Comparative Analysis of Pipe borne Water and Other Sources of Water in Gwagwalada Area Council, Federal Capital Territory, Abuja, Nigeria.

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Abstract
Water in its natural form contains number of salts, alkaline, microbes and particulate pollutants. Due to industrialization and other anthropogenic activities; the purity of water is critically threatened. Because of the increasing relevance of these factors, the necessity of water analysis is felt desirable. An investigative study was carried out to determine the bacteriological and physicochemical qualities of borehole and well water samples in Gwagwalada Area council Federal Capital Territory (FCT), Nigeria. Eight water samples of which four are pipe borne, two borehole and two stream water sources were collected randomly within the geographical location. Physicochemical parameters were determined using standard methods as well as identifications of bacterial isolates. The physicochemical properties analysed showed turbidity results of all the water samples ranging between 3.93 to 5.19 NTU which conforms to WHO drinking water standards, the hardness of both pipe borne and bore whole water ranged from 30 - 34 while both samples of stream water had an increased value of 152 to 200ml/dm^3. Eight genera of bacteria which include Escherichia coli, Klebsiella spp, Salmonella spp, Shigella spp, Enterococcus spp, Proteus spp, Pseudomonas aeruginosa and Staphylococcus aureus were isolated from the water samples. Total heterotrophic count, total coliform count, Salmonella-shigella count and Vibrio cholera count were also analysed on the water samples. It was concluded that not all pipe borne and borehole waters are safe for consumption and stream waters were of poorer bacteriological qualities indicative of health risk to the inhabitants of the geographical location.

Keywords: *Health risk, investigation pollutants, physicochemical properties, water,*

Introduction

The Greek philosopher Pindar described water as the " best of all things" . This view is not surprising since the need for water, throughout human history, has always been appreciated (Biswas, 2008). Most of our water supplies are from surface water which include: rivers, streams, lakes, oceans and seas and these water bodies are likely to be polluted with domestic and industrial as well as agriculture waste. As populations increase, the problem become more serious and as such, water can endanger the health and life of human beings because when polluted by faecal materials it becomes potential carrier of pathogenic organism, however it has been increasingly noted that poor microbial quality water can be harmful to aquatic organism and ecosystem function (Craun *et al.*, 2006; Miller *et al*., 2002; Miller *et*

al., 2011 and Weitz and Wihelm, 2012).Water is one of the most abundant and essential resources of man, and occupies about 70% of earth's surface (Eja, 2002).

Microbial risk assessment and management of water quality is an important concern and focus of governmental regulation and scientific inquiry (WHO, 2004). Micro-organisms (bacteria, protozoans and viruses) are ubiquitous in aquatic environments. Some of these micro-organisms are capable of producing harmful substances to both human health and ecosystem. Microbiologically-contaminated drinking water has long been implicated in human illness and historically, attention has been focused on finished (end product or tap) water quality. Contaminated water sources are vehicles for transmission of waterborne diseases such as cholera, shigellosis and Campylobacteriosis (Burgess & Pletschke, 2009) However, these strategies are increasingly regarded as insufficient to prevent disease outbreak and more attention has been paid in preventing illness from source to tap (Byleveld *et al*., 2008; Summerscales & McBean, 2011). Man can go without food for twenty eight days, but only three days without water, and two third of a person's water consumption per day is through food while one third is obtained through drinking (Muyi, 2007). Basic household water requirements have been suggested at 50 litres per person per day excluding water to gardens (Boss, 2004).

