DISCOVERY

Evaluation techniques for the treatment of well water for drinking purposes: A case study of Elieta community well water

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ABSTRACT

This research work was conducted to demonstrate the suitable techniques applicable for treatment of well water for safe drinking and healthy living for the inhabitants of that environment. In this research work comparison of stream water and well water was examined, the effect of contaminants also examined. The research also evaluates the contaminants of well water in Elieta Community, Ogba/Egbema/Ndoni Local Government area of Rivers Sate, Nigeria. An experimental analysis was conducted for the samples collected and some parameters were separated and tested. After the test it was observed that the well water has an objectionable taste, which could be as a result of total suspended solid. However, treatment methods were recommended to neutralize contaminants and make water healthy for drinking again.

Keywords: Water purity, treatment, environmental, hazard, cleanup, well water, suspended solid

1. INTRODUCTION

Water is a precious resource in Nigeria. It is not just the most common substance known but it is made use of by plants and animals daily. Water is therefore an indispensable commodity to both plants and animals. Hence this essential commodity must be protected from contamination to always give its desired quality. Water is a key factor in the socio-economic development of any nation. Water is essential for better quality of life but the quality of water available and taken is becoming an increasing problem in many parts of the world (Bailey et al., 1978). Even though the water is available, the question that comes to bear in mind is of what quality it is. In Nigeria, the water situation is fast becoming critical. Presently, only about 53 percent of the Nigerian population has access to safe water. Therefore, water borne diseases such typhoid, diarrhea and malaria are rife. Studies conducted by the Federal Office of Statistics and United Nations Children and Education Fund show that at 1999, only 54 percent of households in Nigeria obtain water from "safe" sources. With the trend of events, one doubts whether the number not have reduced for urban centers (Belan, 1981). The question that readily comes to mind on the water supply debacle also relates to the operations of the various state water Boards or corporations. Their services are to say the least, epileptic. Individuals therefore resort to creating borehole waters and hand dug water wells (Camp and Meserve, 1974).

Many communities obtain their drinking water from shallow, unlined and uncovered hand-dug wells or open springs. Villagers draw up water by dropping a bucket down into the well on a rope, contaminating the water with everything the bucket has touched. It is common for dirt debris and small animals to fall into these uncovered wells and open strings. In addition to the problem of contamination, many wells and springs dry up in the summer, placing a huge burden on the Women and children who carry water over long distances.

To solve some of these problems, this work looks at well waters, to analyze the well water and treat them to save rural communities dealers suffering from water borne diseases. It also deals with planning conditions and maintenance of hand dug wells for water supply to communities in the rural areas. To do this water samples will be collected from selected well water and analysis will be conducted and possible determine a treatment method for such well water collected. The purpose of this research is to analyze a selected hand dug well and compare the results with that of the Federal Environmental Agency FEPA guidelines for quality drinking water (The Caxton Encyclopedia, 1979). Also, from the results of the analysis obtained, determine treatment methods for such a well.

2. EXPERIMENTAL METHODS AND RESULTS

This experiment was carried out in the laboratory of the department of chemical / Petro chemical Engineering, Nkpoiu, port Harcourt.

Materials

The materials used in this experiment include

1. Buffer powder
2. Electrodes -
3. Potassium Dichromate (Reagent)
4. Silver Nitrate (Reagent)
5. Hydrogen Peroxide solution (Reagent)
6. Hydrochloric acid (Reagent)
7. Ethylene Diamine Tetracidic (EDTA) (Reagent)
8. Salicyclic acid (Reagent)
9. Barium Chloride (Reagent)
10. Erichrom Black T. Indicator
11. Ammonia

Equipments used

The equipment comprises of the following

1. Retort Stand
2. Pipette Burrette
3. Measuring cylinder
4. Beaker
5. Heating Oven
6. Filter Paper
7. Analytical balance

Collection

A sample of water was collected from a hand dug water well. The well is situated in Elieta Community of Ogba/Egbema/Ndoni L.G.A. of Rivers State. This well was dug by Masons in 1979. The well serves a community of about 100,000 people. The depth of the well is estimated to be about 15 feet in dept.

Procedures

The sample of water was collected and analyzed for its quality. A simple analysis tool was used called the titration method. The following qualities were tested to see if the water sample collected and analyzed meets FEPA's guide line for safe drinking water, total dissolved solids (TDS), total suspended solid (TSS), total hardness (TH), Iron (Fe), Ph, Chloride (Cl), Salinity, Sulphate ($S0_4$). These items were analyzed, used their appropriate materials and equipment.

