African Journal of Biomedical Research, Vol. 11 (2008); 285 - 290
ISSN 1119 – 5096 © Ibadan Biomedical Communications Group

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Full Length Research Article

Physico-Chemical and Bacteriological Analyses of Water Used for Drinking and Swimming Purposes in Abeokuta, Nigeria.

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ABSTRACT

Physicochemical and bacteriological analyses were carried out on well water, stream water and river water used for drinking and swimming purposes in Abeokuta, Nigeria. The results obtained were compared with WHO and EPA standards for drinking and recreational water. With the exception of Sokori stream and a well water that did not comply with Turbidity and Mg^{2+} standards respectively, all others were within the standards set for P^{H}, Color, Total solids, Total dissolved solids, acidity, total hardness, Ca^{2+} hardness, chloride and Iron. None of the samples complied with bacteriological standards as Total coliform counts generally exceeded 1,600 MPN/ml, and pathogen count such as *Salmonella-Shigella* counts and *Vibrio cholerae* counts were very high. The presence of pathogens in water for drinking and swimming purposes is of public health significance considering the possibility of the presence of other bacteria, protozoa and enteric viruses that are implicated in gastro-intestinal water borne diseases and the low infectious dose for these water borne pathogens.

(Afr. J. Biomed. Res. 11: 285- 290)

Key words: *drinking water, swimming, bacteria, analysis, Abeokuta*

Received:
October 2007

Accepted (Revised):
May 2008

Published
September 2008

* *Address for Correspondence*

Abstracted by:
African Index Medicus (WHO), CAB Abstracts, Index Copernicus, Global Health Abstracts, Asian Science Index, Index Veterinarius, Bioline International , African Journals online

INTRODUCTION

The public health significance of water quality cannot be over emphasized. Many infectious diseases are transmitted by water through the fecal-oral route. Diseases contacted through drinking water kill about 5 million children annually and make 1/6th of the world population sick (WHO, 2004). Water is vital to our existence in life and its importance in our daily life makes it imperative that thorough microbiological and physio-chemical examinations be conducted on water. Potable water is the water that is free from disease producing microorganisms and chemical substances that are dangerous to health (Lamikanra, 1999). In Nigeria, majority of the rural populace do not have access to potable water and therefore, depend on well, stream and river water for domestic use. The bacterial qualities of groundwater, pipe borne water and other natural water supplies in Nigeria, have been reported to be unsatisfactory, with coliform counts far exceeding the level recommendation by W.H.O (Dada *et al*., 1999a, 1999b, Edema *et al*., 2001). The reason for elucidation of important parameters in water quality assessment may be attributed to the fact that in the overall potability of water, such parameters should not be ignored (Osuinde and, Enuezie 1999).

Bathing and swimming in streams and river are also common among children and adults in the local community. The probability of ingesting infective dose of disease causing microorganism is very high considering the fact that water borne pathogens generally have low infective dose. The objective of this work is to evaluate the general bacteriological and physico chemical parametres of the sources of water used for drinking and swimming purposes in Abeokuta, Nigeria.

MATERIALS AND METHODS

Sample Collection

Well water samples with different proximity to refuse dump, and surface water from stream and river were collected from different locations (Obantoko, Kuto, Isale igbein and Adedotun) within Abeokuta, Southwest Nigeria. The stream sample was collected at the same point with the users fetching point while the river sample was collected upstream to users swimming area. Samples were collected in triplicates into sterile bottles and transported to the laboratory in ice-box.

Physico-Chemical Analysis

The physico-chemical tests included the determination of temperature, turbidity, odour, colour, total solid, total dissolved solid, total suspended solid, pH, conductivity, iron content, acidity, total hardness, and chloride content using the methods of FAO (1997a).

