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Elemental Analysis of Tap and Borehole Waters in Maiduguri, Semi Arid Region, Nigeria

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Abstract: A reconnaissance survey of drinking water from boreholes and taps was conducted in Maiduguri aiming at assessing their safety or otherwise, in response to the increasing volume of solid waste materials in the city. Except for the *p*H of borehole waters in Polo area (6.296), the *p*Hs of all the waters fall within safe limit. The concentration of major ions (Na, K, Ca, Mg and Fe) fall far below the WHO recommended limit and thus the water can be said to be excellent in terms of these elements. But the concentrations of Cr and Cd in all the waters studied are in excess of the WHO recommended limit of (0.003mgl^{-1}) for safe drinking water. The concentration of Zn (3.256) in borehole waters in Bulumkutu zone also slightly exceeded the WHO recommended safe limit of 3.000 mgl^{-1}for drinking purpose. Although safe drinking water may contain naturally occurring minerals and chemicals elements such as calcium, potassium, sodium, etc, which are actually beneficial to human health, efforts must be strengthened to ensure that drinking water is free from disease-causing organisms, harmful chemical substances and radioactive matter, tastes good, aesthetically appealing and be free from objectionable color or odor.

Key words: Water quality guideline · Tap water · Borehole water · Consumption · Health

INTRODUCTION

In recent years, attention has been shifted on the increasing concentration of metal elements in groundwater corresponding to the increase in land-dumping of metal and metal-containing solid wastes. This is attributed to human interference, proliferation of industries and recent developments in agricultural practices in urban and peri-urban areas. Constituents such as metal elements are leached from the soil surface and move into aquifer systems and thus degrade the quality of the ground water.

Maiduguri is a port city and the major trade center in the north eastern region of Nigeria. Traders and other travelers from within and outside Nigeria, including Sudan, Niger republic, Cameroun republic, Republic of Chad, etc, frequent the city for varying purposes because it is the major gate-way city into Nigeria from these countries. The city also has a federal university and several tertiary institutions that are attended by students from all over Nigeria and beyond. There are also industrial units of different sectors, such as plastics, metal, paper, leather, beverages and confectionaries. Consequently, the population in this city has been growing steadily. The city is therefore dotted with large garbage of solid wastes presumably generated by daily man's activities. These wastes, over the influence of climatic parameters, could leach down and pollute aquifers.

Owing to the increasing demand for water, the numbers of boreholes in the city have been correspondingly increasing annually to the extent that borehole water is becoming the principal and sometimes the only source of drinking water in many communities within Maiduguri. The increasing groundwater usage is based on the postulation that groundwater, being precluded from the atmosphere, is less susceptible to pollution. This is true to some extent only. However, groundwaters are sometimes known to be vulnerable to quality problems that may have serious impact on human health. For instance, Wilson and Hawkins [1] observed concentrations of As between 240 mgl^{-1} and 1.2 mgl^{-1} in the Fairbanks area, Alaska. But water, which is the most precious natural resource, needed for life after oxygen and acclaimed the "Key" to health, should be qualitative Umara *et al*. [2] before being used. The quality of water varies with its purpose, thus the quality required for

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domestic, industrial and irrigation purposes vary widely [2]. Polluted waters, irrespective of the pollutants, when consumed, may lead to variety of diseases, such as cholera, typhoid, dysentery, skin and mental disorders, etc.

To safeguard the health of people and to reduce to the barest minimum to ugly experiences of drinking and/or using low quality waters [3], it is necessary that the quality of water should be monitored with the view to finding lasting solution to health problems associated with the use and drinking low quality waters.

Although groundwaters are usually less contaminated than surface waters, pollution of this major water supply has become an increasing source of concern due to contamination by various toxic substances. Both liquid and solid wastes materials dumped either on soil surface or buried are known to decompose to produce leachates that penetrate aquifers and contaminate the groundwater thereby rising the potential toxicity of the water to consumers. Burying and surface dumping of both industrial and domestic waste materials are nowadays a common practice among rural and urban dwellers.

The quality of groundwater however, principally depends on the element(s) present in it, which it might have acquired from the soil or rock through which it passed while penetrating down. The world health organization WHO [4] has in 1993 set a quality guideline for drinking water and recommends that the properties of every drinking water should fall within the acceptable limit set by it.