In addition to human consumption and health requirements, water is also needed in agriculture, industrial, recreational and other purposes. Water is also considered a purifier in most religion. The provision of water in the past was solely a government affair; however, the inability of the government to meet the daily demands of water for the people has forced some private individuals and communities to seek alternatives and self-help measures of providing water. In some localities, they dig wells due to its affordability. For pathogens transmitted by the faecal-oral route, drinking water is only one vehicle of transmission. Improvements in the quality and availability of water, in excreta disposal and in general hygiene are all important in reducing faecal-oral disease transmission (Amyes, 2007; Genthe and Srauss, 2007). In some communities, water from deep wells is sold to the public without reference and conformance to requisite quality standards such as set by the World Health Organization (WHO). Diseases contacted through drinking water kill about 5 million children annually and make 1/6th of the world population sick (WHO, 2004). Water can be perfectly clear in appearance, free from peculiarities of odour and taste, and yet be contaminated. As a potential carrier of pathogenic microorganisms, water can endanger health and life. WHO recommends that no faecal coliform be present in 100ml of drinking water. Also infectious diseases caused by pathogenic bacteria, viruses and parasites (e.g., protozoa and helminthes) include; typhoid, paratyphoid, cholera, amoebiasis, trichinosis, gastroenteritis, shigellosis, diphtheria etc., are the most common and widespread health problems associated with drinking water (De Zuane, 2009; Olawuyi, 2006; Schleifer and Klipper-Balz, 2008). Some of these micro-organisms are indigenous to this natural water while others are transient, entering the water from external environment (Potter, 2006). Coliform bacteria are commonly used as bacterial indicator of water pollution, which is present in the environment particularly in the faeces of all warm-blooded animals and humans (Howard *et al*., 2002). Their presence in drinking water indicates that disease-causing organisms could be in the water system and may pose an immediate health risk in water (Tebutt, 2007).

Over the years, Gwagwalada town is threatened by ground water pollution making the inhabitant vulnerable to health hazards associated with polluted ground water due to their high dependence on the ground water. The situation is likely to be exacerbated by poor

economic situation of the inhabitant, poor planning system, high standard of living caused by proximity of the town to the Federal Capital City and being the University town of the FCT (Ishaya and Grace, 2007). Due to poor knowledge of ground water quality by the inhabitant of the town, this study was instigated. Therefore this study was aimed at characterizing bacteria isolates as well as physicochemical properties of pipe borne water and other sources of water in Gwagwalada Area Council of Abuja, Nigeria and assessing the quality of water and potential sources of water contamination in such areas.

Materials

Sample Collection

Water samples were collected randomly from eight different sources within the Gwagwalada metropolis of FCT, Nigeria, comprising; four tap water samples from different residents, two borehole water samples from different locations and two stream water samples. Sterile universal sampling bottles were used, labelled and transported immediately. The samples were thereafter brought to the laboratory for analysis in a cellophane bag containing ice block. The samples were examined within two hours of collection.

Table 1: Randomly selected sample locations, sources and sample identification code

Sample location	Source of sample Samples	identification code
Government day secondary school phase III.	Borehole water 1	B1
Obana street	Borehole water 2	B2
University of Abuja Girls hostel mini campus	Tap water 1	T1
University of Abuja Boys hostel mini campus	Tap water 2	T2
Kontagora Estate	Tap water 3	T3
Kutunku	Tap water 4	T4
Along GTBank	Stream water 1	S1
Along UBA bank	Stream water 2	S2

Methods

Preparation of Medium

Seventy-three grams of lactose broth were weighed using an analytical weighing balance and dissolved in 1000 ml of sterile distilled water inside a conical flask. Fifty-two grams of MacConkey agar powder were dissolved in 1000 ml of sterile distilled water, 36 g of Eosin Methylene Blue powder was dissolved in 1000 ml of distilled water, 28 g of nutrient agar powder was also dissolved in 1000ml of distilled water and 111. 02g mannitol salt agar was dissolved in 1000 ml distilled water. For proper dissolution and homogenization, the media

were shaken vigorously and melted using a water bath at the temperature at 45°C for 40 min before sterilizing in an autoclave at 121°C for 15 min. Media were aseptically dispensed into oven-sterilized Petri-dishes and allowed to solidify under laminar air-flow.

Total Bacterial Count

Total bacterial count was determined by pour plate technique using standard methods. Nutrient agar medium was used for the enumeration of bacteria in the samples. Mannitol salt agar was used for the isolation of *Staphylococcus aureus* while *Salmonella* sp was isolated on *Salmonella-Shigella* agar.

Total Coliform Count

This was determined by MPN index method using 5-5-5 regimen. MacConkey broth was used and positive result was indicated by acid and gas production on incubation at 37 °C for 48 hour (Cheesebrough, 2006).

