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Assessment of Physicochemical and Bacteriological Quality of Well Water Samples in Ido Community, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to investigate the physicochemical and bacteriological quality of well water samples in Ido community. Thirty water samples were collected from five different wells (six samples from each well) and subjected to standard microbiological and physicochemical analysis. All physicochemical properties showed difference (p<0.05) in all the wells analyzed except temperature and turbidity. Temperature ranged between 25.3±3.5^{0}C and 26±2.35^{0}C; pH, 6.3±0.7 and 6.9±0.3; electrical conductivity, 127.6±1.9 and 157.8±7.7µs/cm; total suspended solids, 25.2±8.9 and 53.2±1.8mg/l; turbidity, 0.15±0.7 and 1.20±1.4NTU; dissolved oxygen, 4.40±2.8 and 5.35±2.1 mg/l; Biological Oxygen Demand, 9.40±2.8 and15.4±2.8mg/l; Chemical Oxygen Demand, 177.2±1.6 and 260.3±1.6mg/l; chloride, 59.8±8.5 and 101.2±2.6mg/l and total hardness, 246.6±1.9 and 395.6±2.7mg/l. All values fell within WHO standards except Chemical Oxygen Demand (WHO Standard 40mg/l) and total hardness (WHO Standard 100mg/l). Results of microbial population did not show any difference (p>0.05) across the wells. However, Total Heterotrophic Bacteria ranged from 2.15±0.91×10^4 to 5.3±0.86×10^{4}cfu/ml; total coliform, 3.00±0.77×10^4 to 6.18±0.73×10^4 cfu/ml; Total feacal coliform, 2.61±0.71×10^4 to 4.39±0.76×10^4 cfu/ml; Total vibrio count, 2.68±0.81× 10^3 to 4.4±0.86×10^3 cfu/ml; Total salmonella shigella count. 2.02±0.84×10^3 to 4.8±0.95×10^3 cfu/ml. Total

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coliform bacteria ranged from 220 to > 1600 coliform MPN index /100ml^{-1}, while thermo tolerant coliform bacteria ranged from 220 to 1600 coliform MPN index /100ml^{-1}. A total of forty bacterial isolates belonging to ten genera were identified. They include species of *Bacillus* 22 (26.4%), *Staphylococcus* 14(16.8%), *Vibrio* 13(15.7%), *Serratia* 6(7.3%), *Enterobacter* 6(7.3%), *Chromobacterium* 4(4.8%), *Salmonella* 4 (4.9%), *Shigella* 4(4.8%) and *E. coli* 4(4.8%). This result highlights the fact that well water in Ido community are not safe microbiologically for drinking without additional treatment such as boiling or disinfection and this could lead to outbreak of water borne diseases. Good and proper environmental and personal hygiene is advocate especially by the users of those wells to prevent their contamination with bacterial pathogens.

Keywords: Well water; physicochemical analysis; bacteriological analysis; bacterial pathogens.

1. INTRODUCTION

According to the world health organization [1] over 1.1 billion people suffer from disease caused by contaminated water. Each year over 1.8 million people die from diarrheal diseases, and also 90% of these deaths are of children under five (5) [1]. The most common and widespread health risk associated with drinking water is contamination, either directly or indirectly by human or animal excreta that contain pathogenic microorganisms. Drinking such contaminated water or using it in food preparation may cause different infections [1].

In Nigeria, especially in the rural and sub urban communities depend on hand dug well for their water sources which is mostly for domestic use [2,3]. A well is a human made hole that is dug or drilled deep enough to meet the water table. If the well is dug beneath the water table, water will fill the open space to the level of the water table and can be drawn out by a bucket or by pumping [4]. There are many ways a well can be contaminated. Toxic materials spilled or dumped near a well, polluted water can leak through the walls of poorly maintained or carelessly constructed well. Wells can also be contaminated through septic tanks placed close the wells. Flood can also impact the quality of well water [5]. Ido town does not have access to safe and reliable sanitation facilities. In addition, majority of the households do not have sufficient understanding of hygienic practices regarding food, water and personal hygiene. As a result, over 75% of the health problems in Ido town are due to communicable diseases attributed to unsafe and inadequate water supply, and unhygienic waste management, particularly human excreta [6].