This research work was therefore conceived to investigate the presence or otherwise and concentration of some elements in borehole and tap waters in Maiduguri to ascertain whether the waters are within the acceptable standards for human consumption as set by WHO [4] and or not to recommend appropriate measure accordingly.

MATERIALS AND METHODS

Study Area: The study was conducted in Maiduguri (11.05° N, 13.05°E, 345 m above mean sea level) in the semi arid zone of northern Sahel savannah, Nigeria [5]. According to Hess *et al*. [6], the climate of the region is characterized by a cool-dry season (October to March), hot season (April to June) and a rainy season (July to September). The area is fragile and highly susceptible to drought with relative humidity of 13% in dry seasons and 80% in rainy seasons. The area is also highly vulnerable to desertification [5, 7].

For the purpose of this study, the entire Maiduguri town was divided into four (4) zones, namely Mairi, Polo, Federal lowcost and Bulumkutu zones respectively.

Sample Collection: Water samples were collected from both taps and boreholes from each of the zones. Four (4) water samples each from both taps and boreholes were taken from each of the zone to form a total of 32 samples which were later bulked in to eight (8) samples. The water samples were then labeled as either “B” or “T” to represent water samples from boreholes or taps respectively. Tap water usually comes from the Maiduguri Water Treatment Plant often referred to as *Mothercat*-the engineering firm that was contracted to construct it. The plant draws surface water from *Lake Alau* that is located some 15 km south of the Maiduguri city. All the samples were stored in laboratory at 4°C to avoid possible alteration of the original properties of the samples before the commencement of the analyses.

Sample Analyses: The pH and electrical conductivities of the samples were determined using WTW-Multiline P4 Universal Meter. Chemical analyses of the samples were carried out using appropriate certified and acceptable international procedures outlined in the Standard Methods for the Examination of Water and Wastewater [8]. Sodium (Na) and potassium (K) were analyzed by flame photometric method, calcium (Ca) by EDTA titration, magnesium (Mg) by calculation after EDTA titration of calcium and total hardness. Heavy metals were analyzed using UNICAM 969 atomic absorption spectro-photometer. Total hardness was obtained as the sum of the concentrations of Ca^{2+} and Mg^{2+} present in the samples. An ionic error balance was computed for each chemical sample and used as a basis for checking analytical results. In accordance with international standards, results with ionic balance error greater that 5% were rejected.

RESULTS AND DISCUSSION

The temperatures of the samples vary widely from 20.5°C to 36.1°C with an average of 28.3°C (Table 1). Most of the water samples were found to have temperatures higher than the natural background levels of 22°C-29°C for waters in the tropics [9]. While cool waters are generally more palatable for drinking purposes, waters with temperature above the normal human body temperature are usually not preferred in tropics, though not totally objected. There is no guideline value recommended WHO [4] with regards to temperatures of drinking water.

Table 1: Concentration (mgl^{-1}) of some elements in Tap and Borehole waters in Maiduguri

	Location	TEMP.°C	*p*H	Na	K	Ca	Mg	Hard-Ness	Cr	Fe	Zn	Cd
A1	Mairi BW	31.3	7.4	3.084	0.891	4.912	3.926	8.838	0.028	0.018	1.622	0.01
A2	Mairi TW	20.5	7.786	3.851	1.222	3.119	4.825	7.944	0.001	0.023	1.002	0.001
B1	Polo BW	38.5	6.296	2.019	2.951	1.248	0.982	2.23	2.31	0.022	1.223	0.863
B2	Polo TW	30	7.574	2.98	3.981	2.008	1.298	3.306	1.11	0.0461	1	0.222
C1	Federal lowcost BW	36.1	7.932	4.123	0.688	0.864	0.926	1.79	3.822	0.019	2.322	2.1
C2	Federal lowcost TW	30.2	7.402	4.982	0.862	0.921	1.234	2.155	1.343	0.029	1.201	0.112
D1	Bulumkutu BW	33.5	6.143	2.946	1.608	5.127	3.825	8.952	4.389	0.012	3.256	2.222
D2	Bulumkutu TW	26	6.93	3.256	2.198	6.234	4.489	10.723	2.21	0.089	1.321	1.321
	WHO (1993) MPL		6.5-8.5	200	195	75	150	0.003	0.3	3.000	0.003	

M.P.L = Maximum Permissible Limit

Table 2: Hardness classification of water

Water status	Hardness mgl^{-1}
Soft	0-60*
	0-75†
Moderately Hard	61-120*
	76-150†
Hard	121-180*
	151-300†
Very Hard	>180*
	>300†

† After Freeze and Cherry [13]
*After Hem [14]

However, high temperature may not be desirable as it encourages the growth of micro- organisms, which have the potentials of altering the taste, odor and color of the water. Metal corrosion problems are also associated with high temperature especially when the *p*H of the water happens to be skewed to extreme.

