Full Length Research Paper

Evaluation of the minerals, heavy metals and microbial compositions of drinking water from different sourcesin Utagba-Uno, Nigeria

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The presence of heavy metals in drinking water is of public health significance because of their toxicity at even low concentrations. Water should also be free of microorganisms.The quality of drinking water from tap, rain,river and bottled water within Utagba-Uno, a rural community in Ndokwa, Delta State was evaluated by determining the minerals, heavy metals and microbial compositions. The nine water samples analyzed included three bottled water samples (BW),tap water sample (TW), rain water sample (RW) and four river water samples (RS).The heavy metal concentrations from < 0.001 –0.21 mg/l were below the maximum acceptable concentration (MAC) of 0.5 – 50 mg/l.The calcium and sodium levels from < 0.001 – 0.35 mg/l and < 0.001 – 0.14 mg/l, respectively were below the MAC of 200 mg/l. The magnesium levels for most of the water samples were higher than the MAC of 0.1 mg/l.*Escherichia coli* was the most prevalent organism with percentage prevalence of 46.6% while *Staphylococcus aureus* was the least prevalent organism with percentage prevalence of 1.4%. Government should provide quality drinking water in Utagba-Uno. Sources of bottled water should be known and the mineral contents determined before consumption.

Key words: Composition, drinking water, heavy metals, microbial, minerals, Utagba-Uno.

INTRODUCTION

Water is essential to health, however its purity, portability and the mineral content is important for consumption by humans (Kawther and Alwakeel, 2007). The chemical quality of drinking water during recent years have deteriorated considerably due to the presence of toxic elements, which even in trace amounts can cause serious health hazards (Ikem et al., 2002). Water should be free from any organisms. But unfortunately water is not always found pure (Sasikaran et al., 2012). It is therefore important to determine the levels of minerals, heavy metals and also microbiological content of drinking water. Epidemiological studies have reported the occurrence of disease including the problems with reproduction, congenital malformations of the central nervous system, cardiovascular disease and even death due to exposure to trace elements and mineral in water (Kawther and Alwakeel, 2007). Water borne disease is related to faecal pollution of water sources, therefore

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water microbiology is largely based on the need to identify indicators of feacal pollution such as coliforms and *Escherichia coli* (Barrell et al., 2000).Since water borne minerals are in ionic form and are easily absorbed by the gastrointestinal tract, it has been suggested that drinking water may be an important source of mineral intake (Azoulay et al., 2001). The shift in consumption from tap water to bottled water may therefore have implications for health and disease (Kawther and Alwakeel, 2007).

Historically, most communities settle along river banks. Due to increased human activity, industrialization, use of fertilizers and man-made activity, water is highly polluted with different harmful contaminants (Patil et al., 2012).Domestic, industrial and commercial use of water is becoming scarce as a result of pollution of water bodies by heavy metals and contaminants (Ehi-Eromosele and Okiei, 2012).Therefore, the objective of this study was to determine the minerals, heavy metals and microbial contents of different sources of drinking water in Utagba-Uno, a rural community in Ndokwa, Delta State, Nigeria. Due to the scarcity of clean water and lack of adequate treatment of domestic sewage, the use of contaminated water is a common practice with the people of this community. Such waters are polluted by excessive quantities of nutrients, pathogens and toxic chemical substances that affect both the ecosystem and the public's health (Lee-Smith and Prain, 2006).

MATERIALS AND METHODS

Sample collection

Nine water samples were collected in duplicate for the various sources of drinking water in the community.Commercially available bottled water (BW) samples were bought and labeled BW 1, BW 2 and BW 3. Tap water (TW) and Rain water (RW) samples were collected using sterilized 1 L bottles with stoppers. River water (RS) samples were collected at depths 20 – 30 cm water surface forthe upper stream (RS1), mid-stream(RS2), lower stream(RS3) and terminal part (RS4) of the river using sterilized 1 L plastic cans (Karikari and Ansa – Asare, 2006). All thesamples were kept at room temperature (25 – 30°C) and analysis carried out after 24 h of collection of samples (Amajor et al., 2012).

Mineraland heavy metal analyses

The samples were analyzed for minerals and heavy metals by the procedure of AOAC (2000) using the Atomic Absorption Spectrometer AAS (Techmel & Techmel Model PG 50, USA). The water samples were analyzed in triplicates with average concentration of the metals present in mg/l after extrapolation from standard curves.