Bacteriological Analysis

Bacteriological characteristics were determined as described by Bezuidenhout *et al*., (2002). The Most Probable Number- multiple tube technique was used for coliform enumeration. Nutrient agar (NA), Salmonella- shigella agar, Thiosulphate citrate bile salt sucrose agar were used to determine heterotrophic bacterial, *Salmonella* and *Shigella, Vibrio cholerae* respectively. All plates were incubated at 35^{o}C for 24hrs. Presumptive colonies were confirmed by gram staining and biochemical reactions and each plate was given a positive or negative score. Isolates were confirmed by some conventional biochemical test SCA, (2002).

RESULTS

The physico-chemical analysis (Color, odour, Turbididty, Total solids, Total dissolved solids, Total suspended solids, total hardness, Ca^{2+} hardness, Mg^{2+} hardness, acidity, chloride and iron) is presented in Table 1.

Sokori stream and Lafenwa river water samples have the highest colour of 10HU while the well close to refuse disposal site and well far from refuse disposal site have colour of 5HU. All the water samples have no objectionable odour (Table 1).

The pH of the water samples ranged from 6.8 to 7.3 while the turbidity of water samples also

ranged from 2.5 – 7.0 NTU for all the water samples. Conductivity measured at (us/cm) also ranged from 468-810(us/cm). Sample C (Sokori stream) has the lowest conductivity of 468Us/cm while sample A (well far from refuse disposal site has the highest conductivity of 810(us/cm) (Table 1).

Table 1: Physicochemical Analysis of Water Samples From Water Sources

Parameters	Sample A Well water 1	Sample B Well water 2	Sample C Stream water	Sample D River water	WHO Standard	EPA Standard
PH	6.8	7.1	7.3	7.2	6.5	6.5-8.5
Conductivity(μs/cm)	810	775	468	678	NS	NS
Color (HU)	5	10	10	5	6	15
Odor	U	U	U	U	U	U
Turbidity (NTU)	3.0	2.5	7.0	5.5	6.0	0-5
Total solids (Mg/l)	420	400	350	380	500	500
Total dissolved solids (Mg/l)	356	340	208	298	500	500
Total suspended solids(Mg/l)	64	60	142	82	NS	NS
Acidity	0.2	0.1	0.1	0.1	0.3	0.3
Total Hardness (Mg/l)	108	95	72	78	500	500
Ca^{2+} hardness (Mg/l)	49	47	44	47	75	65
Mg^{2+} hardness (Mg/l)	59	48	28	31	50	50
Chloride	220	190	112	157	200	250
Iron	0.1	0.3	0.3	0.3	0.3	0.3

U = Unobjectionable; NS- No Standard

Table 2: Bacteriological Analysis of Water

Sample Code	Raw water Samples	Total Heterotrophic Count	Total Coliform count	Salmonella-Shigella Count	Vibrio cholerae count
A	Well water 1	$6.3x10^6$	1,600	Not detected	Not detected
B	Well water 2	$1.57x10^7$	>1,800	Not detected	Not detected
C	Stream water	$2.01x10^6$	>1,800	$6.0x10^3$	$5.0x10^3$
D	River water	$1.0x10^6$	>1800	$2.8x10^4$	$2.8x10^4$
	WHO Standard	$1.0x10^2$	Zero per 100ml	Zero	Zero
	EPA standard	$1.0x10^2$	Zero	Zero	Zero

Table 3. Microbial Isolates From Water Samples

	Well water 1	Well water 2	Stream water	River water
Pseudomonas sp.	+	+	+	+
Escherichia coli	+	+	+	+
Enterobacter aerogenes	+	+	+	+
Staphylococcus aureus	+	+	+	+
Salmonella typhosa	-	-	+	+
Shigella sp	-	-	+	+
Vibrio cholerae	-	-	+	+
Proteus sp.	+	+	+	+
Klebsiella sp.	+	+	+	+

Total solids ranged from 350–420mg/l for all samples, while total dissolved solid ranged from 208-356mg/l and Total suspended solid ranged form 60-142 (mg/ml) while With the exception of sample A whose acidity was 0.2, other samples had acidity of 0.1. Highest value for Total hardness (108mg/l) was observed with sample A while sample C had the least (72mg/l), Ca^{2+} and Mg^{2+} ranged from 44-49mg/ml and 28-59mg/ml respectively. Chloride also ranged from 112-220mg/l while Iron content also ranged from 0.1-0.3. (Table 1).

