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Bacteriological and Physicochemical Quality of Hand-dug Well Water Used for Drinking and Domestic Purposes in Dareta Village, Anka, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author CH designed the study and wrote the first draft of the manuscript. Authors HHR, UUU, CH managed the analyses of the study. Author BG performed the statistical analysis. Authors UUU, MLB managed the literature searches and protocol. All authors read and approved the final manuscript

Original Research Article

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ABSTRACT

Aim: To determine the bacteriological quality and physicochemical properties of hand-dug well water used as sole source of water for domestic consumption in Dareta village, Anka, Nigeria.
Study Design: In this study ten (10) different well water samples were collected from Dareta village for bacterial assessment and the physicochemical properties.
Place and Duration of Study: This study was carried out in National Research Institute for Chemical Technology, Zaria, Nigeria, between July and November, 2012.
Methodology: The samples were also cultured into bacteriological peptone water for enrichment. The culture in bacteriological peptone water was diluted in distilled water using serial dilution for total bacterial count. Some biochemical tests were carried out to identify the pathogens, also MPN was done for total coliform count. The temperature and TDS of the water samples were measured using HACH conductivity/TDS meter and the

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pH was conducted using Lutron pH 201 meter.
Results: The physicochemical properties of the water indicated that the temperature was 26-29ºC, pH ranged from 5.82 - 6.65 and total dissolved solid ranged from 60 - 380 mg/ml. The result of heterotrophic plate count showed bacterial count range from 33 × 10^2 - 110 × 10^4cfu/ml. The most probable number result was from 23 - 1600MPN/ml. The pathogens isolated were *Salmonella spp* (40%), *Escherichia coli* (80%) and *Pseudomonas aeruginosa* (50%).
Conclusion: In conclusion, the presence of these pathogens in the water indicates that none of the water used for domestic purposes in this village meet the maximum acceptable value.

Keywords: Well water; total coliforms count; total bacteria count; physicochemical properties.

1. INTRODUCTION

Water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability. Safety and quality of drinking water is always an important public health concern [1,2,3]. The provision of portable water to the rural and urban population is necessary to prevent health hazards [4,5]. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is palatable and safe for drinking [6]. Potable water is define as water that is free from diseases-producing microorganisms and chemical substances deleterious to health [7]. Water borne diseases continue to be one of the major health problems especially in developing nations.

In developing countries like Nigeria, especially in the rural and sub-urban communities, water for drinking and other domestic uses is mostly obtained from wells dug by inhabitants [8]. In addition to the well water other available sources of water in rural communities are streams and rivers. Such wells and streams are subject to contamination with pathogenic bacteria because of human activities more especially children and their proximity to defecating environment and latrines [9,3]. Also poor wastewater and solid waste management, poor construction and inadequate protection of the wells and presence of latrines closer to the wells predispose them to contamination [10]. Natural groundwater is usually of good quality, but this can deteriorate due to inadequate source protection and poor resource management. Mechanisms of groundwater recharge and the natural attenuation capacity also depend on soil type and geomorphologic characteristics [11,12].

The prevalence of diseases such as diarrhoea, typhoid fever, cholera and bacillary dysentery among the populace has been traced to the consumption of unsafe water and unhygienic drinking water [13]. The consumption of drinking water contaminated with pathogenic microbes of faecal origin is a significant risk to human health in the developing world, especially in remote rural areas and peri-urban `shanty' communities. Over 3 million deaths per year are attributed to water-borne diarrhoeal diseases, especially among infants and young children in poor communities in Africa, Asia and South [14]. The most dangerous form of water pollution occurs when faecal contaminants enter the water supply. Pathogens such as *Salmonella* species, *Shigella* species, *Vibrio cholerae* and *E. coli* that are shed in human and animal faeces ultimately find their way into water supply through direct and indirect deposition of contaminants from faecal source into the wells either by humans, animals [15] and probably wind blow which carry some soil pathogens to the wells.

Enteric pathogens are typically responsible for several waterborne sicknesses [16,17]. Contamination of water is a serious environmental problem as it adversely affects the human health and the bio-diversity in the aquatic ecosystem. The use of indicator bacteria such as faecal coliforms (FC) in water quality determination on fresh water source is widely used [18]. Currently, coliforms and *Escherichia coli* are of great importance among bacterial indicators used in water quality definition and health risk [19]. The aim of this research was to determine the bacteriological quality of well water in the heart of Dareta village in Zamfara State, Nigeria.

