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Water Supply and Bacteriological Qualities of Drinking Water in Primary Schools of North Central Nigeria

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ABSTRACT

Adequate water supply and potable drinking water are essential for all growing children. This study was carried out to investigate the water supply and bacteriological qualities of drinking water in primary schools located at North central Nigeria. One thousand five hundred and fourteen water samples were collected from 48 schools located at North central Nigeria. A well-structured questionnaire was used to interview 1,514 primary school children with the consent of their parents. Results that 1066 (70.4%) children had access to drinking water while 448 (29.6%) did not. The sources of drinking water was 383 (25.3%) from piped water; 463 (30.6%), tube well; 131 (8.7%) covered well; 27 (1.8%), rain water; 11 (0.7%) open well; 18 (1.2%) tanker truck; 24 (1.6%) stream; 246 (16.2%) bottled water and 104 (6.9%) sachet water. On the utilization of water supply, 1004 (66.3%), responded that drinking from the main source is currently available for the school while 510 (33.7%) said it is not available. The response to treatment of water showed that 623 (41.1%) always treat their water before using it; 361 (23.8%) sometimes; 530 (35.1%), never; 697 (46%) responded to boiling; 354 (23.4%), chlorine; 285 (18.8%), water filter; 99 (6.5%) solar disinfection; 79 (5.2%) let it stand and settle. The distribution of the bacterial isolates from water samples showed that *Staphylococcus aureus* has the greatest number of isolates with 319 (21.1%); *Escherichia coli* with 76 (12.3%) occurrence. *Klebsiella pneumoniae* had 200 (13.2%) isolates; *Enterobacter* species had 76 (5.0%) isolates; *Pseudomonas aeruginosa*, 162 (10.7%); *Salmonella* species, 56 (3.7%) and *Shigella* species, 94 (6.2%). It was recommended that Governmental agencies ensure that every school complies with the provision of potable drinking water for their pupils.

Keywords: Water, Potable, Bacteria, Microorganism, Disease

INTRODUCTION

Water supply is the provision by public utilities, commercial organizations, community endeavors or by individuals of water, usually by a system of pumps and pipes. An adequate supply of clean water is a prerequisite for sustaining human life, maintaining ecological systems and for achieving sustainable development. [1] For a large percentage of the world's population, drinking water supplies and sanitation services are neither safe nor adequate. Currently, over 1 billion people do not have access to an adequate supply of safe water for household consumption and nearly 3 billion lack a sanitary means of excreta disposal. [2] The provision of safe water and the management of wastewater have had a central role in reducing the incidence of many waterborne or water-related communicable diseases. One of the major achievements of the past 150 years is the extent to which diseases associated with

water have become of minor significance in the mortality and morbidity statistics of most developed countries and of some developing countries especially for richer groups living in major cities. [3] The diseases associated with contaminated water, however, remain serious public health problems for most of the world's population. At the same time, water shortages in many countries are now imposing serious constraints on municipal and community development, as well as on the expansion of food production and the growth of industry. [3] Countries with relatively low per capita levels of available freshwater are finding it difficult to meet the increasing demands for fresh water from expanding populations and the growing demands from agriculture and industry. [4]

Generally speaking, water supply can be derived from three major sources. The sources are precipitation, underground water supply and surface water supply. Precipitation is rain, snow, hail, dew, etc. and is the primary source of water on the surface of the earth. Rain is the condensed and vaporized moisture of the atmosphere falling in separate drops. Other forms of rain under this category include hail, ice, snow, dew, mist, etc. [5] Rainwater is soft and remains the purest water that occurs in nature when it is collected or harvested under hygienic conditions. Historically, the use of rainwater as a source of water supply dated backs to 4,000 years ago in the Mediterranean region. Equally, ancient Roman villages and cities were planned to take advantage of rainwater for domestic purposes many centuries ago. [6] Underwater ground supplies include springs and wells.