Results of the bacteriological analysis of the water sample are presented in Table 2. The total viable counts for all water samples were quite high ranging from 6.3 x 10^6 cfu/ml to 2.01 x 10^7cfu/ml. The river sample has the highest microbial load of 2.01 x 107 while well water far away from refuse site had the least value of 1.0 x 10^2cfu/ml. (Table 2).

The most probable number (MPN) for presumptive total coliform count of the water samples ranged from 1,600 to >1,800 MPN per 100ml. Water samples B, C and D had total coliform count greater than 1,800MPN per 100ml while sample A had the lowest total coliform count of 1,600MPN per 100ml. (Table 2).

Vibrio cholerae count of water samples, C and D ranged from 5.0 x 10^3cfu/ml to 57 x 10^3cfu /ml and sample C having the lowest of 5 x 10^3cfu/ml while samples A and B showed no growth of *Vibrio Sp*. (Table 2). Salmonella and Shigella counts for samples C and D ranged from 6.0 x 10^3cfu/ml to 2.8 x 10^4cfu/ml. Sample D has the highest Salmonella- shigella count of 2.8 x 10^4 cfu/ml. (Table 2). The bacteria isolated from water samples in this work included *Escherichia coli, Enterobacter aerogenes, Pseudomonas spp, Staphylococcus aureus, Salmonella typhosa, Shigella spp, Vibrio cholerae, Proteus spp, Klebsiella spp*. (Table 3) with *Salmonella, Shigella* and *V. cholerae* not isolated from the well waters sampled.

DISCUSSION

Heterotrophic count (HPC) measures a range of bacteria that are naturally present in the environment (EPA, 2002). The total bacterial counts for all the water samples were generally high exceeding the limit of 1.0X10^2 cfu/ml which is the standard limit of heterotrophic count for drinking water (EPA, 2002). The high total heterotrophic count is indicative of the presence of high organic and dissolved salts in the water. The primary sources of these bacteria in water are animal and human wastes. These sources of bacterial contamination include surface runoff, pasture, and other land areas where animal wastes are deposited. Additional sources include seepage or discharge from septic tanks, sewage treatment facilities and natural soil /plant bacteria (EPA, 2002). These contaminants are reflected in the highest bacterial load obtained in this study for the river and Sokori stream water samples. The microbial count was higher in well water close to refuse disposal site as compared to well water far away but both microbial count are lower than that of river water. Generally, underground water is believed to be the purest known (Gordan and John, 1996; Prescott *et al*, 2002) because of the purification properties of the soil however, it can also be contaminated. Groundwater are found to be contaminated due to improper construction, shallowness, animal wastes, proximity to toilet facilities, sewage, refuse dump sites, and various human activities around the well (Bitton, 1994). The presumed reason for contamination of well water accounts for why the microbial load of well water close to refuse disposal site have higher microbial count than the one far away from refuse disposal site. Environmental Protection Agency (EPA) establishes heterotrophic plate count as a primary standard, which are based on health considerations.

Accordingly, the total coliform count for all samples were exceedingly high the EPA maximum contamination level (MCL) for coliform bacteria in drinking water of zero total coliform per 100ml of water (EPA, 2003). The high coliform count obtained in the samples may be an indication that the water sources are faecally contaminated (EPA, 2003; Osuinde and Enuezie, 1999). None of the water samples complies with EPA standard for coliform in water. According to EPA standard, every water sample that has

coliform must be analyzed for either fecal coliforms or *E. coli* (EPA, 2003) with a view to ascertaining contamination with human or animal waste and possibly pathogenic bacteria or organism, such as Gardia and Cryptosporidium may be present (EPA, 2003).