Faecal Coliform Count

Faecal coliform count was determined using Eosin Methylene Blue medium employing the pour plate technique. On Eosin Methylene Blue (EMB) agar, *E. coli* strains appeared as greenish metallic sheen colonies and this was further confirmed by the ability of the organism to ferment lactose (Burnett and Beauchat, 2011).

Morphological Growth and Identification of Isolates on media

The cultural characteristics of the isolates on different solid agar were examined. The growth patterns, colony size, edge, elevation on the plates were recorded after 48 h of incubation at 37°C. Gram staining technique was carried out for the identification and differentiation of each isolated bacteria. The size and arrangement of colonies into shapes (rods or round and chains) were also recorded (Ryan and Ray, 2008). Microbial identification was performed using the keys provided in the Bergey's Manual of Determinative Bacteriology (1994).

Biochemical tests for identification of isolates

Some tests were carried out namely: Catalase, Urease, Oxidase, Indole, haemolysis, gram reaction, acid and gas production and Citrate following standard procedures (Sule *et al.*, 2009).

Physiochemical Analysis

The physiochemical tests included the determination of temperature, turbidity, odour, colour, total solid, total hardness, total alkalinity, pH, conductivity, iron content, acidity, total hardness, and chloride content using the methods of FAO (1997).

Results

The result of the physicochemical analysis of the water samples are shown in Table 2. It was observed that pH of all the tested samples were between the ranges of 6.5 to 6.9. Pipe-borne water, borehole and stream waters analysed maintained normal temperature range of 28.7^0C and 29.1^0C respectively. The colour of both pipe borne and borehole water samples ranged between 11 to14 (pteo) except that of stream water which had a massive increasing values of 50 and 38 (pteo). The turbidity of the borehole and pipe-borne water samples ranged from 3.73-4.20 NTU and 5.03 – 5.19 for the stream water. The total hardness values of the present study revealed that the borehole water recorded the highest value (200) while pipe borne water recorded the lowest (30-32) value. The dissolved oxygen was observed to be in the range of 7.04 – 8.17.

Table 2: Results of physiochemical analysis for the Different Water Sample

	Water Sample							
Parameters	T1	T2	T3	T4	B1	B2	S1	S2
DO_2 (mg/l)	8.17	8.13	8.17	8.17	8.00	8.07	7.54	7.04
PH	6.8	6.8	6.8	6.6	6.8	6.9	6.9	6.5
Conduc.	80.2	80.6	80.2	80.1	80.6	80.2	277.0	193.0
Temp.(°C)	29.1	29.0	29.1	29.0	28.7	29.0	29.1	29.1
Turbidity	3.93	4.20	3.93	3.88	3.73	3.78	5.19	5.03
Colour(pteo)	13.0	14.0	13.0	12.0	12.0	11.0	50.0	38.0
T.Alk.	36.0	38.0	36.0	36.0	38.0	38.0	168.0	77.0
T. H	30.0	32.0	30.0	30.0	34.0	32.0	200.0	152.0
Chloride	15.62	17.04	15.62	15.55	17.04	17.04	19.88	13.55

Keys:

T.Alk = Total alkalinity Turb = Turbidity

T.H = Total hardness DO_2 = Dissolved oxygen

The morphological characteristic of the isolated bacteria were recorded having high occurrences of cocci, raised elevation, opaque, with flowery odour and sizes ranging between 0.2 - 0.6 nm and 4 -5 nm. The different surfaces and colours of the isolated bacteria are recorded in Table 3. *Staphylococcus aureus* gave the highest rate of occurrence followed by *Escherichia coli* and *Pseudomonas aeruginosa*, while occurrence of *Vibrio cholerae*, *Salmonella spp*. and *Shigella* spp. were the least (Table 5). The Most Probable Number (MPN) of coliform bacteria was estimated using Cheeseborough (2006) MPN standard table. The most probable number (MPN) for presumptive total coliform count of the water samples ranged from 28 to 1,600 per 10ml. T3 water sample had the lowest with 21 colonies (Table 5). *Vibrio cholerae* count of water samples, ranged from 6.3 x 10^5cfu/ml to 7.4 x 10^5cfu /ml for both samples of stream water, all bore hole and tap water samples showed no growth of *Vibrio* Sp. (Table 4). *Salmonella-Shigella* counts for samples ranged from 1.3 x 10^5cfu/ml to 5.0 x 10^5cfu/ml. S1 sample has the highest *Salmonella- shigella* count of 5.0 x 10^5 cfu/ml. Three samples of tap water (T1, T2, and T3) and a sample of borehole water (B1) had no growth (Table 5).

