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ANALYSIS OF SELECTED PHYSICAL AND CHEMICAL PARAMETERS IN DRINKING WATER SAMPLES COLLECTED FROM COTTON TREE COMMUNITY, ROBERTSFIELD HIGH WAY, LIBERIA

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ABSTRACT

Access to safe drinking water is a daunting challenge for most residents of sub-Saharan Africa, especially West Africa. Liberia being a West African nation, the availability of safe drinking water is a very serious issue in the water and sanitation and health sector. Montserrado County, one of the political sub-division of Liberia in which the capital, Monrovia, is located has been experiencing serious problem with safe drinking. Residents are often compelled to obtain drinking water from several sources including hand-dug wells, bore-holes, public water supply and even local streams. In this study, the physical and chemical quality of four drinking water sources, used by residents of Cotton Tree Community located on the Robert's international Airport high way, were assessed to determine their safety for human consumption. The levels of Lead, Mercury, Cadmium, Chromium, Zinc, Phosphates, Nitrites, Nitrates and Sulfates were determined using a DR/890 Spectrophotometer (Hach) with appropriate reagents and standards. Turbidity was measured with formazin standards. The pH of the samples was recorded. At all four sampling points, the pH, turbidity, Lead, Zinc and Sulfate levels were all below Ministry of Health (MOH) and World Health Organization (WHO) permissible limits. High concentrations of Nitrate, Phosphate and hexavalent Chromium were recorded at all sampling points. Nitrite and Mercury levels were higher than MOH WASH and WHO limits at two points, while Cadmium concentrations were within permissible limits at all points except one. The results obtained in this study indicate that the water from the studied water sources is not suitable for human consumption based on some of the selected parameters and may pose a potential health risk to consumers. There is thus a need for urgent intervention in order to remedy the situation.

KEYWORDS: Safe drinking water, Sub-Saharan, Turbidity, Spectrophotometer.

INTRODUCTION

Water is an essential resource for living systems, industrial processes, agricultural production and domestic usage. It can be obtained from two main natural resources: groundwater and surface water. Groundwater includes borehole water and well water while surface water includes fresh water lakes, rivers, streams, etc. Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock or formations. A unit of rock or an unconsolidated deposit is referred to as an aquifer when it can yield a usable amount of water. Groundwater can be a long term reservoir of natural water cycle as opposed to short term reservoirs. The availability of borehole water has major public health benefits, since it typically reduces the risks of the public contracting water-borne diseases. Certain problems have beset the use of groundwater around the world. Just as river waters have been over used and polluted in many parts of the world, also the aquifers. The quality of these ground water sources is affected by the characteristics of the media through which the water passes on its way to the ground water zone of saturation It has been reported that the heavy metals discharged by industries, traffic, municipal wastes, hazardous waste sites and from fertilizers used for agricultural purposes and accidental oil spillages from tankers can result in a steady rise in contamination of ground water (Biney *et al.*, 1991).

Portable water is water that is safe to drink or to use for food preparation, without risk of health problems. The chemical quality of water refers to the nature and concentration of dissolved substances (such as organic and inorganic chemicals including metals), and the Physical quality refers to water quality properties such as conductivity, hydrogen ion concentrations (pH), turbidity and temperature (DWAF, 2000). The presence of microorganisms as well as dissolved substances and physical parameters should not be above specified recommended limits in order for the water to be regarded as suitable for human consumption. The nature and content of chemical substances affect life in groundwater but also affect the health of individuals consuming this water (Elleta *et al.*, 2010). Naturally, groundwater contains some impurities, even if it is unaffected by human activities. The types and concentration of natural impurities depend on the nature of geological material through which groundwater moves and the quality of recharge water (Balakrishnan et al., 2011). As reported by Brandi *et al*. (2006), groundwater moves through sedimentary rocks and soil and picks up a wide range of compounds such as Magnesium, Calcium and Chlorides.

