The Quality of Shallow Underground Well-Water in Sapele Local Government Area of Delta State, Nigeria, West Africa

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ABSTRACT

Well water samples were taken from six different locations at Sapele Local Government Area in Delta State, Nigeria. The samples were properly collected and in-situ analysis were done for some physicochemical parameters such as conductivity, turbidity, pH and temperature using a calibrated Search Tech, PHS-7010 multimeter. The Chloride, calcium, alkalinity and total hardness determinations were done titrimetrically while gravimetric method was used to analyze the total dissolved solids and total suspended solids of the water samples. The concentrations of heavy metals (zinc, lead and cadmium) were assayed using Varian AA240 atomic absorption spectrometer (AAS). Additionally, bacteriological examination of the water samples was conducted using Inoculation method to determine the level of microbial contamination such as faecal coliform and Escherichia coli (E. coli) count, to assess the water qualities potential health risks. The results obtained from physicochemical analysis gave the following range: conductivity (110.6 - 130.7µs/cm), pH (5.00 - 6.90), temperature (21.00 - 23.00 ^{0}C), chloride (0.00 - 17.70mg/L), Calcium (0.00 - 1.92mg/L), total dissolved solids (50.90 - 69.20 mg/L), turbidity (0.00 - 2.00 NTU), alkalinity (10.80 – 13.60 mg/L), total hardness (6.28-8.65mg/L) and total suspended solids (not detected in any of the samples). Concentrations of the heavy metals determination showed that Zn ranged from 0.012 - 0.080mg/L, there was no trace of Pb and Cd. Bacteriological analysis indicated that samples did not meet the standard of world health organization (WHO) as they contained fecal coliforms ($1.4x10^2$ - $7x10^2$ CFU/mL). Based on the results obtained from all the analysis, the physicochemical parameters and heavy metals fell under permissible limit by world health organization (WHO) but bacteriological parameters did not. Hence, the water should be treated before consumption.

Key words: Well-water; Sapele Nigeria; physicochemical parameters; heavy metals; WHO; bacteriological parameters

INTRODUCTION

A well is an excavation or a structure created in the ground by digging, driving, boring or drilling, to access ground water in underground aquifers [1][2].

The well water is drawn by a pump or using containers such as buckets, that are raised mechanically or by hand. Well can vary greatly in depth, water volume, and water quality. Well water typically contains more minerals in solution than surface water [3][4]. Quality well water can be significantly increased by lining the well, sealing the well head, fitting a self-priming hand pump, constructing an apron, ensuring the area is kept clean and free from stagnant water and animals, moving sources of contamination (latrines, garbage pits and carrying out hygiene education) [5].

The quality of groundwater is a function of natural processes as well as anthropogenic activities [6][7][8]. About forty percent of water used in California comes from underground. During the 1976-1977 droughts the

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proportion rose to fifty-three percent, in some locations, water from wells is the only water available. Reckless disposal of pollutants into soil and water bodies has severe implications for human health globally [9]. As the population of people in Sapele Local Government Area continues to rise, human activities including soil infertility remediation, indiscriminate refuse and waste disposal and the use of septic tanks, soak away pits and pit latrines are on the increase. It is ironical that one way in which groundwater quality can decline is through the well [4]. This occurs when, because of inadequate construction, wells provide a physical connection between sources of pollution and usable water. The geological environment has some natural defenses against pollutants, but each time we penetrate that environment, we may carelessly establish avenues for their uncontrolled introduction. Abandoned wells pose a particularly serious threat, not only to groundwater quality but also to the safety of humans, especially children, and to animals [4][5][9][10]. Such wells are frequently forgotten and once out of mind, there is little chance of preventing them from eventually becoming a problem. These activities are capable of producing leachates into the environment. The consumption of bacterial infected water and water contaminated by some metals has negative consequences on the health of the consumers [1][3][6][13]. The incidence of groundwater contamination by naturally occurring arsenic has been reported in other countries including Mexico, Chile, Argentina, Mongolia, Ghana and Taiwan. A properly constructed or an adequately destroyed well should maintain, as far as practicable, those subsurface conditions which prior to the construction of the well, prevented the entrance of unsanitary and inferior quality water into usable ground water supplies [11]. Standard for the construction of water wells and for the destruction of so called ‘abandoned’ well can be a significant factor in the protection of well water quality and should contribute to the betterment of the health and welfare of the inhabitants of Sapele Local Government Area of Delta State. The assessment of water quality lies on carefully examining the delicate interface between Physics, Chemistry and Biological [12]. The biological methods show the degree of the ecological imbalance, while the chemical methods measure the concentration of the pollutants. The assessment and evaluation, as well as devising method for the abatement of water pollution require a study of these three components namely: physicochemical parameters, heavy metals and bacteriological parameters [11][12][14].