The results for the biochemical analysis were also recorded, having gram negative *bacilli* (GNB) as the most dominant species, oxidase test seemed to be positive only on *Streptocoocus spp*. isolated from the stream 2 (S2) water sample. Furthermore, the rest of the biochemical tests analysed for the samples include; catalase, coagulase, haemolysis, indole, simmon citrate test, acid and gas production test, lactose and urease test (Table 6).

Table 3: The Morphological Characteristics of Isolated Bacteria

Samples	Surface	Shape	Elevation	Consistency	Odour	Opacity	Colour	Suspected organism
T1	rough	cocci	raised	mucoid	flowery	opaque	creamy	*Staphylococcus aureus*
T2	smooth	rod	raised	soft	flowery	opaque	pink	*Escherichia coli*
T3	smooth	rod	raised	soft	flowery	opaque	white	*Streptococcus spp*
T4	rough	cocci	raised	soft	flowery	opaque	creamy	*Staphylococcus aureus*
B1	smooth	rod	raised	soft	flowery	opaque	pink	*Escherichia coli*
B2	smooth	cocci	raised	soft	flowery	opaque	white	*Streptococcus spp*
S1	rough	rod	heaped	mucoid	no odour	opaque	pink	*Klebsiella pneumoniae*
S2	rough	rod	raised	mucoid	flowery	opaque	pink	*Enterobacter spp*

Table 4: The Microbial isolates from water samples.

Organisms	**T1**	**T2**	**T3**	**T4**	**B1**	**B2**	**S1**	**S2**
E.coli	+	-	-	+	+	+	+	+
Proteus spp	-	-	-	-	-	-	+	+
Staph. aureus	+	+	-	+	+	-	+	+
Klebsiella spp	-	+	+	-	-	-	+	+
Vibrio cholerae	-	-	-	-	-	-	+	+
Salmonella spp.	-	-	-	-	-	-	+	+
Shigella spp.	-	-	-	-	-	-	+	+
S. faecalis	-	-	-	-	-	+	+	+
Pseudomonas aeruginosa	-	+	+	-	+	-	+	+

KEYS:

S. faecalis = *Streptococcus faecalis*

- = Absence

+ = Presence

Table 5: The Total Bio load of Analysed Water Samples

Samples ID	Total heterotrophic count (cfu/ml)	Total coliform count (cfu/ml)	Salmonella-shigella count (cfu/ml)	*Vibrio cholera* count (cfu/ml)
T1	1.2×10^5	28	Not detected	Not detected
T2	1.5×10^5	27	Not detected	Not detected
T3	2.0×10^5	21	Not detected	Not detected
T4	2.1×10^5	33	1.3×10^5	Not detected
B1	4.8×10^5	110	Not detected	Not detected
B2	3.7×10^5	56	5.0×10^5	Not detected
S1	1.68×10^5	1600	3.7×10^5	6.3×10^5
S2	1.82×10^5	1600	5.5×10^5	7.4×10^5

KEYS:

T1=Tap 1 B1=Borehole 1 S1=Stream 1T2=Tap 2

B2=Borehole 2 S2=Stream 2 T3=Tap 3

T4=Tap 4 ID=Identification code

Table 6: The Biochemical results for identification of isolates

Biochemical tests	T1	T2	T3	T4	B1	B2	S1	S2
Gram reaction	GPC	GNB	GPC	GPC	GNB	GNB	GNB	GNB
Indole	+	-	-	-	+	+	-	-
Citrate	-	+	-	-	-	-	+	+
Catalase	+	-	-	+	-	-	-	-
Oxidase	-	-	-	-	-	-	+	-
Coagulase	-	-	-	-	+	-	+	+
Haemolysis	-	-	+	+	-	-	-	-
Urease	+	-	-	+	-	-	-	-
Acid & gas production	NAG	AG	A	NAG	AG	AG	A	A
Lactose	-	+	-	-	+	+	+	-