2. MATERIALS AND METHODS

2.1 Sample Collection and Laboratory Analysis of Samples

Samples of water were collected in labelled sterile sample bottles and were transported to the laboratory in a portable sample thermocool containing ice for bacterial analysis. In the laboratory, samples of the water collected were culture into tubes containing bacteriological peptone water and incubated for 48 hours at 37ºC for enrichment.

2.2 Physicochemical Properties

Temperature was measured at the site of the sampling using HACH conductivity/TDS Meter (model 44600.00). pH was conducted electronically using Lutron pH 201 meter. TDS was also determined using HACH conductivity/Total dissolved solid meter (model 44600.00).

2.3 Heterotrophic Plate Count

Samples that were inoculated into bacteriological peptone water for enrichment were serially diluted with sterile distilled water following ten-fold dilution procedure in ten test tubes [20]. That is 1ml of the sample was collected using 1.0mL sterile pipette and dispensed into 9ml of distilled water and then different dilutions were made in 9ml of distilled water in the remaining tubes. 1ml of the diluted sample in the last three test tubes was spread on sterile Petri dishes containing nutrient agar and were incubated for 24 hours at 37ºC. The colonies of bacteria on the nutrient agar plates were counted and each number was recorded.

2.4 Identification of Specific Bacteria

The last three diluted samples in the tubes were spread on different selective media; Salmonella-shigella agar, Pseudomonas CN agar and Eosin methylene blue agar. All the plates were incubated for 24 hours at 37ºC. The 24 h old cultures of the organism were subjected were to biochemical tests such as indole, catalase, oxidase, urease and H_2S test [21]. The bacterial isolates were subjected to Gram staining as described by [22].

2.5 The Most Probable Number (MPN)

The microbial quality of the drinking water samples was assessed by making use of the multiple tube fermentation technique. Total coliforms were estimated by using the 5-tube most probable number (MPN) method. Sterile lactose broth of single strength and double strength was used for the presumptive test and samples of 10ml, 1ml and 0.1ml were inoculated into respective dilution tubes containing inverted Durham's tubes and incubated at 45ºC for 24 hours.

The MPN was estimated by counting the number of tubes in each group that showed gas and acid production following the incubation period using the method of [14]. Contents of tubes showing growth were streaked on Eosin Methylene Blue (EMB) agar for isolation of *E. coli* and incubated at 37ºC for 24hours for confirmative test. Colonies showing typical *E. coli* characteristics (green metallic sheen) were selected and were re-inoculated into tubes of lactose broth. Growth characteristics in lactose broth (production of gas and acid) as well as reactions to indole and glucose showed completed test for coliform bacteria [23].

3. RESULTS AND DISCUSSION

The total dissolved solids of the water sample ranged from 60 - 380mg/ml as described in Fig. 3.1, which was below the allowable limit, the pH of the water samples collected from the well ranged from 5.82 - 6.13 which were at weak acidic pH as seen in Table 3.1. In drinking water the maximum allowable limit of pH is between 6.5 and 8.5. The temperature of the water samples ranged from 26 - 29ºC. In Nigeria, the maximum allowable limit of total dissolved solids in drinking water is 500mg/ml, temperature is ambient temperature [24].

The range of total bacteria count was from 23×10^2 - 110×10^4cfu/ml as indicated in Table 3.1. The count revealed that 1ml of the water from W_1 has the highest number of bacteria with counts of 110×10^4cfu/ml, which means that W_1 was more contaminated follow by W_6 with a total bacterial count of 108×10^4cfu/ml. The least count of the bacteria was obtained from W_{10} with a total count of 33×10^2cfu/ml as shown in Table 3.1. This result indicates that none of the water samples is fit for consumption and children could be responsible for the high bacterial load as seen in Fig. 2.1.