Determination of p^H

The PH meter was standardized using 4, 7, 9, buffer powder. Then 200 ml of the sample was poured into a beaker and the electrode was dipped into the beaker. The sample with electrode inside was allowed to stabilize for about 10 minutes and the pH was read.

Determination of chloride (Cl)

50 ml of sample was poured into a beaker and 0.5 ml of potassium dichromate (10%) was then added into the sample. The sample was then titrated with Silver Nitrate solution (0.11) until the reddish pink colour was observed. The content of Chlorine in the sample was calculated as expressed as;

$$\text{Chloride mg/l} = \frac{0.1 \text{ titer x } 35, 50}{\text{Ml of sample}} \quad (1)$$

Determination of iron (Fe)

50 ml of sample was poured into beaker and four drops of concentrated HCL was also added, heat to boiling point and allowed to cool. Take 50 mil of the cooled sample and add 0.5 ml of salicycle acid solution (0.5N) and 0.5 ml of hydrogen peroxide solution. Then titrate with EDTA solution (O.I.N) until light red colour was observed. The content of non in the sample is expressed as:

$$\text{Non (ms/L)} = \frac{\text{(M x ML) EDTA x 55.800}}{\text{ML of sample}} \quad (2)$$

Where,

M = Molouity of EDTA.

ML= Titre of EDTA.

Determination of sulphate (SO+)

100ml of sample was poured into the bicker few drops of Methyl red indicator was added. Also 50% hydrochloric acid was added until a faint red colour appears. Then add 2ml in excess. Boil this solution, when boiling add 5ml of barium chloride (0.5N) hip. Keep off hot beaker and stand for one hour. Filter using a filter paper whose light is noted, and wash with hot water. Dry filter papers for one hour in oven at 180 C for one hour and then cool and weigh (Washed Alayande, 1988).

The sulphate content of the sample was called as

$$\text{Sulphate (Ms/L)} = \frac{\text{Initial - final x 4T5 L}}{\text{ML sample}} \quad (3)$$

Determination of total hardness (TH)

50ml of sample was poured into the beaker and 'ml of ammonia buffer solution (0.5 N) and two to three drops of Erichrom Black T indicator was added. The mixture was titrated with 0.1M EDTA to the end part colour, blue. The total hardness of the sample is thus expressed as:

$$\text{Total hardness (mg/L)} = \frac{\text{0.01 x titrate x 40.1 x}}{\text{ML of sample}} \quad (4)$$

Determination of total dissolved solids (TDS)

Wash, dry and weigh a 250ml beaker. Add 100ml of sample to the beaker and dry heat the beaker to total dryness and allow the beaker to cool for few minutes and reweigh. The total dissolved solids in the sample are thus obtained similarly.

Determination of total separated solid (TSS)

Shake sample very, well and pour 100ml into a beaker. Filter the sample using filter paper. The filter paper should be weighed before use. Dry the filter paper in an oven at 180^{oc} for one hour and weigh. The total suspended solids of the samples were obtained as:

$$\text{TSS (Mg/L)} = \frac{\text{Initial – final}}{\text{Ml of sample}} \quad (5)$$

3. RESULTS

The results of the experiment connected out on the sample are tabulated below in table 1.

Table 1 Results of Hand dug well water analysis.

S/No	Characteristics	Samples
1.	Total dissolved solids (TDS)	850 ppm.
2.	Total suspended solids	900 ppm.
3.	Total hardness	100 ppm
4.	Iron (Fe)	0.02 ppm.
5.	PH	8.30
6.	Chlorides (CL-)	84 ppm
7.	Salinity	550 ppm
8.	Sulphate (S0$_4$)	1.24 ppm.

Analysis of results

New wells are expensive, but they are a good investment for the future. Getting the most from such an investment means locating the well away from contamination source and working to maintain the quality of the well. The analysis of results obtained would recall who safe this well water if for drinking, domestic and other purposes. It is therefore, very important to compare the results obtained so far with that of the Health Organization International Standards for standards for drinking water. Table 2 provides the WHO standards for drinking water (Roche, 2003).