Spring is the natural outflow of subsurface or underground water at the earth's surface. It is also called outcropping of the water table. Spring is commonly found on the slopes of hillsides and river valleys as water holes. [7] As a gift of nature, spring can be tapped to complement the water requirements of a household and small community but cannot meet the demand of a big town. This is because some springs are seasonal and this makes the water yield to be very small and erratic. The water yield of a spring depends on the position of the water table and can be soft, hard, pure or impure. To drive this point home, spring water derived from shallow spring is opened to many abuses and contamination and therefore must be disinfected before consumption. [7] However, water derived from deep seated spring is of good quality and can be consumed with little or no treatment. [6] Wells can be shallow or deep. Shallow wells are dug to tap water from the first pervious strata or layers without meeting any impervious strata below water table. The depth of shallow wells is not more than 3 meters deep. They are dug manually. As the name denotes, they are shallow and hence not suitable for adequate water supply because they yield small quantity of water and are seasonal in nature. They dry up during the dry season. The shallow wells are open to pollution and contamination due to surface wash and other contaminants. Deep wells are the wells dug to tap water from the water bearing strata that are enclosed between two impervious layers. They are usually more than 30 meters in depth. [8] The yield of water from this type of well is large and reliable because it is not affected by fluctuation in water level. The water supply from this source is of good quality because much of the pollution is removed due to the time it takes to travel or percolate down to the second aquifers stratum.

Waterborne or water related diseases encompass illnesses resulting from both direct and indirect exposure to water, whether by consumption or by skin exposure during bathing or recreational water use. [9] It includes disease due to water-associated pathogens and toxic substances. A broader definition includes illness related to water shortage or water contamination during adverse climate events, such as floods and droughts, and diseases related to vectors with part of their life cycle in water habitats. [10] Water associated disease covers the wide range of

diseases in which water plays apart, such as legionnaires' disease, as well as diseases related to lack of water for washing and hygiene. The advantage of the term "water related disease" is that it includes both water borne and water associated ill health, although diseases with an indirect association and another major mode of spread are usually excluded from specific surveillance systems.

Contaminated drinking water when used in the preparation of food can be the source of foodborne disease through consumption of the same microorganisms. [11] Most waterborne diseases are characterized by diarrhea, which involves excessive stooling, often resulting to dehydration and possibly death. [9] According to the World Health Organization, [12] diarrheal disease accounts for an estimated 4.1% of the total daily global burden of disease and is responsible for the deaths of 1.8 million people every year. Further estimates suggest that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene and is mostly concentrated on children in developing countries. [13] Most waterborne diseases are often transmitted via the fecal-oral route, and this occurs when human fecal material is ingested through drinking contaminated water or eating contaminated food which mainly arises from poor sewage management and improper sanitation. Fecal pollution of drinking-water may be sporadic and the degree of fecal contamination maybe low or fluctuate widely. [14] In communities where contamination levels are low, supplies may not carry life-threatening risks and the population may have used the same source for time immemorial. However, where contamination levels are high, consumers may be at a significant risk of infection.

In rural African regions, fecal contamination of water arises from runoffs from nearby bushes and forest which serve as defecation sites for rural dwellers. [12] Waterborne disease can be caused by protozoa, viruses, bacteria, and intestinal parasites. Some of the organisms remarkable for their role in the outbreak of waterborne disease include Cholera, Amoebic dysentery, Bacillary dysentery (shigellosis), Cryptosporidiosis, Typhoid, Giardiasis, Paratyphoid, Balantidiasis, Salmonellosis, *Campylobacter* enteritis, Rotavirus diarrhea, *E. coli* diarrhea, Hepatitis A, Leptospirosis and Poliomyelitis. [11] Adequate and potable drinking water supply is a necessity for school children. Only when they are in good health are they able to study and live a good life. Johnson and Paul [15] reported that diarrhea deaths among children have more than halved from 1.5 million in 1990 to 622 000 in 2012. Inadequate water sanitation accounts for over 1000 child deaths per day. The objective of this study is to investigate the water supply and bacteriological qualities of drinking water in primary schools located at North central Nigeria.

MATERIALS AND METHODS

Sample Collection

One thousand five hundred and fourteen water samples were collected from 48 schools located at North central Nigeria. A well-structured questionnaire was used to interview 1,514 primary school children with the consent of their parents. Water samples were collected from water sources in sterile containers and transported to the laboratory for bacterial analysis.

Preparation of Media and Diluents

All bacteriological media (Nutrient agar, Salmonella Shigella Agar, Mannitol Salt Agar, Campylobacter Blood Free Agar, Eosin Methylene Blue Agar and MacConkey Agar) were prepared according to manufacturer's specification. Nutrient agar was used in the isolation of heterotrophic bacteria, MacConkey Agar for faecal coliform bacteria, Eosin Methylene Blue Agar for *Escherichia coli*, Mannitol Salt Agar strictly for *Staphylococcus aureus* and Salmonella Shigella Agar for the isolation of *Salmonella* and *Shigella* species.

