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CHARACTERIZATION OF UNDERGROUND WATER RESOURCES OF MINNA, NIGERIA FOR DOMESTIC USES

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ABSTRACT

The general water shortage afflicting Minna, the capital of Niger State of Nigeria has made people resort to access underground and subsurface water through sinking of shallow, intermediate and deep wells to alleviate their problems particularly during dry seasons of the year when temperatures are quite high (above 40^0C) and most surface water is dried up coupled with minimal supplies from state public water board. This study adopted 11 sample wells in the categories affordable by most citizens located at different parts of the town for physic-chemical and biological characterization to ascertain compliance of their water samples with the World Health Organization's guidelines for safe drinking water. They were measured with tape rule and found to belong to the shallow well category as their depths ranged from 1.2 to 15.0m and widths 1.0 to 5m. Standard test methods as described by Degrémont (2010) schedule of water analyses were adopted for the physic-chemical examinations that included turbidity, PH, temperature, alkalinity, hardness, colour and chloride ions. Bacterial micro-organisms present were determined with Eosin methylene blue agar (EMB) system. The result showed that all samples were unsuitable biologically as each well water contained bacterial presence in excess of Nill/100ml and none satisfied the physic-chemical qualities specified by WHO standard. Appropriate mechanical, biological or chemical treatment would be needed to purify water from each well to make it suitable for human consumption so as to solve un-investigated problems that ignorant consumptions of the raw well water might have been causing to citizens.

KEYWORDS: *Minna, well water, physic-chemical, WHO guideline, e-coli, enterobacter/aerogen.*

1.0 INTRODUCTION

Water is one of the critical natural resources desperately needed for survival of all living things. Water is needed by man for drinking, food preparation, cleaning/hygiene, growing his crop, tendering animals and other essential use in commerce and industry. Accessibility to safe water is universally considered as a basic right of every country citizen. Unfortunately this necessity remains unrealized for a large majority of people living in rural and urban settlements in most developing countries of the world that includes Nigeria. Although the world is made up of over 70% of surface and underground water, most of this water contains certain mineral, gases, bacteria/virus, solid/liquid contaminants, undesired taste and odour [1]. Presence of these organic and inorganic matters in water causes many life threatening diseases like dysentery, gastroenteritis, cholera, typhoid e. t. c. It is in respect of this danger posed by consumption of unsafe water to human health that United Nations declared provision of portable water for citizens as one of Millennium Development Goal (MDG). However by 2015, the targeted year for the realization of these goals, many Nigerian communities just like most developing countries are yet to have access to safe water.

This shortage has forced citizens to individual effort of sourcing water from any available and affordable means for daily sustenance. Common sources of water include rain water (seasonal), public water supply (available to only a few), underground water through shallow/deep wells and surface water from rivers and streams. In Minna, Niger State of north central Nigeria, general water shortage afflicting the country has made people resort to access underground and subsurface water through sinking of shallow and intermediate/deep wells to alleviate the problem particularly during dry seasons of the year when temperatures are very high (above 40^0C) and most surface water is dried up coupled with minimal supplies from state public water board. Due to poor economic situations of most people using this type of water they cannot afford the high cost of the technology for sinking wells up to the depths that produce clean water nor that for treating such water. They use the water as obtained from the wells. The state department responsible for sampling, testing such water for suitability or otherwise for human and advice users accordingly are not forthcoming with vital service. These expose people that consume such water to high risks of water borne diseases.

Well water contains organic compounds originating from decaying organic matters from agricultural runoffs. It also contains synthetic inorganic materials resulting from use of some processed products like detergents, pesticides, herbicides, solvents, domestic and industrial wastes. Presence of the contaminants influences quality and usefulness of natural water resource. Those who are aware of dangers of untreated water and resort to packaged water popularly referred to as sachet water or pure water in Nigeria for drinking are still not completely protected from water related diseases contacted through other uses of water. Moreover most packaged water producers in town source their raw water from these same wells and lack the required treatment technology to make the water absolutely safe for human despite regulations by the National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria [2]. Hence the need for its treatment before use by man to forestall health hazards [3]. Treatment will bring the main chemical constituents common with well water within acceptable limits for human consumption and other domestic/industrial uses.