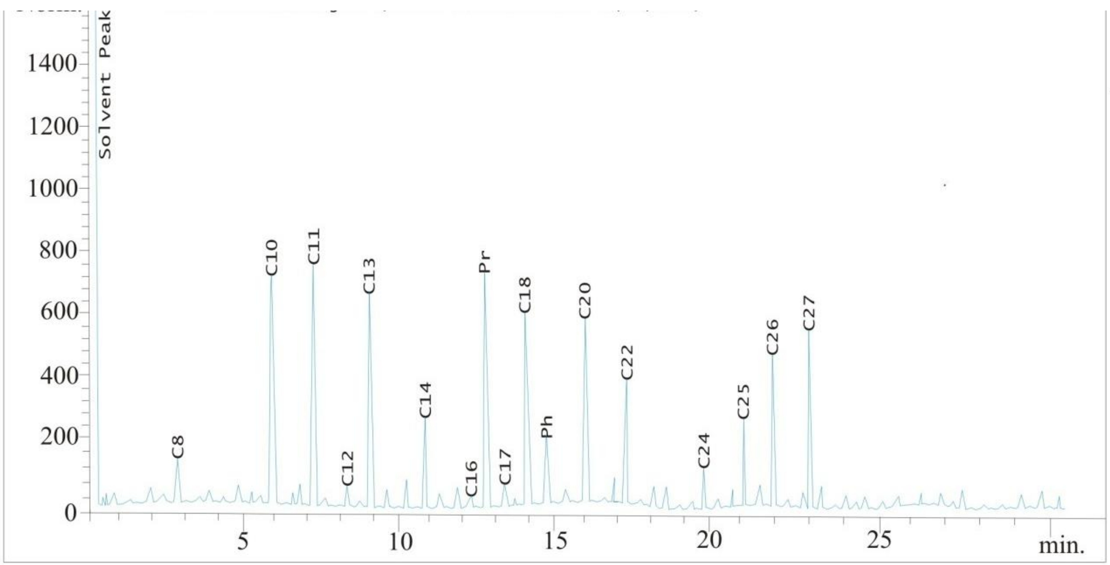

Figure 1 GC Analysis of contaminants Concentration on Stream and Well water against Time (6hr)

Figure 1 shows gas chromatographic analysis results of contaminant concentration on stream and well water in relation to time of investigation. The following compounds were identified as C8 (n-octane), C10 (Decane), C11 (n-undecane), C12 (n-dodecane), C13 (n-tridecane), C14 (n-tetradecane), C16 (n-hexadecane), Pr (priscine), C17 (n-heptadecane), C18 (n-docosane), Ph (Phypane), C20 (n-icosane), C22 (n-docosane), C24 (n-dentacosane), C25 (n-tetracosane), C26 (n-hexacosane) and C27 (n-heptacosane). The degree of concentration in terms of individual hydrocarbon can be written as C11 > C10 > Pr > 13 > C18 > C20 > C27 > C26 > C22 > C25 > C14 > Ph > C24 > C8 > C17 > C12 > C16.

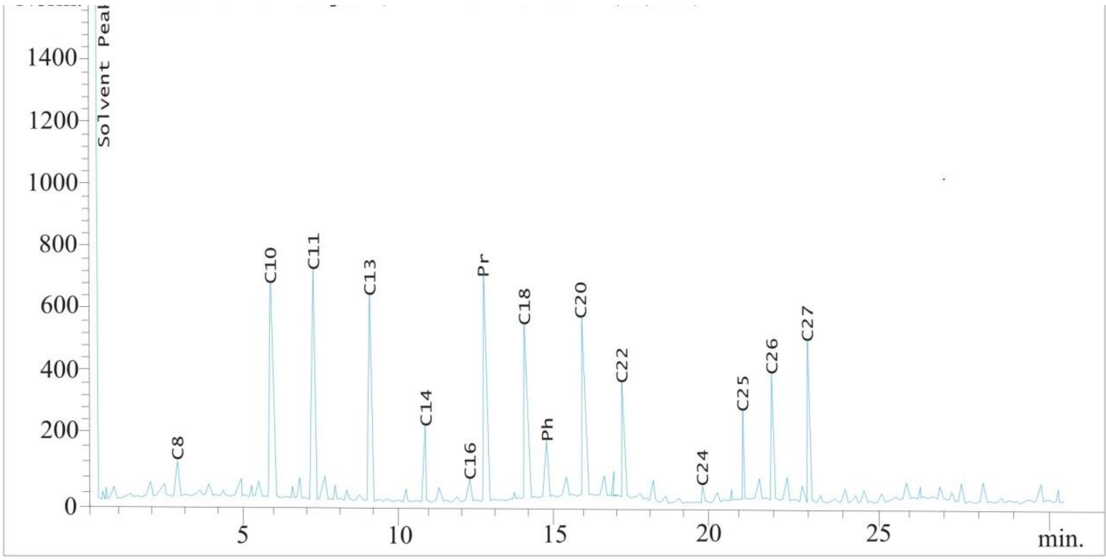

Figure 2 GC Analysis of contaminants Concentration on Stream and Well water against Time (2hr)