Characterization and identification of microbial isolates

Microbial isolates were characterized based on cultural (colonial), microscopic and biochemical methods with reference to standard manuals. [16] The identities of the isolates were cross-matched with reference to standard manuals for the identification of bacteria. Biochemical tests carried out include catalase test, coagulase test, oxidase test, sugar fermentation, hydrogen sulfide production test, urease test, IMViC test, indole test, and citrate utilization test.

RESULTS

Figure showed that 1066 (70.4%) children had access to drinking water while 448 (29.6%) did not. Table 1 showed the sources of drinking water for the school. It showed that 383 (25.3%) got their drinking water from piped water; 463 (30.6%), tube well; 131 (8.7%) covered well; 27 (1.8%), rain water; 11 (0.7%) open well; 18 (1.2%) tanker truck; 24 (1.6%) stream; 246 (16.2%) bottled water and 104 (6.9%) sachet water. Table 2 showed the response to questions on drinking water. On the utilization of water supply, 1004 (66.3%), responded that drinking from the main source is currently available for the school while 510 (33.7%) said it is not available. Data show that those who responded to the question, Is piped water currently used for drinking in the school? "Yes" was 703 (46.4%); "No" was 811(53.6%); Is protected well/spring currently used for drinking in the school? "Yes", 192 (12.7%); "No", 1322 (87.3%); Is unprotected well used in the school? "Yes", 130 (8.6%), "No", 1384 (91.4%). Table 3 showed the response to questions on water sources. The response to the question is lake/river/stream water currently used for drinking in the school? "Yes", 134(8.9%), "No", 1380 (91.1%); Is lake/river/stream water currently used for drinking in the school? "Yes", 8.9%, "No", 91.1%. The response to treatment of water is shown in Table 4 which showed that 623 (41.1%) always treat their water before using it; 361 (23.8%) sometimes; 530 (35.1%), never; 697 (46%) responded to boiling; 354 (23.4%), chlorine; 285 (18.8%), water filter; 99 (6.5%) solar disinfection; 79 (5.2%) let it stand and settle. The distribution of the bacterial isolates from water samples were shown in Table 5. *Staphylococcus aureus* has the greatest number of isolates with 319 (21.1%); *Escherichia coli* with 76 (12.3%) occurrence. *Klebsiella pneumoniae* had 200 (13.2%) isolates; *Enterobacter* species had 76 (5.0%) isolates; *Pseudomonas aeruginosa*, 162 (10.7%); *Salmonella* species, 56 (3.7%) and *Shigella* species, 94 (6.2%).

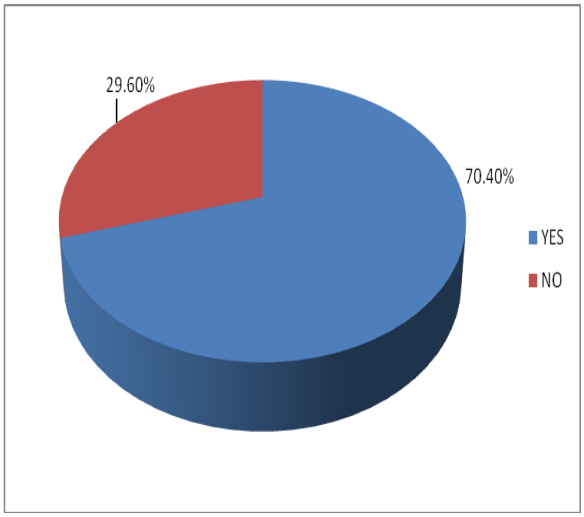

Figure 1: Accessibility to drinking water

Table 1: Main source of drinking water for the school

Source	n	%
Piped water	383	25.3
Tube well / Borehole	463	30.6
Covered Well / Spring	131	8.7
Rainwater Catchment	27	1.8
Open well / Spring	11	0.7
Cart/Tanker Truck	18	1.2
Lake/River/Stream	24	1.6
Bottled Water	246	16.2
Sachet Water	104	6.9

Table 2: Response to questions on drinking water

Question	YES		NO	
	n	%	n	%
Is drinking from the main source currently available for the school?	1004	66.3	510	33.7
Is piped water currently available in the school?	848	56	666	44
Is piped water currently used for drinking in the school?	703	46.4	811	53.6
Is protected well/spring currently available in school?	332	21.9	1182	78.1
Is protected well/spring currently used for drinking in the school?	192	12.7	1322	87.3
Is unprotected well/spring currently available in the school?	157	10.4	1357	89.6
Is unprotected well used in the school?	130	8.6	1384	91.4
Is rainwater currently available in the school?	174	11.5	174	11.5
Is rainwater currently used for drinking in the school?	192	12.7	1322	87.3
Is packaged bottled water currently available in the school?	428	28.3	1086	71.7
Is packaged bottled water currently for drinking in the school?	370	24.4	1144	75.6
Is sachet water currently available in the school?	525	34.7	989	65.3
Is sachet water currently used for drinking in the school?	455	30.1	1059	69.9
Is tanker/truck/cart water currently available in the school?	170	11.2	1344	88.8
Is tanker/truck/cart water currently used for drinking in the school?	155	10.2	1359	89.8