Wells in Ido community are being polluted by dumping of materials into the well by the individuals coming to draw water from it. The aim of this study is to assess the physicochemical and bacteriological quality of well water samples in Ido community and also to know if the well waters are fit for human consumption and to tell the authorities how the community lacks access to a potable water sources.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Ido is a community situated in Asari Toru Local Government Area in Rivers State. Ido is 1.8 km from Buguma (capital of Asari Toru Local Government Area), and 49.7 km from Port Harcourt. The community is located between latitude 4°44'10" N and longitude 6°46'4"E. several contamination of these wells are deposited by these individuals who use the well. The study area was selected based on the population density and activity such as improper disposal of waste, carelessness of individuals who come to fetch water from the well and also unavailability of potable water.

2.2 Sample Collection

Using GPS, the coordinates was determined. A total of thirty (30) well water samples were collected using sterile plastic bottles from the various wells on a monthly basis for three (3) months (April-June). Samples for physicochemical analyses were collected using sterile glass bottles and transported in an icepack to the laboratory for analysis. The sampling points are: location A (Edwin's compound), location B (Teacher's compound), location C (Robinson's compound), location D (Okusi's compound) and location E (Iga's compound).

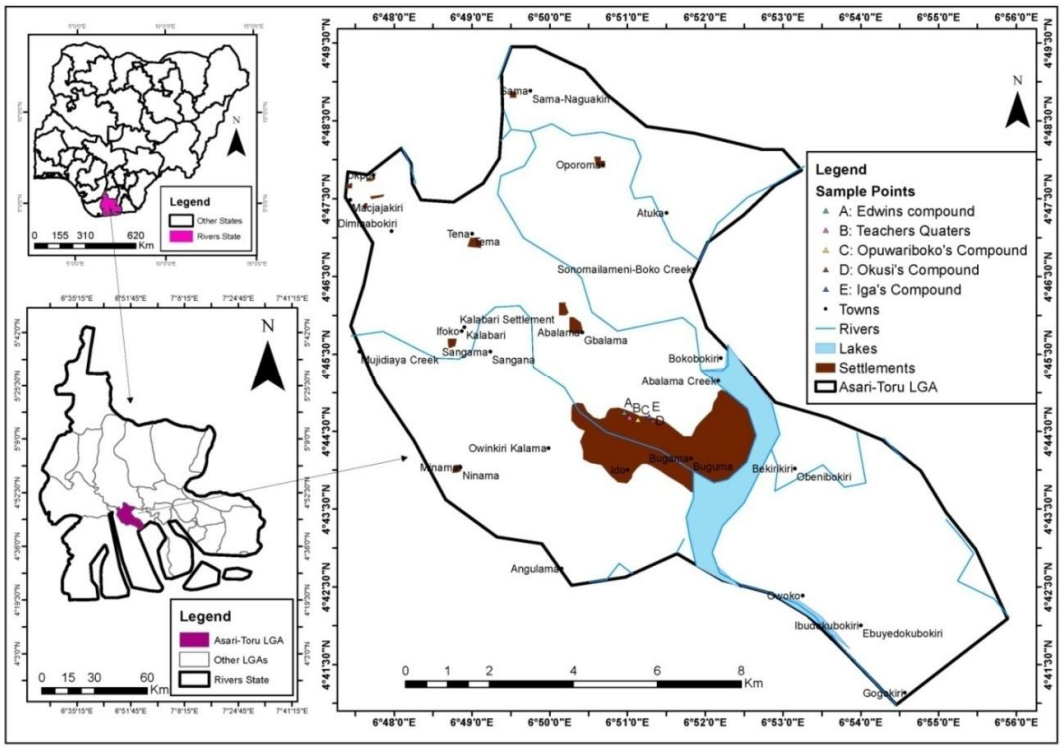

Fig. 1. Map showing the different sampling points in Ido community in Asari Toru LGA, Rivers State Nigeria