As a part contribution towards finding solution to this problem this research paper is aimed at identifying some strategic shallow/intermediate and deep wells in Minna town from which most citizens draw their water for characterization to ascertain their suitability or otherwise for human consumption. The main objectives of this are to obtain World Health Organisation's (WHO) standard for water quality for human consumption, characterize sampled water from wells at different parts of Minna for chemical and biological analyses and to compare result obtained with WHO standard to ascertain the level of contamination, usability and otherwise for domestic uses. The significance of the work when completed lie in the fact that citizens of Minna would become better informed about the qualities of sub-surface and underground water resources available to them and guide them on use and treatment of water. This will reduce incidences of water borne disease and improve living standard.

2.0 MATERIALS AND PROCEDURES

2.1 Materials:-The major materials used for the experimental aspect of this work included raw water samples collected from eleven (11) wells located at different parts of Minna town, wooden tape rule, assorted chemical reagents obtained from licensed industrial and laboratory chemical dealers in Minna, spectrophotometer, digital PH meter, burettes, glass beakers, pipettes, glass test tubes, hand gloves, plastic containers of varied sizes and WHO standard for safe drinking water (table 1) [4].

Table 1 WHO Guidelines for safe drinking water

Parameters	WHO Permissible Limits
Temperature	30^0C
Odour	Unobjectionable/odorless
PH	6.5-8.5
Hardness	500mg/l
Total Dissolved Solids	1500mg/l
Turbidity	5NUT
Conductivity	120YS/cm^3
Chloride Ion	250mg/l
Alkalinity	100mg/l
Colour	15TCU
Appearance	Clear
Bacteriological	
Coliform	Nil/100ml

E.Coli	Nil/100ml

2.2 Experimental Procedures

A wooden tape rule calibrated to take linear measurement was used to determine vertical depth of each of the wells investigated. Water sample was collected from each well through the mounted pumping facilities (for motorized well) and manually collected for non-motorized wells. Samples were stored in clean/labelled plastic containers to protect it from any environmental contamination awaiting tests and analyses. The experimental works were broken into two parts and conducted as follows:

2.2.1 Physico-Chemical Analysis of raw water samples obtained from wells:-Standard analysis was done to determine the physical parameters sample to evaluate water portability. Digital PH meter was used to measure the PH of water and turbidity meter was used to measure turbidity of water samples. A spectrophotometer was used to measure light transmission ability of water samples in accordance with Degrémont, A.8 [5]. For total alkalinity, methyl orange was used in titration. Alkalimetric reagent was made up of two acids, HCl and H_2SO_4 and was also used in the titration in accordance with Degrémont, A.21, A.24 [5]. Test for hardness was done with 20 drops of KIO buffer that helped to bring specimen to uniformity with 5 drops of erichrome black or net measured and added as the indicator. Procedures stated in Degrémont, A.29 was adopted by which disodium ethylene chiamine tetraocetate was used in the titration process. For chlorine and ion tests, 4 drops of phenolphthalein was added to raw well water specimens with 5 drops of potassium dichromate indicator before sample was titrated with silver nitrate as recommended by Degrémont, A.5 [5].

2.2.2 Bacteriological analysis:-This was carried out on raw water samples to determine extent and types of bacterial presence. This will enable adequate information on the biological treatment that should be recommended for a water sample to adequately domesticate as safe for human use. The multiple tube fermentation method of preliminary processing of raw water for analyses was used prior to carrying out bacteriological analysis on cultured test sample [6]. Analyses were conducted in sequences of presumptive and confirmative tests.

(a) Presumptive test:- In this stage, lactose broth (liquid) was used for the analysis. Exactly 10ml of each raw well water sample was inoculated in 10ml lactose broth. Each sample was then inoculated between at temperature of 37°C to 38°C for 24 hours. On observation, presence of gas, acid and cloudy appearance accordingly showed test sample was contaminated. This was adopted as in the WHO annex 5 guideline for drinking water quality [4].

(b) Confirmatory test: Raw well water samples were streak on an EMB plate (Eosin methylene blue agar). Specimens were then inoculated for a period of 24hours and when exposed to presence of green metallic shine showed presence e-coli (Escherichia coli); as an indication of any faecal contaminants. After exposure, a pinkish growth with dark spots showed presence of enterobacter aerogen while a pure pinkish growth indicated presence of other coliforms. The tests and their interpretations were all done in compliance with WHO Guidelines for drinking-water quality [7]; [8]. Pysico-chemical and bacteriological analyses were carried out in the departments of Chemistry and Chemical Engineering of the Federal University of Technology Minna and the facilities at the water quality laboratory of Niger state Water Board, Minna, Nigeria.