Table 3: Response to questions on source of water

Variable	YES		NO	
	n	%	n	%
Is lake/river/stream water currently available in the school?	126	8.3	1388	91.7
Is lake/river/stream water currently used for drinking in the school?	134	8.9	1380	91.1
No water source is currently available	140	9.2	1374	90.8

Table 4: Response to treatment of water

Treatment of water from the source before use	n	%
Always	623	41.1
Sometimes	361	23.8
Never	530	35.1
Method of treating water from the source before drinking		
Boiling	697	46.0
Add Chlorine	354	23.4
Use water filter	285	18.8
Solar disinfection	99	6.5
Letting it stand and settle	79	5.2

Table 5: Distribution of bacterial isolates from water samples

Bacterial Isolates	**n**	**%**
Staphylococcus aureus	319	21.1
Klebsiella pneumonia	200	13.2
Bacillus cereus	101	6.7
Enterococcus species	129	8.5
Pseudomonas aeruginosa	162	10.7
Escherichia coli	186	18.9
Enterobacter species	76	12.3
Salmonella species	56	3.7
Shigella dysenteriae	94	6.2

DISCUSSION

Although 70.4% of the children had access to drinking water, the remaining 29.6% that did not have access to drinking water are at high risk of water-related diseases. Many of the children were dissatisfied with the level of water supply and utilization. Some children especially in the urban arrears were giving water bottles or sachet water by their parents to take to school. This clearly shows that those pupils who expressed dissatisfaction over water supply had no access to water as they actually were not drinking water supplied by the school. This is higher than the result got by Kotingo et al [17] who found 8% of primary schools in the Niger Delta not to have water supply. Even among those pupils that had access to water, only 46.4% of them had access to piped water; the others had to make due with other sources such as well, stream and rain water. These water sources are not reliable as they are not sterilized water. Those who brought their water from home had reduced risk of exposure to diseases, but the rest of the pupils who drank water from other sources are most likely to be exposed to pathogenic microbes. This was confirmed when the water from all these sources were taken to the laboratory for analysis. The bacterial isolates are shown in Table 5. *Staphylococcus aureus*, *Klebsiella pneumonia*, *Escherichia coli*, *Salmonella* species and *Pseudomonas aeruginosa* were some of the common bacteria isolated at the laboratory. Similar studies [18,19] on bacteriological qualities of water also found these bacterial isolates from samples taken to the laboratory.

Staphylococcus aureus was isolated in 21.1% of the water samples. It is a commensal and opportunistic pathogen that can cause wide spectrum of infections, from superficial skin infections to severe, and

potentially fatal, invasive disease. [20] They can survive in water bodies in room temperature and is of major concern in public health programs worldwide. [21] Following ingestion of contaminated water, the incubation period of the disease depends on amount of toxin ingested. Symptoms include hyper salivation, nausea, vomiting, and abdominal cramping with or without diarrhea. [22] *Klebsiella pneumonia* was isolated in 13.2% of the water samples. They have been found in a variety of environmental situations, such as soil, vegetation, or water. They are found in aquatic environments receiving industrial wastewaters, food with a high content of sugars and acids, frozen orange juice concentrate, and plant byproducts. [23] *Shigella dysenteriae* are Gram-negative, non-spore forming, non-motile, straight rod-like members of the family *Enterobacteriaceae*. The bacterium was isolated in 6.2% of the water samples. The incubation period is 1 to 4 days. The disease usually begins with fever, anorexia, fatigue and malaise. [24] They can be found in water bodies and cause the disease Shigellosis. Patients display frequent bloody stools of small volume and abdominal cramps.

In conclusion, majority of the primary school children did not have access to potable drinking water. Among the children with access to drinking water, the major sources were borehole water and piped water. The major bacterial isolates in the water samples were *Staphylococcus aureus*, *Klebsiella pneumonia*, *Bacillus cereus*, *Pseudomonas aeruginosa*, and *Escherichia coli*. Governmental agencies must ensure that every school complies with the provision of potable drinking water for their pupils.

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