2.3 Physicochemical Parameter

The following physicochemical parameters for the well water were analyzed; pH, Temperature, electrical conductivity, total hardness, chloride, turbidity, total suspended solids, total dissolved solids, biological oxygen demand, and chemical oxygen demand. The pH was measured with a pH meter with glass electrodes, temperature was measured with mercury in glass thermometer graduated in centrigade, and electrical conductivity was measured with EC meter after standardization with potassium chloride (KCl) solutions. Turbidity has to do with the visual property, a process by which light is scattered due to the presence of colloidal particles such as silt, clay, finely divided natural and artificial substances found in the water. It was measured by using a standardized Hanna H198703 Turbidimeter. Formazin polymer is used as a reference to compare intensity of light scattered by the sample. Dissolved oxygen was analyzed using Winkler's method where 2ml of manganese sulfate and 2ml of alkali-odide- azid reagent is added to the collection bottle and mixed by inverting several times without introducing oxygen inside bottle. Biological oxygen demand was measured using airtight bottle where 2 ml of manganase sulfate and alkali-odide-azid reagent is added. The sample is mixed by inverting many times and incubated at a specific temperature for 5 days. Chemical oxygen demand is a measure of oxygen proportion of the untreated matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The water sample was collected in clean glass bottles as described by APHA [7].

Fifty milliliters of the sample was pipette into 500ml Erlenmeyer flask with 24/40 ground glass joint. Chloride is measured to avoid the interference of sulphate and sulphide where 1ml of hydrogen peroxide was added to 100ml of the sample. Total suspended solid was analyzed using vacuum pump with distilled. Water was applied to wash the membrane filter (pore size 0.45µm). Suction was done to remove water. The membrane filter was carefully separated, placed in the crucible and dried in the oven at 103^0C for 1 hour. During the analysis, the dried filter paper was wetted with a small volume of distilled water and placed in the filtration unit. About 50ml of homogenously mixed sample was filtered

through the membrane. Here the membrane filter was carefully removed and transferred to the crucible. The crucible and content were placed in the oven and dried to constant weight at 103°C, [7].

2.4 Enumeration of Total Bacteria

Serial tenfold dilution was used for enumeration and isolation of bacteria. this was carried out by transferring1 ml of each water sample into 9 ml of normal saline in test tubes to give 10^{-1} dilution. further serial dilutions were done up to 10^{-3} dilution. Aliquot (0.1 ml) of appropriate dilution was spread plated on to the surface of sterile dried agar media using sterilized bent glass rod. The media used were nutrient agar for heterotrophic bacteria, MacConkey agar for total coliform bacteria, Eosin methylene blue agar for total faecal coliform bacteria, Thiosulfate-citrate bile salts-sucrose agar for vibrio bacteria and Salmonella Shigella agar for Salmonella and Shigella bacteria. The inoculated plates were incubated 37°C for 24-48 hours except faecal coliform bacteria plates incubated at 44.5±2°C for 2-3 days. After incubation, the plates were counted and the number of colonies in each plate was recorded accordingly.

2.5 Estimation of Total Coliform and Feacal Coliform

Multiple tube method was used for the water analysis. This technique is called the most probable number technique (MPN) as described by Pepper and Gerba [8]. The MPN test was done using fifteen (15) test tubes for each sample (10 ml, 1 ml and 0.1 ml). Double strength MacConkey broth and single strength MacConkey broth was used for the MPN technique. Ten milliliter (10 ml) of each samples were put in the double strength MacConkey broth while one milliliter (1 ml) and zero point one milliliter (0.1 ml) of each of the samples was put in the single strength MacConkey broth. The tubes and content were first sterilized by autoclaving with the insertion of Durham tubes at a temperature of 121°C for 15 minutes and left to cool before adding the various samples. The tubes were shaken to mix the contents properly and incubated at 37°C for 24 hours. After incubation, the test tubes were examined and those that produced acid and gas were counted for the presence of acid and gas. After which the tubes were further incubated for another 24hours and then observed for positive or negative reaction and the results recorded. Positive reactions were indicated by change in color of the medium from purple to yellow and collection of gas in the inverted Durham tubes. It is done in 3 stages viz;