Microbial analysis

Microbial analysis was determined by measuring 1 ml of the water samples with sterile pipette into 9 ml of sterile distilled water to give a 10^{-1} dilution. Further dilutions to a range of10^{-6} were obtained.

From these dilutions, 1 ml was aseptically plated out using pour plate method for total viable counts on nutrient agar (Lab M Ltd, UK). The nutrient agar was incorporated 5% actidione to inhibit fungal growth (AOAC, 2001). Incubation was at 28 ± 2°C for two days. The multiple tube technique was used to determine the total coliform and *E. coli* counts (APHA, 1995). Colonies with greenish metallic sheen on eosin methylene blue (EMB) agar after 72 h were counted as *E. coli* colonies. The different colonies were subcultured onto nutrient agar for purification and isolation and were transferred onto agar slants. Identification was based on Bergey's Manual of Determinative Bacteriology (Holt et al., 1994).Fungal colonies were determined by using potato dextrose agar (PDA) (Lab M Ltd, UK) supplemented with 10% lactic acid and 0.5% chloramphenicol. Fungal identification was by wet mount method as described by Yarrow (1998).

Statistical analysis

Thedata was subjected to descriptive statistical analysis to determine the mean values and standard deviation using Statistical Package for Social Sciences (SPSS). Duncan multiple comparison test was used to determine the significant difference at p < 0.05.

RESULTS

A summary of the mean ± standard deviation of the mineral analysis of the various sources of drinking water is presented in Table 1. BW 1 sample had the highest concentration of minerals (calcium, magnesium and sodium).The RS 1, RS 2, RS 3 and RS 4 water samples had the lowest concentrations of minerals. The concentration of Iron was lowest in RS 4 and BW 3 water samples and the highest concentration was in the BW 2 water sample.The water samples had very low levels of the heavy metals (manganese, lead, cadmium, arsenic, copper, zinc, chromium and nickel) present when compared with the World Health organization (WHO) maximum acceptable concentration (MAC) of 0.003 – 3 mg/l for theanalyzed minerals and heavy metals.

The total coliform counts were highest in the RS 4 water sample with 133 MPN/ 100 ml and lowest in the BW 2 sample with 11 MPN/ 100 ml. The total hetero-trophic counts were highest in RS 3 water sample with 3. 9 x 10^3cfu/ml and lowest in BW 2 sample with 5.0 x 10^1cfu/ml (Table 2). There were no bacterial species present in BW 1 and BW 3 samples.*Salmonella* sp. was present in all the water samples except in BW 1, BW 3 and RW samples, with the highest counts of 3.9 x 10^2cfu/ml in RS water sample.*E. coli* was present in all water samples except the bottled water samples. *E. coli* had highest counts of 2.4 x 10^3cfu/ ml in RS 4 water sample and lowest counts in TW sample. *Klebsiella*sp. had highest counts in RS 4 water sample and lowest counts in TW sample. *Pseudomonas* sp. had highest counts in RS 3 water sample and lowest counts in TW sample with 1.8 x 10^1cfu/ml. *Staphylococcusaureus* was only present in RS 2, RS 3 and RS 4 water samples with highest counts of 1.6 x 10^2 recorded in RS 4 water sample. No fungal species were detected and isolated.

Table 1. Mineral analysis of drinking water from different sources.