Fig. 2.1 One of the wells in the heart of Dareta Village

Table 3.1 Some Physicochemical Parameters and Heterotrophic plate count

Sample	Temperature (^{o}C)	pH	Bacterial Count (CFU/ML)
W_1	27.2	5.82	110×10^4
W_2	26.0	6.13	98×10^3
W_3	28.4	6.53	56×10^3
W_4	27.1	6.56	76×10^4
W_5	29.0	6.43	102×10^4
W_6	26.5	6.50	108×10^4
W_7	27.3	6.41	46×10^3
W_8	28.6	6.34	64×10^4
W_9	26.0	6.55	64×10^3
W_{10}	28.6	6.50	33×10^2

KEY: W= Well1, 2,3,4,5,6,7,8,9,10, CFU = Colony Forming Unit

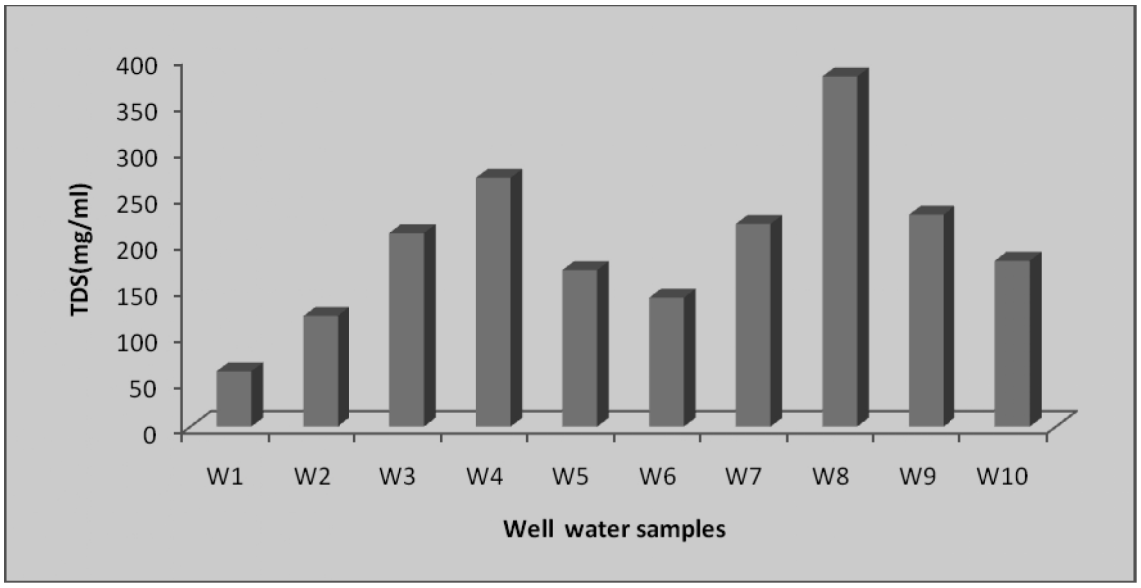

Fig. 3.1 The total dissolved solutes in the well water

The most probable number(MPN) for the presumptive total bacteria count of the water samples ranges from 23 - 1600MPN/100ml as shown in Fig. 3.2. From the Figure it shows that water fromW_1, W_2 and W_6 had the highest total coliform count of 100MPN/100ml, the least total count were from W10, W_3, and W_7 with count of 23MPN/100ml, 36MPN/100ml and 33MPN/100ml respectively. Other total coliform counts obtained are: 170MPN/100ml, 350MPN/100ml, 140MPN/100ml and 60MPN/100ml which were obtained from W_4, W_5, W_8 and W_9 respectively. The result of the MPN has revealed that all the well water were highly contaminated with coliforms and could meet the standard for drinking water. The recommended standard for total coliform or *E. coli* in portable water is less than 2MPN 100 ml, this standard varies from region to region in the world [23].

Table 3.2 Biochemical characteristics of the isolates from each sample

Sample	Oxidase	Catalase	Indole	H_2S	Urease	Pathogen Isolated
W_1	-	+	+	-	-	*Escherichia coli*
	+	-	-	-	+	*Pseudomonas aeruginosa*
W_2	-	-	-	+	-	*Salmonella spp,*
	-	+	+	-	-	*Escherichia coli*
W_3	-	+	+	-	-	*Escherichia coli*,
	+	-	-	-	+	*Pseudomonas aeruginosa,*
	-	-	-	+	-	*Salmonella spp,*
W_4	-	+	+	-	-	*Escherichia coli*
W_5	-	-	-	+	-	*Salmonella spp,*
	-	+	+	-	-	*Escherichia coli*
W_6	-	+	+	-	-	*Escherichia coli*
	+	-	-	-	+	*Pseudomonas aeruginosa*
W_7	-	+	+	-	-	*Escherichia coli*
W_8	+	-	-	-	+	*Pseudomonas aeruginosa*
W_9	-	-	-	+	-	*Salmonella spp*
	-	+	+	-	-	*Escherichia coli*
W_{10}	+	-	-	-	+	*Pseudomonas aeruginosa*