2.6 Presumptive Test

This is used to enumerate and identify the presence of Coliform organisms in the water sample. The production of acid and gas in the Durham tube showed a positive presumptive test within 24 – 48 hours at 37°C and 44°C. Ten milliliter (10 ml) of sterile MacConkey broth (double strength) was pipetted into the first sets of five test tubes with Durham tubes inserted, with ten milliliter (10 ml) of water sample inoculated into each test tubes. Ten milliliter (10 ml) of the sterile MacConkey broth (single strength) was also pipetted into the second set of the test tubes, and was inoculated with 1ml of the water sample. The third set of test tubes. Ten milliliter (10 ml) of the sterile Mac-Conkey broth (single strength) and 0.1 ml of the sample was inoculated. The two sets of test tubes used, one for total coliform and the other for faecal coliform bacteria were incubated at 37°C and 44.5±2°C respectively for 48 hours. The changing of MacConkey broth color from purple to yellow and the presence of gas in Durham tube showed positive presumptive test while no gas after 48 hours of incubation constituted a negative test that is absence of coliform in water sample. The most probable number of the organism was recorded using the most probable number table [8].

2.7 Confirmed Test

The inoculums from positive presumptive test samples were aseptically streaked on a sterile Eosine methylene blue agar (EMB) plate with sterile inoculating loop and incubated at 37°C for 24hr. Colonies of *Enterobacter aerogenes* appeared as pinkish mucoid dark, colonies while *Escherichia coli* appeared as greenish metallic chains [8].

2.8 Completed Test

Typical colonies from the EMB agar plates was transferred to a nutrient agar slope and MacConkey broth fermentation tubes and incubated at 37°C for 24hrs. After the incubation, growth of colorless colonies was seen on the nutrient agar plate showing the presence of coliform while the presence of gas formation in the MacConkey broth tube also showed the presence of coliform. Isolate from the nutrient

agar was gram stained and viewed under microscope. Short gram negative, straight rods, non-sporing, forming gas from Mac-Conkey broth is a positive completed test [8].

3. RESULTS AND DISCUSSION

3.1 Physicochemical Parameters

The results of the physicochemical properties are shown in Table 1. All physicochemical properties showed differences ($p<0.05$) in all the wells analyzed except temperature and turbidity. Temperature ranged 25.3±3.5°C and 26±2.35°C; pH ,6.3±0.7 and 6.9±0.3 (WHO Standard 6.5-8.5°C); Electrical conductivity 127.6±1.9µs and 157.8±7.7 µs/cm(WHO Standard 1000 µS); Total suspended solids, 25.2±8.9 mg/l and 53.2±1.8 mg/l(WHO standard 30 mg/l); Turbidity, 0.15±0.7 NTU and 1.20±1.4 NTU (WHO Standard5NTU); Dissolved oxygen, 4.40±2.8 mg/l and 5.35±2.1 mg/l (WHO Standard 5 mg/l); Biological Oxygen Demand, 9.40±2.8 mg/l and15.4±2.8 mg/l (WHO Standard 14 mg/l); Chemical Oxygen Demand, 177.2±1.6 mg/l and 260.3±1.6 mg/l(WHO Standard 40 mg/l); Chloride, 59.8±8.5 mg/l and 101.2±2.6 mg/l (WHO Standard 250 mg/l) and Total hardness 246.6±1.9 mg/l and 395.6±2.7 mg/l (WHO Standard100 mg/l). all values fell within WHO standards except Chemical Oxygen Demand and total hardness.

The result of the physicochemical parameters of this study revealed the value of total suspended solid to be above WHO expected limit of 30mgl in all the well samples except for that of well B with $25.2±8.9^{a}$ mgl. This could be due to a wide variety of material such as silt, decaying plant and animal matter, industrial wastes, and sewage introduced into the well [9]. High concentrations of suspended solids can cause many problems for stream health and aquatic life [10]. Total suspended solids are a significant factor in observing water clarity [11]. The more solids present in the water, the less clear the water will be. Suspended solids can settle out into sediment at the bottom of a body of water over a period of time [12]. Excessive suspended sediment can impair water quality for aquatic and human life, impede navigation and increase flooding risks [13]. Suspended solids will increase water temperatures and decrease dissolved oxygen (DO) levels [14].