The high number of *Salmonella, Shigella spp* and *Vibrio cholerae* in stream and river samples is not in agreement with EPA water standard for recreational use which states that these pathogenic organism must not be present in water, because they are of public health significance, having been associated with gastrointestinal infections: diarrhoea, dysentery, typhoid fever and other form of infection (EPA, 2003). The non-detection of pathogen in the well water sample may be a reflection on the depth of the well among several other contributing risk factors.

Other bacteria isolated from all water samples such as *Staphylococcus aureus, Pseudomonas aeuruginosa,* and *proteus sp. Proteus spp* are also of public health significance. *Staphylococcus aureus* is known to produce enterotoxin (Bennet and Lancette, 1992). *Proteus spp* belongs to the intestinal flora but is also widely distributed in soil and water (Schlegel, 2003). *Enterobacter aerognes* isolated from the water samples are examples of non fecal coliforms and can be found in vegetation and soil which serves as sources by which the pathogens enters the water (Schlegel, 2002). The British Standard Institute (BSI, 1993) specified that counts greater than 10^4 is considered unsatisfactory for *Enterobacter spp*.

The pH of all the water samples were in agreement with pH assigned by EPA as the standard pH of water which ranges from 6.5 – 8.5 (EPA, 2002). The colour of all the four water samples were also in agreement with the standard limit for colour of drinking water recommended by EPA. The standard colour limit recommended by EPA is 15 (colour unit) (EPA, 2002) while the colour of the water samples in this work ranged from 5-10 (colour units).

The high turbidity observed with the surface waters did not agree with EPA standards on turbidity. High turbidity is often associated with higher levels of disease causing microorganism such as bacteria and other parasites. Rivers may get contaminated from soil runoff, which thereby increases its turbidity, which is a measure of cloudiness of water (EPA, 2002; Schwartz *et al*., 2000). Fewer number of disease causing microorganisms may be an indication of lower turbidity value experienced with well samples. At no time can turbidity (Cloudiness of water) go above 5 nephelometric units (NTU) (EPA, 2002).

The total dissolved solid of all water samples are in agreement with the environmental protection agency standard of 500mg/l. Total dissolved solid in drinking water has been associated with natural sources, sewage urban runoff, industrial waste water and chemical used in the water treatment process (EPA, 2002), though of aesthetic rather than health hazards (EPA, 2002; Ballester and Sunyer, 2000). The water samples analysed in this study all have unobjectionable odour which is in agreement with standard of odour of limit of drinking water which is 3 threshold odour number (EPA, 2002).

The iron content of the water samples used in this study is in agreement with EPA standard of 0.3mg/l (EPA, 2002). The chloride content or limit recommended by EPA is 250mg/l, this is in agreement with the chloride content of all the water samples analysed. All parameters of physicochemical analysis have been documented as National Secondary Drinking Water Regulation (NSDWR), they are non enforceable guidelines regulating contaminants that may cause cosmetic effect (such as taste, odour, or colour) in drinking water (EPA,2002).

The presence of total coliforms, fecal coliform, *E. coli, Salmonella spp, Shigella spp and Vibrio spp* have been documented as national primary drinking water regulations (NPDWRs) or primary standards which protect public health by limiting the levels of contaminants in drinking water (EPA, 2002).

Conclusion and Recommendation

In conclusion, proper well location and construction, control of human activities to prevent sewage from entering water body is the keys to the avoiding bacteria contamination of drinking water. It is evident that water borne diseases are due to improper disposal of refuse,

contamination of water by sewage, surface runoff, therefore programmes must be organized to educate the general populace on the proper disposal of refuse, treatment of sewage and the need to purify our water to make it fit for drinking because the associable organisms are of public health significance being implicated in one form of infection or the other. In areas lacking in tap water as in rural dwelling, educative programmes must be organized by researchers, and government agencies to enlighten the villagers on the proper use of surface water.

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