Water is the basic input in life sustaining system and therefore, the management of water resources is not only of utmost importance but is likely to be an extremely complex problem [6]. The management of water resources that will meet the requirement of our people and various sectors of the economy is expected to be as difficult as the management of energy resources. Obviously, the introduction of pollutants into water sources diminish their quality [15] [16]. Therefore, there is need for a careful assessment of available water and resources, particularly ground water and surface water [17][18]. There is also a need for fostering conservation consciousness and integrated approach to project planning from catchment treatment to command area development with due regard to environmental ecological and human consideration. The integration of land use and water use policies, the adoption of modern techniques and technology in the area of water management are of greater values to maintain the quality of ground water. Clean and hygienic drinking water is necessary for healthy development of human being and animals, and this can be achieved by proper assessment and evaluation of water quality [8][14]. Assessment of water quality of selected locations in Maiduguri, Nigeria was done using standard methods and the result of the research emphasized the need for intervention to improve water quality of the area especially in the old Maiduguri [17]. Physicochemical and biological characterization of Orogodo River in Sub-Sahara Africa was done using standard methods. It was reported that the water samples were polluted and should be boiled before consumption to avoid possible human health problems especially from coliforms and E.coli [16]. Also, Okoye *et al.*, 2024, spotted an increasing trend in the pollution level of some rivers in Ezeagu local government area of Enugu state, Nigeria in a study to determine the water quality index of the rivers [18]. Another study was carried out on the physicochemical properties of potable water in Baham community, western region of Cameroon using gravimetric and titrimetric methods. The results of the study showed that the water samples are not fit for consumption [19]. Okonkwo *et al.*, 2024 used a standard method to conduct a research on the physicochemical, microbiological and mineral quality of selected boreholes and stream waters in Elele community, Rivers State, Nigeria and reported that the parameters analyzed were within WHO limit, thereby pose no threat for consumption [20]. Despite the widespread reliance on well water for domestic purposes in Sapele local government area (LGA), there is a paucity of comprehensive studies on the physicochemical and microbial quality of these water sources. Therefore, this study aims to bridge this knowledge gap by conducting a comprehensive physicochemical and microbial assessment of well water in Sapele L.G. A, providing valuable insights for

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policymakers, public health officials and the communities.

MATERIALS AND METHODS

Sample location

Water samples used in this research were collected from six different locations namely: Sapele, Amukpe, Elume, Ogiede, Adagbrasa and Ugbore, all in Sapele Local Government Area of Delta State, Nigeria. Sapele is situated in the southwestern part of Delta state about 60km southwest of Asaba, 30 km northwest of Warri and 120km southeast of Benin city. It coordinates at Latitude: 5.7833°N and Longitude: 5.6667°E. These six sample locations are known for business, residential, industrial, waste dump site and agricultural areas respectively.

Sample collection

The shallow well- water samples labeled ABCDEF respectively, were collected early in the morning in 1L clean sterile plastic containers for the analysis of their physicochemical properties, although some physicochemical parameters were done in-situ. The samples were labeled according to their collection locations prior to sampling. For heavy metal analysis, the samples were collected and preserved with nitric acid to keep metal ions in solution and prevent microbial interference. Sterile universal bottles were used to collect water samples from each location for microbial analysis. The bottles containing the samples were kept in an ice box and transported to the laboratory. In the laboratory, the samples were stored in a refrigerator at 4^0C for 24 - 48h prior to the analysis. The media used for the bacteriological examination of the samples was similar to the method adopted by Olomukoro *et al*., 2022 [16]. The samples were all sealed and transported to the laboratory for the analysis.