The result of the physicochemistry as revealed on Table 1 also shows the level of hardness in the well water samples to be out of limit of WHO expected limit of 100 mg/l. Hardness of water is merely due to salt of calcium and magnesium [15]. Hard water is water that has high mineral content. hard water is formed when water percolates through deposits of limestone, chalk or gypsum [16] which are made up of calcium and magnesium carbonates, bicarbonates and sulfates.

Hard drinking water may have moderate health benefits, but can pose critical problems in industrial settings, where water hardness is monitored to avoid costly breakdown in boilers, cooling towers and other equipment that handles water. In domestic settings, hard water is often indicated by a lack of foam formation when soap is agitated in water, and by the formation of lime scale in kettles and water heaters [1].

The result also shows that the chemical oxygen demand in the various wells was out of WHO expected limit of 40 mg/l. Chemical oxygen demand is an important water quality parameters because it provides an index to assess the effect discharged wastewater will have on the receiving environment [17]. Higher chemical oxygen demand level shows a greater amount of oxidizable organic material in the well water making the water not suitable for human consumption which will reduce dissolved oxygen (DO) levels [18]. A reduction in dissolved oxygen can lead to anaerobic conditions, which is deleterious to higher aquatic life forms [19]. The chemical oxygen demand test is often used as an alternate to biological oxygen demand due to shorter length of testing time [17]. The results also shows that the amount of total suspended solid is above WHO limit of 30 mg/l except for well B with 25.2±8.9 mg/l. High concentrations of suspended solids can cause many problems for stream health, it is a significant factor in observing water clarity [20]. Excessive suspended solid can impair water quality for aquatic and human life, impede navigation and increasing flooding risks. high suspend solids can increase water temperature and decrease dissolved oxygen levels. this is because suspended particles absorbs more heat from solar radiation than water molecules will and this heat is then transferred to the surrounding by conduction. The physisochemical results also revealed that the biological oxygen demand in the various well is within WHO limit of 14 mg/l except for well B which has a higher BOD of 15.4±2.8 mg/l . biological oxygen demand is the amount of oxygen required for microbial metabolism of organic compounds in water. a high biological oxygen demand indicates the

existence of feacal contamination or particulate and dissolved organic carbon from various sources, either from human nor animal. this kind of contamination can seriously affect human health. chloride in all the wells was within WHO limits of 250 mg/lwith well A having the highest level of chloride although within limit. High level of chloride in water can give a drinking water an unpleasant taste.

Chloride is one of the most common anions found in tap water. It generally combines with calcium, magnesium, or sodium to form various salts: for example, sodium chloride (NaCl) is formed when chloride and sodium combine. Chloride occurs naturally in groundwater but is found in greater concentrations where seawater and run-off from road salts (salts used to de-ice icy roads) can make their way into water sources. As such, well owners near snowy roads or road salting storage facilities are especially at risk for high levels of sodium chloride. Interestingly, there is no federally enforceable standard for chlorides in drinking water, though the EPA recommends levels no higher than 250 mg/L to avoid salty tastes and undesirable odors. This requirement of 250 mg/l has been satisfied in the wells analyzed in IDO community as the levels of chloride in all the wells was within WHO limit.

3.2 Microbiological Analyses

Results of total heterotrophic bacterial count, coliform count, feacal coliform, *Vibrio* count and *Shigella* and *Salmonella* count of the different well water samplea are presented in Table 2. Results of microbial population did not show any difference ($p>0.05$) across the wells, However, Total heterotrophic bacteria ranged from $2.15\pm0.91\times10^4$- $5.3\pm0.86\times10^4$cfu/ml (WHO limit 500cfu/ml); Total coliform, $3.00\pm0.77\times10^4$ to $6.18\pm0.73\times10^4$ cfu/ml(WHO limit 0cfu/100ml); total feacal coliform, $2.61\pm0.71\times10^4$ to $4.39\pm0.76\times10^4$ cfu/ml(WHO limit 10cfu/ml); total vibrio count, $2.68\pm0.81\times 10^3$ to $4.4\pm0.86\times10^3$ cfu/ml(WHO limit 0); and total salmonella shigella count. $2.02\pm0.84\times10^3$ to $4.8\pm0.95\times10^3$ cfu/ml(WHO limit 0).

