bacteria identified in wells

| **Well** | **Gram Reaction** | **Lactose** | **Indole** | **Catalase** | **Oxidase** | **Voges-Proskauer** | **Bacteria** |
|---|---|---|---|---|---|---|---|
| W1 | Gram -, rods | + | + | + | - | - | *E. coli* |
| W2 | Gram -, rods | - | - | - | - | - | *Salmonella* |
| W3 | Gram –, rods | - | - | - | - | - | *Salmonella* |

In Table 1 the enteric bacterial species identified in wells W1, W2, and W3 were shown. The bacterial species in W1 tested negative to Gram reaction, catalase reaction, oxidase test and Voges-Proskauer tests. The organism was identified as *Escherichia coli (E. coli)*. The colonies from W2 and W3 exhibited negative reactions to Gram staining, lactose fermentation, indole test, catalase test, oxidase test, and Voges-Proskauer test. The organism was identified as *Salmonella*.

**Table 2:** Average concentrations of metallic components in wells (*mg/l*)

| **Metal** | **W1** | **W2** | **W3** |
|---|---|---|---|
| Iron (Fe) | 0.9 | 0.05 | - |
| Zinc (Zn) | - | - | 0.07 |
| Lead (Pb) | 0.01 | - | - |
| Calcium (Ca) | 0.21 | 0.03 | 0.79 |
| Magnesium | 0.76 | 0.08 | 2.03 |

In Table 2 the average concentration of Iron (Fe) in wells (W1) and 2 (W2) were shown to be 0.09*mg/l* and 0.05*mg/l* respectively, and water from well 3 (W3) recorded absence of iron (Fe). Zinc (Zn) was not found in wells 1 (W1) and 2 (W2), but its concentration in well 3 (W3) was 0.07*mg/l*. The concentration of lead (Pb) in well 1 (W1) was 0.01*mg/l*, but no Lead (Pb) was found in water well 2 (W2) and 3 (W3). The calcium level in wells 1 (W1), 2 (W2), and 3 (W3) were 0.2*mg/l*, 0.03*mg/l* and 0.79*mg/*l respectively. Magnesium was found in wells 1 (W1), 2 (W2), and 3 (W3) with concentrations of 0.7*mg/l*, 0.08*mg/l*, and 2.03*mg/l* respectively.

## 4. Discussion

The average concentration of iron (Fe) in W1 and W2 were 0.09*mg/l* and 0.05*mg/l* respectively, and no iron was identified in W3 (Table 1). The maximum allowable limits of iron in drinking water are 0.3*mg/l* [1]. In well-water, iron concentrations between 0.3*mg/l* are acceptable [11]. However, no guideline value has been defined for iron [12]. The values obtained from the study were within the acceptable limits in well-water and drinking-water respectively. However, iron does not impose any health hazard [1]. According to WHO [12], at levels 0.3mg/l iron stains laundry, and it imparts no taste to water at concentrations below 0.3mg/l, although turbidity and colour may develop.

No Zinc (Zn) was found in W1 and W2, but its level in W3 was 0.07*mg/l* (Table 1). Just like iron, no guideline value has been defined for Zinc [11]. The maximum permitted concentration of zinc in drinking-water is 3*mg/l* [1], and level of zinc above 3*mg/l* in drinking water may not be acceptable to consumers [13]. However, the concentration of zinc in groundwater do not exceed 0.05*mg/l* [13]. There is no health hazard associated with zinc [1]. However, at levels of about 4mg/l, and in excess of 3-5*mg/l* may impart an undesirable taste to water and may appear opalescent and develop greasy film on boiling respectively [11].

As shown in Table 1 Lead (Pb) level in W1 is 0.01*mg/l*, and no lead was detected in W2 and W3 respectively. The guideline value of lead in drinking water is 0.01*mg/l* [11]. The maximum permitted limit of lead in drinking-water is 0.01*mg/l* [1]. Lead occurs in drinking-water, generally, below 0.05*mg/l* [11]. The concentration of lead (Pb) in the W1 (0.1*mg/l*) is equal to the maximum permitted limit stipulated by [13] [1], and lower than the concentration in drinking water. Lead occurs in drinking water generally below 0.05*mg/l* [11]. Lead is an important toxicant that can exert adverse effects in humans, such as cancer, vitamin D interference, and mental imbalances [10].

As shown in Table 1 calcium (Ca) was obtained in W1, W2 and W3, with concentrations of 0.21*mg/l*, 0.03*mg/l* and 0.79*mg/l* respectively. There is no guideline value defined for calcium [11], but its maximum permitted limit in drinking-water is 150*mg/l* [1], while according to [11], its highest desirable level and highest permissible level are 79*mg/l* and 200*mg/l* respectively. The concentrations of calcium in W1, W2 and W3 are lower than the maximum permitted limit by [1], and that stipulated by [11]. However, calcium causes hardness of water, thereby reducing its domestic and industrial uses. Depending on pH level, calcium level above about 200*mg/l* can result in deposition of scales on heating [11].

The concentrations of Magnesium (Mg) in W1, W2 and W3 were 0.76*mg/l*, 0.08mg/l, and 2.03*mg/l* respectively (Table 1). There is no guideline level stipulated for magnesium in drinking water [11]. However, the maximum allowable level of magnesium in drinking-water is 0.20*mg/l* [1]. The concentration levels of magnesium in W1, W2 and W3 are within the maximum allowable limits stipulated by [1]. Magnesium causes hardness of water, thus limiting is domestic and industrial uses.

Table 1 showed that W1, W2 and W3 were contaminated with enteric bacterial species, *Eschericia coli* (*E. coli*) and *Salmonella*. The maximum permitted level of *E. coli* in drinking-water is 0cfu/100*ml* [1,13]. In other words, *E. coli* should be absent in drinking water. *E. coli* has a moderate persistence in water [13], and its presence in W1, W2, and W3 indicated a recent contamination with human or animal faeces or both. *E. coli* is a normal flora of the intestines of human and warm-blooded animals, where it does not cause any harm, but in other parts of the body, the organism causes serious disease conditions such as urinary tract infections, bacteraemia and meningitis [13,14,15,16]. On the other hand, *Salmonella* infection leads to salmonellosis, typically characterized by bacteraemia, septicaemia, and typhoid fever among other symptoms [13,10,17]. Salmonella accounts for93.8million food-borne illnesses and 155,000 deaths per year [16]. However, the standard for faecal organisms (including *Salmonella*) in drinking water is zero [1,10].

## 5. Conclusion

The results of the study imply that water from wells in New Haven, Enugu State Nigeria are of good quality in terms of lead, calcium, magnesium, iron, and zinc levels. However, the presence of *E. coli* and *Salmonella* posse health dangers, inferring that water from wells in New Haven require treatment before they can used for drinking or cooking, or for any other purposes.

## 6. Recommendations

Following the observations from the study, the researchers recommend as follows:

- Water from the wells in New Haven, Enugu State Nigeria should be boiled and chlorinated for domestic use. Boiling and chlorination ensure that bacterial contaminants are eliminated.
- The authorities concerned should provide adequate pipe-borne water supply for New Haven residents to prevent the possibility of epidemics of water-borne infections.

## 7. Limitation of the Study

- Some households in New Haven did not give the researchers access to their wells for investigation. This limited the number of wells and water samples investigated in the study.

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