Water samples	Minerals and heavy metals (mg/l)											
	Cr	Mn	Pb	Cd	As	Ca	Mg	Zn	Cu	Fe	Ni	Na
BW 1	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.35 ±0.10	0.26 ±0.02	< 0.001 ±0.00	< 0.001 ±0.00	0.02 ±0.03	< 0.001 ±0.00	0.14 ±0.10
BW 2	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	<0.001 ±0.00	0.31 ±0.05	0.23 ±0.20	< 0.001 ±0.00	< 0.001 ±0.00	0.07 ±0.01	< 0.001 ±0.00	0.12 ±0.50
BW 3	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.22 ±0.01	0.16 ±0.07	< 0.001 ±0.00	< 0.001 ±0.00	0.01 ±0.01	< 0.001 ±0.00	0.09 ±0.20
TW	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.14 ±0.03	0.1 ±0.01	< 0.001 ±0.00	< 0.001 ±0.00	0.03 ±0.01	< 0.001 ±0.00	0.05 ±0.01
RW	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.12 ±0.01	0.09 ±0.02	< 0.001 ±0.00	< 0.001 ±0.00	0.03 ±0.00	< 0.001 ±0.00	0.05 ±0.07
RS 1	0.01 ±0.01	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.15 ±0.01	0.11 ±0.01	0.21 ±0.01	< 0.001 ±0.00	0.05 ±0.02	< 0.001 ±0.00	0.06 ±0.03
RS 2	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.08 ±0.02	0.06 ±0.01	< 0.001 ±0.01	< 0.001 ±0.00	0.04 ±0.01	< 0.001 ±0.00	0.03 ±0.05
RS 3	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.03 ±0.01	< 0.001 ±0.00	< 0.001 ±0.00
RS 4	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	< 0.001 ±0.00	0.09 ±0.01	0.07 ±0.02	0.13 ±0.01	< 0.001 ±0.00	0.01 ±0.01	< 0.001 ±0.00	0.04 ±0.03
MAC*	0.05	0.5	0.01	0.003	0.01	200	0.1	3	2	0.5 - 50	0.02	200

Cr= Chromium; Mn = Manganese; Pb = Lead; Cd= Cadmium; As= Arsenic; Ca= Calcium; Mg = Magnesium; Zn = Zinc; Cu = Copper; Fe = Iron; Ni = Nickel; Na = Sodium. *WHO (2008) Guidelines.

Table 2. The summary of the mean total viable counts of microbial population present in the various drinking water samples.

Drinking water samples	Total coliform count (MPN/100ml)	Total heterotrophic bacteria count (cfu/ml)	Total Counts of Bacterial Species Isolated (cfu/ml)				
			Salmonella sp.	E. coli	Klebsiella sp.	Staphylococcus aureus	Pseudomonas Sp.
BW 1	0	0	0	0	0	0	0
BW 2	11	5.0×10^1	5.0×10^3	0	0	0	0
BW 3	0	0	0	0	0	0	0
TW	18	1.2×10^2	1.8×10^1	0.8×10^1	1.6×10^1	0	1.8×10^1
RW	35	9.0×10^2	0	4.1×10^2	0	0	5.0×10^2
RS 1	94	2.1×10^3	1.1×10^2	1.0×10^3	1.9×10^2	0	8.0×10^2
RS 2	78	1.4×10^3	2.4×10^2	8.8×10^2	1.3×10^2	5.6×10^1	9.8×10^1
RS 3	101	2.9×10^2	2.3×10^2	1.5×10^3	1.5×10^2	5.8×10^1	9.9×10^2
RS 4	133	3.9×10^3	3.9×10^2	2.4×10^3	2.3×10^2	1.6×10^2	7.0×10^2
MAC*	0/100 ml	$<10^4$ cfu/ml	0/100 ml	0/100 ml	0/100 ml	0/100ml	0/100 ml

MPN/ 100 ml = Most probable number per 100 millilitres; cfu/ml = Colony forming unit per millilitres; *WHO (2008) Guidelines.

Table 3. Percentage prevalence of bacterial species in the various sources of drinking water.

Water samples	Percentage prevalence of bacterial species (%)				
	Salmonella sp.	*E. coli*	*Klebsiella* sp.	*Staphylococcus aureus*	*Pseudomonas* sp.
BW 1	0	0	0	0	0
BW 2	100	0	0	0	0
BW 3	0	0	0	0	0
TW	15	57	13	0	15
RW	0	45	0	0	55
RS 1	5	48	9	0	38
RS 2	17	63	9	4	7
RS 3	8	51	5	2	34
RS 4	10	62	6	4	18
Mean percentage prevalence (%)	22.1	46.6	6.0	1.4	23.9
MAC*	0	0	0	0	0

*WHO (2008) Guidelines.

RS 4 water sample has highest counts for all the bacterial species except *Pseudomonas* sp.

Table 3 shows that *Salmonella* sp. was the only bacterium and coliform present in BW sample. *E. coli* and *Pseudomonas* species were the only the RW sample. All the bacterial species isolated occurred in RS 2, RS 3 and RS 4 water samples. *S. aureus* was the least occurring organism in the water samples with mean percentage prevalence of 1.4% while *E.coli* was the most prevalent organism with percentage prevalence of 46.6%.