Results of the total heterotrophic bacterial count, coliform count, feacal coliform, *Vibrio* count and *Shigella* and *Salmonella* count of the different well water in Ido Community are represented on Table 2. Highest microbial load of total heterotrophic bacteria was recorded in well B with a population of $5.3 \times 10^4 \pm 0.86^a$ CFU/ml. This number is significantly a determining factor for pollution because microbial contamination compromises the safety of water [21]. The presence of bacteria in water has been recorded in several literatures and this stems from the fact that microorganisms are ubiquitous in nature. Concentrations of total coliforms, faecal coliforms, *Vibrio*, *Shigella* and *Salmonella* in the well water samples were higher than the one reported by [22] indicating the extent of contamination of the water sources making them unsafe for food processing and drinking [23]. The presence of total coliforms, faecal coliforms and higher counts of other indicator microorganisms in the well water samples indicates contamination by potentially dangerous faecal matter and other pathogens that compromise the safety of such water sources (Venkatesan, K. Balaji, M.& Victor, K., 2014). The isolated coliforms were *Escherichia coli,Enterobacter aerogenes* and *Vibrio cholarae* whose counts failed to meet the WHO permissible limit of 0 CFU/100 ml and 10 CFU/ml [1]. The counts ranged from $3.0\times10^4\pm0.77^{4a}$ to $6.18\times10^4\pm0.73^a$ for total coliform, Total feacal coliform counts ranged from $2.61\times10^4\pm0.71^a$ to $4.39\times10^4\pm0.76^{a.}$.Contamination of the well water by coliforms counts exceeded zero colony forming units per milliliter recommended for standard drinking water has been reported by Mahananda, MR, Mohanty BP and Behera NR. [24] and Manhokwe S, Matiashe I and Jombo, T.Z [25]. The level of microbiological contamination in the well water exceeded the limits regarded as safe by East African standard for drinking water.

The most probable number (MPN) per 100 ml obtained for the well water samples (220-1600+) clearly exceeded standard limit of 0CFU/ml and 10CFU/M set by WHO. This suggest that the well water samples have been contaminated by potentially dangerous microorganism and is therefore not fit for drinking purposes. This was confirmed by the characterization of the isolates from the well water samples from the locations under study which were highly contaminated with one or more bacterial pathogens namely *Escherichia coli, Enterobacter aerogenes, Salmonella* spp, and *Shigella* spp. These are pathogenic organisms mainly of faecal origin.

Presence of enteric coliforms especially *Escherichia coli* makes the water samples unsuitable for human consumption according to the guidelines set by WHO for the evaluation of bacteriological qualityof drinking water [26].

Table 1. Variations in physicochemical properties (Mean ± Standard deviation) of well waters samples during the study period

Wells	PH	Temperature (^{0}C)	Electrical Conductivity (µS/cm)	Total Suspended Solids (mg/l)	Turbidity (NTU)	Dissolved Oxygen (DO) (mg/l)	BOD_5 (mg/l)	COD (mg/l)	Chloride (mg/l)	Total Hardness (mg/l)
Well A	6.92±0.03^c	25.6±2.12^a	140.2±4.2^c	41.2±6.0^c	0.15±0.7^a	4.60±1.4^a	10.7±2.8^b	193.8±1.76^d	101.2±2.616^d	324.5±1.202^d
Well B	6.72±0.2^b	25.4±2.82^a	132.4±3.5^b	25.2±8.9^a	1.20±1.4^a	5.35±2.12^b	15.4±2.8^e	260.3±1.06^e	59.8±8.48^a	258.4±4.950^b
ell C	6.44±0.3^a	25.6±3.53^a	127.6±1.9^a	53.2±1.8^d	0.55±0.6^a	4.85±2.1^{ab}	12.2±2.1^c	185.4±2.82^c	73.1±1.90^b	246.6±1.979^a
Well D	6.33±0.7^a	25.3±3.53^a	157.t=8±7.7^e	34.9±0.7^b	0.15±0.7^a	4.40±2.8^a	9.40±2.8^a	177.2±1.62^a	69.4±0.70^b	395.6±2.687^a
Well E	6.35±0.9^a	26.0±3.53^a	151.2±4.2^d	42.2±1.5^c	1.20±0.0^a	4.85±0.7^{ab}	13.6±1.4^d	181.5±1.20^b	84.3±1.76^c	312.4±2.474^c
WHO Standard	6.5-8.5	15.5-32^{0}C	1000µS/cm	30mg/l	5NTU	5mg/l	14mg/l	40mg/l	250mg/l	100mg/l