Figure 2 shows gas chromatographic analysis results of contaminant concentration on stream and well water in relation to time of investigation. The following compounds were identified as C8 (n-octane), C10 (Decane), C11 (n-undecane), C13 (n-tridecane), C14 (n-tetradecane), C16 (n-hexadecane), Pr (priscine), C17 (n-heptadecane), C18 (n-docosane), Ph (Phypane), C20 (n-icosane), C22 (n-docosane), C24 (n-dentacosane), C25 (n-tetracosane), C26 (n-hexacosane) and C27 (n-heptacosane). The degree of concentration in terms of individual hydrocarbon can be written as C11 > C10 > Pr > 13 > C20 > C18 > C27 > C26 > C22 > C25 > 14 > Ph > C8 > C16 > C24.

Table 2 The world Health Organization International Standards for Drinking water.

Description or substance	Nature of trouble which may arise	Permitted level above which trouble may arise	Excessive
Total solids		500 ppm	150 ppm
Colour		5 Hazen units	50 Hazen units.
Turbidity		5	25
Taste		Unobjectionable	Unobjectionable
Odour		Unobjectionable	Unobjectionable
P^h range		7 - 8.5	Less than 6.5 or more than 9.2
Iron Fe^{++}	Taste discoloration deposit and growth iron bacterial turbidity	0.1 - .3 ppm	1 ppm
Maganese Mn^{++}	Taste discoloration deposit in pipes turbidity	0.1 ppm	0.5 ppm
Magnessum	Hardness, taste	30 - 50 ppm	150 ppm
Copper, Cu^{++}	Astringent taste discoloration and	0.05 - 1 ppm	1.5 ppm
Zn^{++}	Astringent, taste, opalescence and saline deposits	5 ppm	15 ppm
Calcium, Ca^{++}	Hardness	75 ppm	2.00 ppm
Magnesium and Sodium sulphate	Hardness, Taste	500 ppm	1000 ppm
Sulphate	Gastro - intestinal irritation	200 - 350 ppm	400 ppm
Chlorides Cl-	Taste, corrosion in hot water supply	200 - 350 ppm	600 ppm

Nitrates, NO -,	Danger of infantile methyamoglobmin bmi if water is consumed by infants	50 ppm 1	Above 50 ppm
Fluoride F	Fluorosis	1.5 ppm	Above 1.5 ppm
Phenelies, substance as phenols	Taste, particularly in chlorinated water	6.601 ppm	6.662 ppm. *
Ammonia Cas MN4+	Growth of organisms danger of corrosion of pipes, dis - difficulties in chlorination	5 ppm	Above 5 ppm.
Free Carbondioxide as (GQ2)	Danger of bringing toxic metals into solution, danger to pipes.	0 ppm for aggressive Co2	
Dissolved 02	Taste and odour corrosion if less than 5 ppm, growth of organism	5 ppm	Less than 5 ppm
Total hardness	Extensive scale formations and soap consumption danger	100 - 500 ppm	Above 500 ppm
The limit recommended	Dissolving heavy metals if the level of hardness is above	$CaCo_3$.	

Comparing the results obtained from the experiment that WHO Standards, the results are good classify this well water safe for drinking, but some results are above the WHO recommendation such as Total dissolved solids.

1. Total dissolved solids
2. Total suspended solids.
3. Salinity.

Table 3 Compares these results with the WHO standards recommended for safe during later.

S/No	Characteristic	Results	WHO
1.	Total dissolved solids (TDS)	850 ppm	500ppm «
2.	Total suspended solids (TSS)	950	500 ppm
3.	Salinity	650 ppm	Less than 500 ppm.

From the above comparison of the analyzed result averages and the maximum allowed values by World Health Organization. (WHO), it shows that, the total dissolved solids (TDS) and total suspended solids (TSS) and the salinity are on the high side (O' Connor et al., 1967; Morley, 1979). Therefore, as evidence from the experimental results and comparison with WHO standards, the well water should be treated for the drinkable of the well water. This also brings to focus the aims and objectives of the research work, white to analyze this hand dug water well and see if parameters analyzed conforms to WHO and recommend or proffer treatment needed for the well water.