3.0 RESULTS AND DISCUSSION

The vertical depths of the wells as obtained with wooden meter rule used for dimensioning them. The diameters of the wells measured 100cm to 500cm as presented in table 2. Wells selected for study were all mounted with either concrete or metal top protective covers to secure its water.

From the table it is observed that the wells fall within the shallow hand dug category which can yield relatively large quantities of water from the shallow sources and are most extensively employed for individual water supplies in areas containing unconsolidated glacial and alluvial deposit (Watt S. B., 1985). However due to the hard rocky nature of Minna most citizens who depend on this type of water sources do not have financial strength to dig deep wells that go beyond depth of surface solid contaminants.

Table 2:- Vertical depths of the sampled wells

S/NO	Well Sample/Location	Depth (m)
1	Well A (Central Minna)	4.3m
2	Well B (Central Minna)	5.2m
3	Well C (Central Minna)	4.6m
4	Well D (Central Minna)	5.5m
5	Dutsen Kura well	5.2m
6	Fadipe well	1.2m
7	Sauk Kahuta well	1.8m
8	Maikunkele well	9.7m
9	FQS well	15.0m
10	Chanchanga well	5.6m
11	Tunga Maje well	4.4m

Solid content of natural water extremely vary as a result of geomorphologic and hydraulic characteristics of the environment in which water collects and of the manner in which it is withdrawn. These factors were not readily controllable with these types of well that are mostly for low income public uses. Therefore, the well water when properly analysed may contain colloids, organic matter, humic compounds like tannin, lignin, phenol, amino acids and hydrocarbon products of decomposition of vegetable matter that will require appropriate treatment processes to make the water safe for human consumption [9]; [10].

Mineral constituents dissolved in natural water constitute dissolved solids. More than 500 mg/l is undesirable for drinking and many industrial uses. Less than 300 mg/l is desirable for dyeing of textile and manufacture of plastics, pulp paper, and rayon. Dissolved solids cause foaming in steam boiler. The maximum permissible content decreases with increase in operating pressure [3]; [10]. Natural minerals commonly contain less than 5,000 mg/l; some brines contain as much as 300,000 mg/l. The rocky sub-terrain nature of Minna could have highly enriched minerals that could generate lots of dissolvable solids into shallow wells that may require treatment for the water.

Table 3 presents the phsico-chemical analyses of the water characteristics which include the PH, turbidity, temperature, total alkalinity, hardness, colouration and chloride ion content in the raw untreated state of the water samples for each of the 11 wells studied.

Table 3:-Result of physico-chemical tests on the raw well water samples

S/N	Water Sample	Turbidity (NUT)	PH	Temp. (^{o}C)	Total Alkalinity	Total Hardness (mg/l)	Colour (TCU)	Chloride ion (mg/l)
1	Well A (Central Minna)	10.5	6.6	31.6	230.0	196.0	151	63.9
2	Well B (Central Minna)	15.7	6.3	31.5	160.0	176.0	169	45.4
3	Well C (Central Minna)	15.8	6.3	31.3	200.0	280.0	119	44.0
4	Well D (Central Minna)	23.7	7.5	31.6	100.0	252.0	Over range	56.8
5	Dutse kura well	3.7	7.7	32.0	210	356	32	120.7
6	Fadipe well	10.5	7.8	31.8	204	166	3	18.5
7	Sauka-kahuta well	4.8	7.1	31.8	228	132	53	42.6
8	Maikunkele well	10.9	7.6	31.8	120	300	68	12.8
9	FQS well	1.4	7.1	31.7	200	234	1	49.7
10	Chanchanga well	26.6	7.0	31.5	142	210	174	17.2
11	Tunga-maje well	4.9	6.9	31.8	200.0	384.0	33	213.0