Table 2. Variations of microbial counts of water samples collected from different wells in the study period

WELLS	THB CFU/ml	TCC CFU/ml	TFC CFU/ml	TVC CFU/ml	TSSC CFU/ml	MPN Index/100
A	2.15×10^4±0.91^a	6.18×10^4±0.73^a	3.67×10^4±0.82^a	3.5×10^3±0.68^a	3.61×10^3±0.87^a	1600
B	5.3×10^4±0.86^a	3.00×10^4±0.77^a	4.15×10^4±0.82^a	4.4×10^3±0.86^a	2.68×10^3±0.81^a	220
C	2.44×10^4±0.84^a	4.13×10^4±0.79^a	2.61×10^4±0.71^a	3.28×10^3±0.67^a	3.83×10^3±0.82^a	1600
D	3.74×10^4±0.98^a	3.99×10^4±0.86^a	4.39×10^4±0.76^a	2.68×10^3±0.81^a	2.02×10^3±0.84^a	1600
E	2.78×10^4±0.88^a	4.8×10^4±0.87^a	3.50×10^4±0.84^a	3.21×10^3±0.96^a	4.8×10^3±0.95^a	1600
WHO Standards	500 Cfu/ml	10 Cfu/ml	0 Cfu/ml	0 Cfu/ml	0 Cfu/ml	

Legend: THB-Total Heterotrophic Bacteria; TCC-Total Coliform count; TFC-Total Faecal coliform; TVC-Total Vibrio Count; TSS-Total Salmonella Shigella count and MPN- Most Probable Number

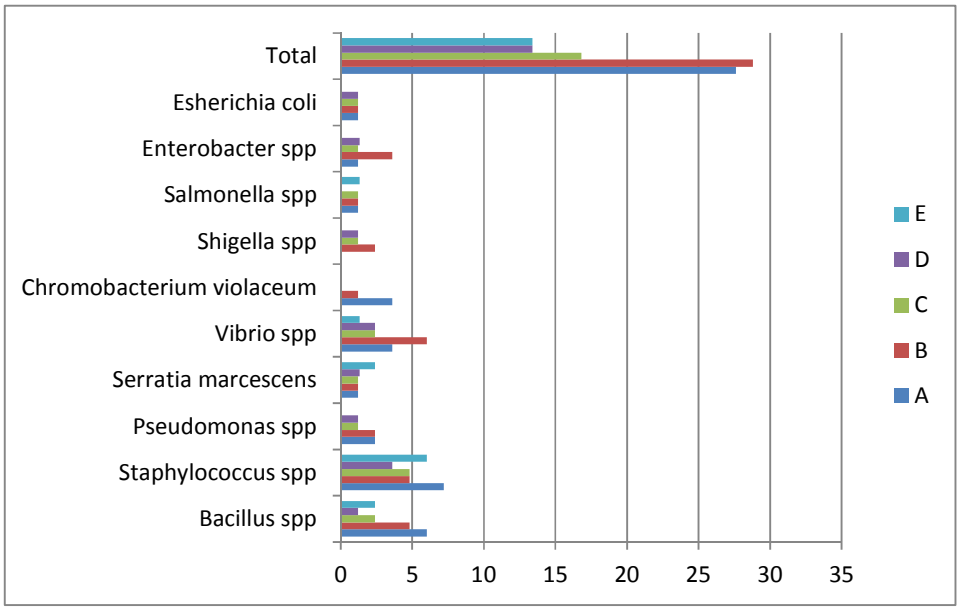

Fig. 2. Percentage of occurrence of bacterial isolates from the various wells in Ido community