KEY: W1-10 = Well water, + = Positive test, - = Negative test

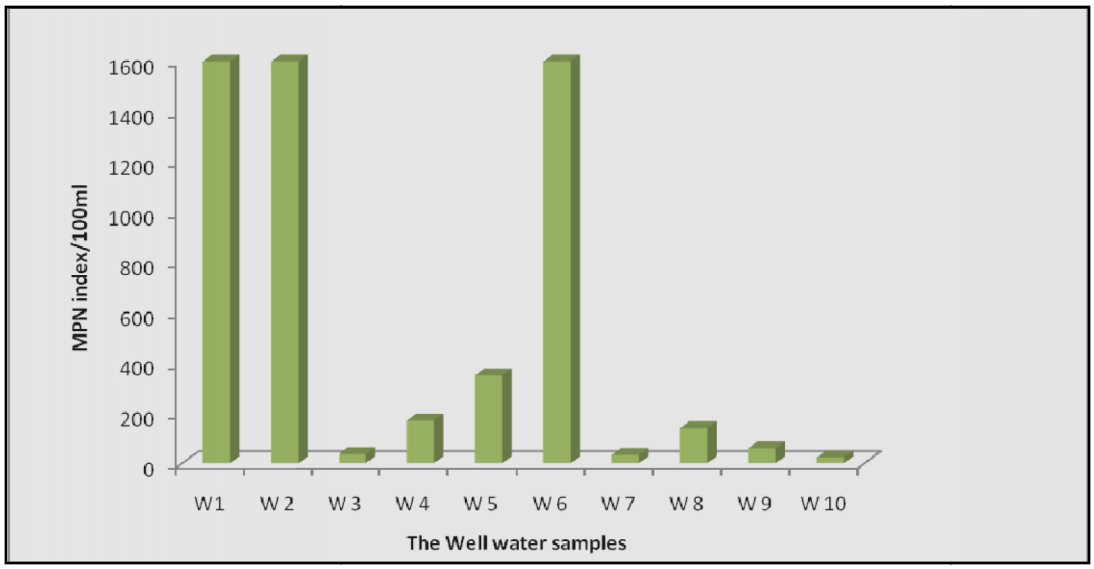

Fig. 3.2 Shows result of completed test of MPN with gas production in fresh lactose broth, staining character of the indicator bacteria and indication of portability for each water sample.

Escherichia coli in drinking water indicate the water has been contaminated with faecal material that may contain disease causing microorganisms, such as pathogenic bacteria, viruses, or parasites. The presence of coliforms group in the water samples generally suggests that a certain selection of water may have been contaminated with faeces either of human or animal origin. Faecal coliforms (FC) are the most widely used indicator bacteria for faecal contamination, as their excreted load is similar or larger than that of pathogenic

organisms, and their survival time in the environment is longer than that of excreted bacteria and viruses [25]. Other more dangerous microorganisms could be present. Table 3.2 shows the various biochemical tests carried out to further identify and confirm the pathogens isolated in sampled wells in Dareta. The pathogens isolated from these wells were *Escherichia coli*, *Pseudomonas aeruginosa,* and *Salmonella spp,* the presence of these pathogens has rendered all the well water unfit for consumption, but yet it has become sole source of water for drinking and domestic purposes by the inhabitants of this village.

These pathogens of faecal origin could find their ways to this water source through indirect and direct deposition of contaminants from faecal source either from humans, animals, birds and wind [26,27]. *Pseudomonas sp.* is a very common contaminant in water systems due to their ease of colonization and they form thick biofilms which consequently has an effect on turbidity, taste and odour of drinking water [28]. The maximum acceptable value of total coliform in drinking water is less than 1 per 100mL and free from faecal coliform [29]. [14,30] reported that consumption of drinking water contaminated with pathogenic microbes of faecal origin is a significant risk to human health in the developing world, especially in remote rural communities. Water should meet different quality specifications depending on the particular uses. Thus, potable and domestic water should contain no pathogens or other contaminants that could be harmful to health of man [31]. Water should have proper organoleptic properties and should be suitable for domestic uses.

4. CONCLUSION

In conclusion, none of the water used for drinking in this village meet the maximum acceptable value. There should be portable supply of water to rural communities for consumption. Water quality should be controlled in order to minimize acute problem of water related diseases, which are endemic to the health of man.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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