The results presented in table 3 were compared with the WHO standard presented in table 1 to ascertain level of suitability of each of the well water sample for humans. Out of the total of 11 wells, only water samples taken from Dutse kura (well with 3.7NUT), Sauka-kahuta (well with 4.8NUT), FQS (well with 1.4 NUT) and Tunga-maje (well with 4.9NUT) satisfied the WHO maximum recommended turbidity of 5NUT for drinkable water. All the samples fell within the upper limits of acceptable WHO PH of 6.5-8.5 for portable water. Based on the ambient sample temperatures, well water samples were slightly above WHO value of 30^0C. This is acceptable because, daily meteorological data always maps Minna as one of the hottest towns of Nigeria. The water from Well D located in central part of Minna with a total alkalinity of 100mg/l was the only sample that satisfied the WHO standard of 100mg/l. Except water from Maikunkele well which was marginally above the requirement all the other wells had water alkalinity quite above WHO standard [3].

The maximum water hardness of 500mg/l that is recommended by WHO was reasonably satisfied by all the well water samples; in fact no sample had a hardness of up to 50% of the standard. By colouration, WHO specifies a value of 15TCU as the maximum that is acceptable for drinking water whereas only the water from Fadipe and FQS wells satisfied this condition. All the other well samples were extremely higher than WHO standard because of heavy presence of series of organic and inorganic compounds that co-exist as micro-pollutants, that even in small quantities are dangerous to a man's health. Concentrations of these substances are such that their removal would require some treatment [11]. The nature of well shallow and absence of concrete ring sealant against pervious earth layer surrounding well. Fadipe well (with a depth 1.2m) is located in that rocky environment which sealed it from contamination by decomposed organic/inorganic matter seepage. The depth of water collection in FQS well (15.0m) was far below the top soil that causes contamination. Each of the samples had chloride ions below 250mg/l recommended by the WHO and are therefore certified suitable for human use. Tunga-maje had 230mg/l and Dutse kura well had about 121mg/l chloride content. These also indicated the dissolved solid in water sample. Chief source of chloride is sedimentary rock that evaporates while the minor sources are igneous rocks that are very prevalent in Minna as shown by the two samples [3]. Chloride in the excess of 100mg/l imparts salty taste that may cause physiological damage [12]. Food process industries require below 250mg/l, implying that water from Tunga-maje and Dutse-kura wells require chloride reduction treatment [13]; [14].

Table 4 shows result of bacteriological analyses on 11 raw well water samples studied. Bacterial organism discovered were enterobacter, aerogen and escherichia-coli as displayed per well in the table. WHO standard (table 1) shows Nill/100ml concentration of the escherichia-coli and other bacterial microorganism present in safe drinking water. However all the well water samples had substantial presence of enterobacter, aerogen and echerichia-coli and therefore do not satisfy WHO requirement for safe drinking except it is treated appropriately [14], [15].

Table 4:-Result bacteriological analysis for raw well water samples.

S/N	Well Sample	Bacteria Present
1	Well A (Central Minna)	Enterobacter/Aerogen
2	Well B (Central Minna)	Enterobacter/Aerogen
3	Well C (Central Minna)	Enterobacter/Aerogen
4	Well D (Central Minna)	E.Coli/Enterobacter/ Aerogen
5	Dutsen Kura	Enterobacter/Aerogen
6	Fadipe	Enterobacter /Aerogen
7	Sauka Kahuta	Enterobacter /Aerogen
8	Maikunkele	E.Coli/Enterobacter/ Aerogen
9	FQS	E.Coli/Enterobacter/ Aerogen
10	Chanchanga	Enterobacter /Aerogen
11	Tunga Maje	Enterobacter /Aerogen

Presence of the harmful bacteria/virus, solid and liquid contaminant, doesn't only give water the undesired taste and odour but also causes many life threatening diseases like cholera, dysentery, gastroenteritis, typhoid e. t. c. Thus, appropriate conditioning treatment of well water from these locations inevitable in order to make such water safe for human consumption for healthier living and longevity [16]; [17].

4.0 CONCLUSION

The research work showed that the depth of the wells analysed fell within the shallow categories of wells due to the economic status of users of the wells and the rocky hard nature of the land where they are located. Their low depths were responsible for presence of decomposed organic matter and other contaminants that affected the physio-chemical and the micro-organic quality of samples. None of the raw well water sample was exactly suitable for human consumption without prior chemical or biological treatment as each contained micro-organisms that including enterobacter, aerogen and escherichia-coli; the presence of which WHO guidelines totally reject in safe human water.

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