Physicochemical Analysis

For pH, temperature and conductivity determination, in-situ analysis was done immediately after each sample was collected at its location using a multi parameter digital tester according to Ikeh *et al.*, 2024 [15].

Turbidity

This was done using a turbid meter, with the digital readout in Nephelometric turbidity unit (NTU).

Total Suspended Solid (TSS), Total dissolved solid (TDS) and Chloride Determination

These were done following a step by step method used by Akaho *et al.*, 2022 [19].

Alkalinity

This was done by adding two drops of menthol orange indicator to 25ml of the sample pipetted into a beaker and titrating using 0.02ml H_2SO_4 solution until the color changed from yellow to a faint orange, indicating the end point [21].

Total Hardness

This was done by adding two drops of Erich Rome black T solution to 25ml of the sample pipetted into a conical flask. Then few drops of ammonium solution were added to make the medium basic. The whole content of the conical flask was titrated against 0.01ml of EDTA solution until the color change from wine red to blue at the end point [21].

Heavy Metals Analysis

Each water sample underwent digestion with aqua regia before analysis. The heavy metals: cadmium, zinc and lead were analyzed using Atomic Absorption Spectrophotometer (AAS) according to the method used by Ikeh *et al.*, 2024 [15].

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Bacteriological Analysis

The samples were collected in 500ml sterilized Schott Duran bottles. The bottles were properly sterilized before the sample collection, and kept in an ice box before being transported to the laboratory for analysis. In the laboratory, they were stored in a refrigerator at 4^0C for 24 - 48h to avoid any form of physicochemical alteration and unwanted growth of microbes. The analysis was done using multi-tube fermentation method. The most probable number (MPN) of bacteria present in the water samples was estimated from specially developed statistical table. Confirmatory test on selective culture medium was also performed [20].

Faecal Coliform

These were analyzed by inoculation method using Lauryl Tryptose Broth (LTB) tubes on E.coli broth and incubating for 24h at 44.5^0C.

E. coli

This was analyzed by streaking method. A sterilized inoculation loop was used to transfer a small amount of the inoculum from a positive E. coli broth tube. The E.coli broth tube previously incubated showed growth of faecal coliform bacterial, indicating a positive result. The inoculum was streaked onto Eosin Methylene Blue Agar plates and incubated for 24 – 48h at 35^0C to allow bacterial growth.

RESULTS AND DISCUSSION

Table 1: Physicochemical Parameters

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	WHO limit
Taste	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless
pH	5.70	5.00	6.20	6.60	5.90	6.90	6.50-8.50
Turbidity (NTU)	0.00	0.00	1.00	2.00	0.00	0.10	5.00
TDS	50.90	60.20	52.40	64.70	69.20	55.80	500.00
Total Hrd(mg/L)	8.65	8.59	6.50	7.33	8.50	6.28	10.00
Conductivity (µs/cm)	110.60	130.70	112.40	100.20	127.10	122.60	1000
Alkalinity (mg/L)	12.80	11.60	10.80	13.60	11.20	13.60	-
Temperature (^{0}C)	21.90	22.30	21.50	21.00	23.00	22.70	25.00
TSS (mg/L)	ND	ND	ND	ND	ND	ND	5.00
Chlo (mg/L)	8.28	12.50	17.70	16.10	10.20	ND	100.00
Calc (mg/L)	1.17	1.34	1.92	1.16	1.50	ND	35.00

TDS: total dissolved solids, Total Hrd: total hardness, TSS: total suspended solids, Chlo: chloride, Calc: calcium, ND: not detected.