Fig. 2 shows the percentage of occurrence of the bacterial isolates within the three months sampling in the different wells. A total of forty bacterial isolates belonging to the ten genera were identified. They include *Bacillus* sp 22(26.4%), *Staphylococcus* sp 14(16.8%), *Vibrio* sp 13(15.7%), *Serratia* sp 6(7.3%), *Enterobacter* sp 6(7.3%), *Chromobactreium* sp 4(4.8%), *Salmonella* sp 4 (4.9%), *Shigella* sp 4(4.8%) and *E.coli* 4(4.8%).

Fig 2 shows that *Staphylococcus* sp was present in all the wells but had the highest occurrence in well A. Which can be attributed to the fact that *Staphylococcus* is widespread in the environment but is found mainly on the skin and mucous membranes of animals. The organism is a member of the normal microbial flora of the human skin and is found in the nasopharynx of 20–30%of adults at any one time and at such can be released by the individuals using the well. *Bacillus* sp was also present in all the wells but had the highest occurrence in well A and E. Although most *Bacillus* spp. are harmless, a few are pathogenic to humans and animals. *Bacillus cereus* causes food poisoning similar to staphylococcal food poisoning. Some strains produce heat-stable toxin in food that is associated with spore germination and gives rise to a syndrome of vomiting within 1–5 h of ingestion. Other strains produce a heat-labile entero toxin after ingestion that causes diarrhoea within 10–15 h *Bacillus* spp. are often detected in drinking-water supplies, even supplies treated and disinfected by acceptable procedures. This is largely due to the resistance of spores to disinfection processes. *Pseudomonas* sp was present in well A, B,C and D but was absent in well E, had the highest occurrence in well A and B. Although *Pseudomonas* spp. can be significant in certain settings such as health care facilities, there is no evidence that normal uses of drinking-water supplies are a source of infection in the general population. However, the ocurrence of *Pseudomonas* spp in these wells can be attributed to the fact people in Ido community are very poor in personal hygiene because this organism is hospital related and can be introduced into the well if the individual using the well has an open wound that is not well treated. It can also be associated with complaints about taste, odour and turbidity of the well. *Serratia* sp was present in all the wells but had the highest occurrence in well E. *Vibrio* sp was present in all the wells but had the highest occurrence in well B. *Chromobacterium* sp was present only in well A and B but had the highest occurrence in well A. *Shigella* sp was present in well B, C and D but had the highest occurrence in well B. *Salmonella* sp was present in well A,B, C and E. *Salmonella* is widespread in the environment and can only be transmitted through the feacal oral route. *Enterobacter* sp was present in well A,B,C and D but had the highest in well B. *Escherichia coli* was present in well A, B, C, and D. *Esherichia coli* is present in large

numbers in the normal intestinal flora of humans and animals, where it generally causes no harm. However, in other parts of the body, *E. coli* can cause serious disease, such as urinary tract infections, bacteraemia and meningitis. Therefore its presence in the wells can be attributed to surface runoff carrying feacal material into the well.

4. CONCLUSION AND RECOMMENDATIONS

This study has shown that there is a high incidence of contamination of well waters by potential pathogens. To reduce the widespread incidence of contamination of well water, it is advocated that wells dug must be deep and covered adequately. Also good and proper personal and environmental sanitary practices must be maintained in and around the wells.

Boiling well water before being used for drinking purposes would also go a long way to prevent incidence of waterborne diseases. Total coliforms presence in the well water is therefore useful for monitoring the microbial quality of drinking water from time to time.

To minimize health risk resulting from the consumption of this contaminated well water, appropriate treatment processes should therefore be utilized for disinfection of well water in Ido community for quality and safe food processing and drinking water.

Consumption of contaminated ground water could therefore be a root cause of diarrheal conditions and deaths reported among the rural population of Ido community. Therefore, disinfection of well water at the point of use for food processing and drinking is necessary.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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