Ground water and surface water quality may also be affected by the presence of heavy metals. The term heavy metal refers to a group of metals and metalloids with specific gravity greater than $4g/cm^3$ or 5 times or more than that of water. Some metals such as Copper, Iron and Zinc are nutritionally essential for healthy life, but can be toxic at high concentrations (Duruibee*et al.*, 2007). Heavy metals pollution can arise from many sources but most commonly from purification of metals in industries. They are common in industrial applications such as in the manufacture of pesticides, batteries, alloys, electroplated metal parts, textile dyes, steel, etc. Many of these products are in our homes and add to the quality of life. Heavy metals exist in water in colloidal particulate and dissolved phases, with the occurrence in water bodies being either of natural origin such as eroded minerals, leaching of ore deposits and volcanic extruded products or of anthropogenic origin which includes solid waste disposal, industrial or domestic effluents and harbor channel dredging. Groundwater assessment and chemical analysis for heavy metals is very important as they are harmful and insidious pollutants because of their non-biodegradable nature and their potential to cause adverse effects in humans Hg (mercury), Cd (cadmium) and Pb (lead) have been reported to be dangerous to health and to the environment. Toxic metals may also replace other substances in other tissue structures (Duruibee*et al.*, 2007). These tissues such as the arteries, joints, bones and muscles are weakened by replacement processes. Toxic metals can alter biochemical activities such as inhibition of enzymes, genetic damage, cardiovascular problems and hypertension. There is an increase in epidemiological evidence indicating an association between water quality and mortality from cardiovascular and other chronic diseases. Statistically, significant positive correlation between mortality from various types of cancer and concentration of several trace elements in water supplies has also been shown (Moodley *et al*., 2007).

Toxic chemicals and heavy metals routinely penetrate and pollute our natural water sources thereby exposing consumers to long term health consequences such as liver damage, cancer and other serious health conditions. Most borehole water and well water in local communities of Nigeria are not safe for drinking due to heavy industrial and environmental pollution (Kalagbor et al, 2013). If water is badly polluted, it might be obvious from its appearance or odour. It could be colored or turbid or have solids, oil or foam floating on it. Some may have odour or smell as a result of industrial effluents discharged into them. However, many harmful materials and toxic metals in water are invisible and odorless and so in order to go beyond the obvious to determine these materials and their concentration (levels), chemical analysis must be conducted (Jackson *et al.*, 2007).

This study therefore, was geared toward investigating the presence and concentration of Lead, Mercury, Cadmium, Chromium, Zinc, Phosphates, Nitrites, Nitrates and Sulfates and of selected physical and chemical parameters in drinking water samples collected from four sampling points (2 hand pumps, 1 well and 1 stream) in Cotton Tree Community. The four sampling points were selected because they are the points frequently used by residents and other consumers.

MATERIALS AND METHODS

A. Sample Collection and Preparation

A total of eight drinking water samples from four sampling points (two samples per sampling points) were collected. Water samples were randomly collected in June 2016, during the raining season, from four points, namely, 2 public water supply points, 1 well and 1 stream in the Cotton Tree Community in plastic bottles (300 mL). Upon collection, the samples were transported to the Environmental Protection Agency's (EPA) laboratory for analysis. All samples were placed in a freezer at 4^oC and analyzed within 24 hours of sampling to avoid contamination.

All plastic containing the samples were placed in glassware and the glassware containing the samples were first soaked in detergent solution overnight; the plastics were rinsed with distilled water and placed in the glassware and soaked in 10% (v/v) HNO_3 overnight. They were later rinsed with distilled water and the same procedure was repeated using 0.5% (w/v) $KMnO_4$, and again rinsed with distilled water. All washed plastic and glassware were allowed to air-dry prior to use.

The water samples were analyzed for the presence of Hg, Cd, Pb, Zn, NO_2^-, NO_3^-, PO_4^{-3} and $SO4^{-2}$, with appropriate reagents and standards. Turbidity was measured using a T-100 Turbidity-Meter (Oakton) with formazin standards. The pH of the samples was recorded using a Digital Microprocessor, Bench Cyber Scan pH 510 (Orion).

Prior to the analysis, the samples were thawed at room temperature, and all the instruments were fully calibrated.

The laboratory procedures were carried out using appropriate instruments and reagents. For each contaminant, a step-by-step analysis was conducted using the instrument operational manual.

RESULTS AND DISCUSSIONS

A. Physico-chemical properties of drinking water in Cotton Tree Community

The Physico-chemical parameters are directly related to the safety of the drinking water for human consumption. These parameters are used to find out the quality of water for drinking purpose. A total of ten (10) physico-chemical parameters were investigated using laboratorial experiments.

The physical and chemical water quality parameters analyzed in the laboratory were pH, Turbidity, Nitrate (NO_3^-), Nitrite (NO_2^-), Phosphate (PO_4^{-3}), Sulfate (SO_4^{-2}), Zinc (Zn), lead (Pb), Mercury (Hg) and Cadmium (Cd). The results are summarized in Table 1.0.