The world health organization specified pH value for drinking water is 6.5 – 8.5, hence, pH values recorded require some adjustment to meet with WHO standard. Fluctuations were observed in all the pH values. This fluctuation may be due to increase in temperature that suppresses the solubility of carbon dioxide, or due to

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leakage in supply lines through which domestic waste water enters, which causes an alteration in pH values of water. Conductivity values of drinking water sample collected from wells were found to be 110.6μs/cm, 127.1μs/cm and 122.6μs/cm for sample B (130.7μs/cm) having the highest electrical conductivity value. WHO recommended conductivity value for drinking water is 1000 μs/cm. hence, sample values fall below the permissible value or WHO. Electrical conductivity has a close relationship with total dissolved solids. Thus, high conductivity values indicate that there are high concentrations of TDS in water. Water with high conductivity value has a salty taste. Temperature, total hardness TDS fall below WHO permissible limit. Well water sample A, B, C, D, E, and F respectively, had turbidity values in the range 0.00 - 2.00 NTU which fell below WHO permissible limit of 5.00 NTU. High turbidity in water provides a growth medium for pathogenic microbes which are associated with diseases such as diarrhea, vomiting, abdominal cramps, and so on. WHO recommended TSS concentration value is 5.00mg/L but was not detected in the water samples. The result obtained showed that chloride and calcium contents in the water sample fell below WHO limit.

Table 2: Heavy Metal Analyzed

Metal	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	WHO limit
Pb (mg/L)	ND	ND	ND	ND	ND	ND	0.010
Cd (mg/L)	ND	ND	ND	ND	ND	ND	0.003
Zn (mg/L)	0.013	0.080	0.017	0.022	0.012	0.014	3.000

ND: Not Detected

The result showed that the concentrations of zinc in the water sample fell below WHO limit while cadmium and lead were not detected. The overall results for heavy metals analysis indicated that the water samples are not polluted with the heavy metals. Although zinc is needed in minute amount by living organisms for metabolism, excessive intake can cause neurological, gastrointestinal and immunological problems. Cadmium and lead have no known biological role, their presence at any concentration is dangerous [15]. These metals likely originate from a combination of geological sources, industrial activities and agricultural runoff in the region.

Table 3: Bacteriological Analysis

Organism	Sample A count (CFU/mL)	Sample B count (CFU/ mL)	Sample C count (CFU/ mL)	Sample D count (CFU/mL)	Sample E count (CFU/mL)	Sample F count (CFU/mL)	WHO limit
Faecal coliform	$3x10^2$	$1.8x10^2$	$5x10^2$	$7x10^2$	$2.6x10^2$	$1.4x10^2$	0
E-coli	Absent	Absent	Absent	Absent	Absent	Absent	0

Results from bacteriological analysis indicate that the sample do not meet with the bacteriological standards of WHO, hence, they are not fit for consumption. The results showed that only 13% of samples were negative for bacterial contamination, 40% were found in the satisfactory level and 47% were found to be highly contaminated. The result is an indicative of human or animal waste contamination due to rapid urbanization and population growth in Sapele LGA.

CONCLUSION

The physicochemical parameters analyzed fell below WHO permissible limit, while bacteriological parameter (faecal coliform) were above the limit. Presence of E-coil indicated that the water is fiscally polluted. The main cause of this problem is poor sanitary condition and improper management of waste disposal, which contaminate and alter the quality of the drinking water. Due to poor water quality, the inhabitants of Sapele

Local Government Area of Delta State could be exposed to health problems linked with drinking water and outbreaks of water borne diseases. The result indicates that the drinking water is highly vulnerable to bacterial contamination. Water contamination may be due to cross contamination with waste water, poorly constructed well head, short distance between water supply network and sewage supply pipes, construction of septic tanks near well and drinking water supply lines. Runoff, infiltration of waste water and direct deposition of waste water through leakage are some of the major problems.

RECOMMENDATION

In view of the health risk present, it is suggested that the well water should be treated before consumption. The Nigerian regulatory bodies like the National Agency for Food and Drugs Administration and Control (NAFDAC), Federal Environmental Pollution Agency (FEPA) should at least visit these rural areas and organize public seminars and teaching in order to educate the masses on the danger associated with the intake of these pollutants found in the well water and on some primary treatment method.

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