The *p*Hs of the samples was generally within the 6.5 to 8.5 as recommended by WHO [4] (Table 1). But the *p*H of Polo BW (6.296) and that of Bulumkutu B.W (6.143) shows that they are mildly acidic. Acidity increases the capacity of the water to attack geological materials and leach toxic trace metals into the water, making it potentially harmful for human consumption. Thus, the moderate acidity of these waters suggests that the waters were susceptible to some degree of trace metal pollution, possibly present in the rock matrix through which the water percolated. Furthermore, acidity gives a sour taste to water. The *p*H for waters thus points that the consumers of these waters may suffer some taste problem.

Na, K, Ca, Mg, Fe and Zn are among the general elements essential for human health and metabolism and should be available in normal drinking water [10]. However, if one or more of these elements occur in the water above certain limits, the water may become objectionable to consumers and even become hazardous to health. When Na+ exceeds the recommended limit of 200 mgl^{-1}, the water tastes salty. It is noticeable from Table 1 that with exception of Zn, theses major constituents are generally low and well below the WHO recommended guideline maximum values for water potability. They, therefore, pose neither physiological nor aesthetic problem to the usage of the waters studied for drinking or domestic purposes. But the Zn concentration in borehole waters in Bulumkutu zone slightly exceeded the recommended WHO limit. Caution should be exercised if it is to be consumed.

Carlos *et al*.[11] reported that consumption of Zn in excess of WHO recommended value may lead to gastrointestinal disturbances such as pain, cramping, nausea and vomiting, diarrhoea and pancreatic toxicity.

As at the time of this study, all of the water samples fall within the "Soft" category as compared to the hardness status as presented in Table 2. Total hardness is an important criterion for ascertaining the suitability of water for domestic, drinking and many industrial uses [12]. The use of the hard waters for domestic purposes may, therefore, lead to soap wastage or more soap requirement for washing, it also bring eye and skin discomfort. Hard water therefore has both economical and medical implications. Moderate hardness often referred to as temporary hardness can be treated by simple boiling.

The WHO [4] standard for cadmium and chromium for drinking water is 0.003mgl^{-1} respectively. With exception of tap waters from Mairi zone, all the waters studied showed Cr and Cd values were far above the recommended value. Cadmium is a highly toxic metallic pollutant that does not have any metabolic benefit. For instance, people will suffer from renal tubular disease if they consume Cd in excess of the permissible level [15]. The presence of these metal elements is attributed to the rock through which the water must have passed, or which forms the aquifer from which Maiduguri inhabitants get their water.

Most of the waters therefore need to be appropriately treated with respect to these two major toxic metallic elements before consumption.

CONCLUSION

This study investigated the potential danger or otherwise that may be associated with drinking tap and borehole water in Maiduguri. It found that the concentration of chromium and cadmium in the waters samples are in excess of the WHO [4] recommended safe limits for drinking water. Zn was also found to be present above the WHO [4] recommended safe limits in tap waters of Bulumkutu zone. Also, borehole waters from Bulumkutu and Polo zones are slightly acidic. All other elements and parameters studied however indicated that the waters were within the No-Problem zone. It is therefore recommended that commensurate measures be taken by the appropriate authorities to ensure proper treatment of the waters to safeguard the health of the innocent consumers with regard to *p*H, Zn, Cr and Cd in the affected zone(s). Routine analyses of this type should also be embarked upon on a regular basis. It is also recommended that the catchment area that forms the source of water meant for consumption should be examined for septic facilities and other potential sources of contamination within or near it and appropriate remedial measures be taken to forestall possible further contamination of the waters beyond it present tolerable state. Hygienically approved and scientifically feasible technologies for wastes disposal (both solid and liquid) should be explored and adopted to check the possibilities of indiscriminate land-dumping of potentially hazardous wastes materials. Water users should also be on watch and to report every exceedance of any physical or chemical standard to the appropriate authorities in order to sustain water's fitness for consumption.

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