DISCUSSION

This study showed the presence of low concentrations of heavy metals in the different sources of drinking water samples. All the water samples had concentrations <0.001 mg/l for Cr, Mn, Pb, Cd, As, Zn, Cu and Ni which was below the maximum acceptable concentration (MAC) set by World Health Organization (WHO, 2008). The concentration of iron in the water samples was higher than that of the other heavy metals, though still below the MAC of 0.5 – 50 mg/l. The presence of toxic elements in soil or rocks, whether due to natural geochemistry or human activities, including pollution, usually influences human health indirectly ingested via drinking water or food (Salem et al., 2000). Toxic doses of chemicals cause either acute or chronic health effects. The levels of chemicals in drinking water, however, are seldom high enough to cause acute health effects. They are more likely to cause chronic health effects that occur long after exposure to small amounts of chemicals (Salem et al., 2000).Examples of chronic health effects include cancer, birth defects, organ damage disorders of the nervous system and damage to the immune system (USGAO, 2000). Pb, Zn, Cu, Mn, Ni, Cd, Cr and Mo are toxigenic

and carcinogenic agents found as contaminants in human drinking water supplies in many areas around the world (Groopman et al., 1985).

This study showed lower mineral contents for Ca and Na than the MAC of 200 mg/l. The bottled water samples contained higher Ca and Na concentrations. The Mg content of the water samples were higher than the MAC of 0.1 mg/l. Consumption of drinking water moderately high in Mg can be expected to reduce cardiovascular disease mortality (Calderon and Hunter, 2009).The bottled water (BW) and tap water (TW) samples which were the popular sources of drinking water in the community had low Ca and Na contents. This is comparable with the study of Azoulay et al. (2001), where the bottled water consumed by North Americans had insufficient quantities of Ca and Mg and too much Na. The mineral content of the TW sample in this study was lower than the BW sample. The recommended dietary intakes of Ca (1000 mg/day), Na (500 mg/day) and Mg (420 mg/day) (DRIS, 1997) are best filled by consumption of foods in which these minerals are abundant and bioavailable (Azoulay et al., 2001).

The presence of bacteria in all the water samples except BW 1 and BW 3 is an indication that there are no good sources of drinking water in the community. *Salmonella* sp., the only coliform bacteria present in BW 2, indicated that the water was contaminated during bottling and is not an indication of faecal contamination (WHO, 2006). Coliform bacteria may indicate a problem with the quality of the water source or indicate possible contamination during the bottling process (FSAI, 2009). Due to the nutrient depleted environment of bottled water, microorganisms are adapted to starvation conditions allowing them to survive for long periods of time (Leclerc and Moreau, 2002). The RS water samples were the most contaminated with bacteria. The presence of *E. coli,*

afaecal coliform, with percentage prevalence of 46.6% in the water samples except the BW samples shows that the water samples are polluted. Water found to contain *E. coli* must be considered unsafe for consumption due to the strong association between *E. coli* and faecal contamination (FSAI, 2009). The incidence of *E. coli* and other coliform bacteria (*Salmonella* sp. and *Klebsiella*sp.) in the drinking water samples showedthe microbiological contamination of the source water, problem with water treatment, pipes which distribute the water and pollution by human activities and this indicates that the water consumedwillcausedisease(ODHS,2002).*Pseudomonas* sp. was isolated in all water samples except the BW samples and this may be associated with superficial or local infectione.g external ear infection (FSAI, 2009). *Pseudomonas* species especially *P. aeruginosa* is an opportunistic pathogen associated with contaminated bathing water. This could be the reason for the high counts in the river water samples (RS). The occurrence of *S. aureus,*with percentage prevalence of 1.4%, only in the river water RS 2, RS 3, RS 4 samples could be due to environmental pollution of water ways.

Conclusion

This study determined the minerals, heavy metals and microbial contents of different sources of drinking water in Utagba–Uno. The heavy metal levels were very low but deficient in Ca and Na contents when compared with WHOguidelinesforthemaximumacceptableconcen-trations. The presence of *E. coli* and other coliforms in all the water sources except bottled water BW1 and BW3 is an indication that the drinking water sources are unfit for consumption. Drinking of the contaminated water can expose the human body to various water borne diseases.

Conflict of interests

Theauthor(s) didnot declare anyconflict of interest.

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