KEYS:
- = Absence + = Presence GPC = Gram positive cocci GNB= Gram negative bacilli
NAG =No acid and gas production A= Acid production AG = Acid and gas production

Discussion

An investigative study was carried out to determine the bacteriological and physicochemical qualities of borehole and well water samples in Gwagwalada Area council FCT, Nigeria. Pipe-borne water, borehole and stream waters analysed maintained normal temperature range of 28.7℃ and 29.1℃ respectively. This range could influence the rate of proliferation of microorganisms (Onweluzo and Akuagbazie, 2010). It was observed that pH of all the tested samples were between the ranges of 6.5 to 6.9. This is within the range of WHO and Nigerian standard for drinking water maximum permissible limit of 6.5 – 8.5 (Okonkwo *et al*., 2006). The resulted pH range of the above analysis is close to neutrality and would support the growth of most bacterial species (Okonko *et al*., 2008).

The mineral composition of the site could affect the colour of the water especially if iron compounds are present. The turbidity of the borehole and pipe-borne water samples ranged from 3.73 - 4.20 NTU. This is also in conformity with the acceptable values (Hughes and Koplan, 2005). Turbidity, results from the presence in the water samples of particulate matters such as clay, silt, finely divided organic matter etc. These colloidal materials provide adsorption sites for chemicals that may be harmful to health or cause undesirable tastes or odours (Umeh *et al*., 2005).

Dissolved oxygen (DO) is an important parameter which is essential to the metabolism of all aquatic organisms that possesses aerobic respiration, DO in water may also be due to direct diffusion from air and photosynthetic activity of autotrophs (WHO, 2006). The values of DO obtained in this study are within the recommended standards except for the samples of stream water analysed. The content of chloride is more than the permissible level which is alarming which might have contributed to the total hardness of the samples, also the degree of hardness ranges from hard to extremely hard which is undesirable (WHO, 2004). The principal natural sources of hardness in water are dissolved polyvalent metallic ions predominantly, calcium, and magnesium (WHO, 2011). Hardness occurs due to presence of bicarbonates and carbonates of calcium and magnesium ions are called temporary hardness. However, sulphates and chlorides of calcium and magnesium cause permanent hardness (Generalic, 2017). Furthermore, the high degree of mineralization associated with alkaline water from the analysed result of both pipe borne and borehole water will result in the encrustation of water

pipes and water using appliances. The isolation of coliform from the water sources is an indication of faecal contamination of the water sources like the borehole, pipe borne and the stream water. Their presence also indicates poor sanitary condition of the water sources. However, two tap water samples (T1 and T2) contained *Staphylococcus aureus* and *Streptococcus spp* that produces partial and complete haemolysis *in vitro* (on blood agar), the presence of these organisms in the body could cause critical health condition. The results of this study demonstrate clearly the presence of pathogenic microorganisms and indicator organisms in the water samples. According to Burgess and Pletschke (2009), bacteria that are typically transmitted by the faecal– oral route include *Salmonella* spp., *Shigella* spp., pathogenic *Escherechia coli*, *Campylobacter* spp., *Vibrio cholerae* and *Yersinia enterocolitica*. Therefore, Contamination from faecal origin may be the major and prominent source of contaminant in the water samples due to poor method of faecal waste disposal (Olawuyi, 2006).

Conclusion

The bacteriological analysis results of the 8 selected water samples were not acceptable since they were all found to yield moderate to heavy growth of bacteria, thereby making them unfit for human consumption and other domestic purposes. The samples of stream water analysed are not safe for drinking, not just due to the unhygienic environment where it is sourced, but also because most of its physicochemical properties and heavy and trace metal contents are above the maximum permissible levels for drinking water. Proper borehole location and construction, appropriate chlorination and other water treatments, control of human activities to prevent sewage from entering water body are the keys to avoid bacterial contamination of drinking water.

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