Treatment steps

Table 3 has shown that the hand dug well water should be treated for the following: -

Total dissolved solids (TDS)

Total suspended solids (Tss)

Total dissolve solids (TDS)

Dissolved solids are those solids that are in solution with the water or any solvent in study. Thus, dissolved solids include salts, organism and labile materials, they can be removed from the solution by mere filtration. Filtration can be defined as a physical chemical process for separating suspended and colloidal impurities from water by passage through a bed of granular material water fills the pores of the filter medium, and the impurities are absorbed on the surface of the grains or trapped in the openings.

There are several ways to classify filters. They can be described according to the direction of flow through the bed, that is, down flow, up flow, bi flow, radial flow, horizontal flow, fine to coarse, or coarse to fine. They may be classed according to the type of filter media used, such as sand, coal (or anthracite), coal, sand, multilateral, mixed media, or diatomaceous earth. Filters and also classed by flow rate slow sand filters, rapid sand filters, high-rate filters. Another flow characteristics of filters is pressures or granting flow (Perry and Green, 1984; Delyannis and Delyannis, 1980).

The removal of suspended particles in a filter consists of at least two steps:

The transport of suspended particles to the solid-liquid surface of a grain of filter media or to another flow particle previously materials in the bed.

The attachment and absorption of particles to this surface

Filters are highly efficient in removing suspended and collided materials from water. Impurities affected by filtration include; durability, bacteria, algae, virus, colour, oxidized iron and manganese, radioactive particles, chemicals added in pretreatment, heavy metals and many other substances.

Total suspended solids (TSS)

These are undissolved solids impurities contained in water because of man's activities, environmental or natural factors. The simplest way to clarify muddy water is to allow the suspended material in it to settle. This process, called sedimentation, takes place when water is allowed to stand in a reservoir or flow through a series of setting tanks. Sedimentation alone is insufficient to remove all the suspended matter, silt particles small enough to be in colloidal suspension cannot be removed on this manner.

Salinity

The high salinity obtained from the sample shows that, the water contains from the sample shows that, the water contains salt. This is very true because the water belt below ground is very saline especially in the Kalahari Kingdom which is surrounded by the salt water.

The treatment step for salinity is Desalting or desalinization. It is commonly applied to effect.

1. Partial or
2. Complete demineralization of highly saline waters such as sea water (35,000 ppm of dissolved salts) or brackish waters.

Process one is applied to lower the saline content to a degree which renders the water suitable for drinking purpose (preferably 500 ppm salinies or less) and other general uses. Process two applies mainly to 'furnishing water for use in high present boilers and for certain other industrial uses.

In the U.S, the Federal Office of saline water programs was initiated to study various desalting process and its work has been expanded to the building of demonstration plants to appraise the particle performance of fine process.

1. The long tube-critical multiple effect distillation process
2. The multi stage flash-evaporation
3. The freezing process
4. The electricalysis process and
5. The forced circulation vapour-compression process

In process 1, 2 and 5 saline wielders are purified by evaporation; the vapour is condensed in such a manner to recover and reuse as much of its heat content as possible and the concentrated brine is discharged to waste. Such process has been employed for decades on ships and elsewhere. Process 3 is carried out by freezing highly saline waters so as to form a slung of ice crystals and brine, from which the lie crystals are separated, rinsed and melted. Process 4, involves no phase change, but in-exchange membranes in an electric field, depends on the fact that, when a direct electric current of closely spaced, alternatively placed cations, exchange and anion-exchanger membranes, cations pass through the cations-exchange membranes and anions through the anion-exchange membranes, resulting in a salinity decrease in one space and a salinity increase in the next space and so on throughout the stack. The increased - salinity water may be run to waste and the decreased salinity water may be in circulated. Through the stack or passed through a series of stacks. This process does not produce completely demineralized water, but riches the. salinity of brackish water so as to make it suitable for drinking and general uses.

4. CONCLUSION

A good quality (potable) drinking water should be free from diseases causing organisms, harmful chemical substances and radioactive matter. Good quality drinking water should taste good. Its aesthetics should be appealing and it should be free from objectionable colour and odour. From the experiment conducted, it could be seen that the water is acidic because the p^H (4.30) is below 7.0 which is the standard given by the World Health Organization (WHO).

Low p^H water is corrosive which can cause leaching of metal, from the plumbing system or forming scales in pies. Also, from the tabulated result, it could be seen that the Iron (Fe) content in the water is more, compared to World Health Organization Standard. From the table (3) total suspended solid TSS is supposed to be 500 ppm maximum as seen in the WHO standard, but the experiment result gives 900 ppm. This could be reason for the taste in water.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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