Table 1.0: Mean values of selected physico-chemical parameters of water at different sampling points in Cotton Tree Community.

Parameter, Unit	Well	Public water supply #1	Public water supply #2	Stream	**WHO Standard	*MOH Standard
pH	6.9	7.2	7.5	6.6	6.5-8.5	6.5-8.0
Turbidity, NTU	3.23	0.85	0.82	6.20	≤5.0	≤5.0
Lead, mg/L	0.00	0.00	0.00	0.08	0.01	≤0.1
Mercury, mg/L	0.02	0.00	0.00	0.04	0.001	≤ n.d
Cadmium, mg/L	0.00	0.00	0.00	0.04	0.003	≤ n.d
Chromium,	0.32	0.02	0.04	0.52	0.05	≤ 0.05
Zinc, mg/L	0.03	0.13	0.05	0.00	3.00	≤ 1.00
Sulfate, mg/L	2.00	23.00	4.00	2.00	250.00	≤ 150.00
Nitrate, mg/L	1.60	1.10	1.80	0.70	50.00	≤ 40.00
Nitrite, mg/L	5.00	0.10	0.20	0.00	1.00	≤ 0.10
Phosphate, mg/L	1.96	0.00	0.01	2.16	0.01	≤ 0.01

nd = not detected

pH

According to the WHO, the minimum and maximum allowable pH ranges from 6.5 to 8.5 for portable water. There is no health risks related to consuming slightly acidic or basic water. However, when water has a pH that is too low, it will lead to corrosion and pitting of pipes in plumbing in distribution systems. (Herreros, 2008)

Water sources in Cotton Tree Community had a pH ranging from 6.6 to 7.5 (Table 1-0). The lowest pH was recorded for the stream, while the highest pH was recorded for Hand pumps # 2. The pH for all the water samples fell within the recommended limits of WHO and the Ministry of Health of Liberia (MOH), indicating that the water in the study area is safe with respect to pH.

Turbidity WHO (2012) standard for turbidity states that the maximum allowable permissible limit value must always be low, preferably lower than 1 NTU. It is recommended that for water to be disinfected, the turbidity should be reliably less than 5 NTU and preferably have a median value of less than 1 NTU. (Duruibe et al, 2007)

Figure 1-1 shows the results of turbidity of drinking water samples at the sampling points. The results show that the turbidity of the water at three of the four sampling points fell much lower than the maximum permissible value recommended by both WHO and Ministry of Health of Liberia (MOH). The stream recorded the highest turbidity (6.20 NTU). This high turbidity could be attributed to the presence of suspended organic matter in the stream.

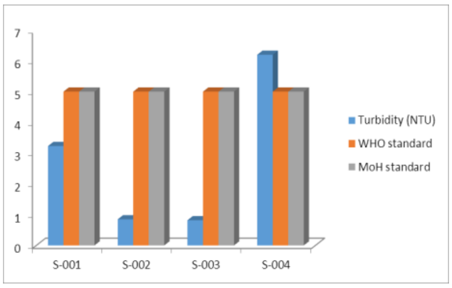

Figure 1-1: Turbidity of water samples as compared to the WHO and MOH Maximum Permissible Limits

Sulfate

High sulfate levels (1000 mg/L) have been shown to have a laxative effect on humans and can cause mild gastrointestinal irritation. According to WHO (2012) guideline, the maximum permissible limit of sulfate in drinking water supply is limited to 250mg/L. The laboratory results of the study area at all sampling points as shown in Table 1.0 and Figure 1-2 were far below the maximum permissible limit set by both WHO and Ministry of Health of Liberia,. Therefore, the results clearly indicate that there is no significance effect on the health of the users considering sulfate levels.

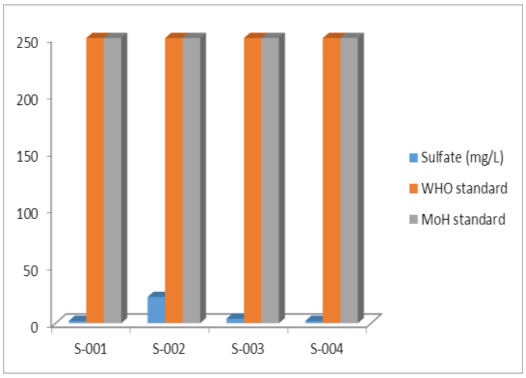

Figure 1-2: Sulfate content of water samples as compared to the WHO and MoH Maximum Permissible Limits

Phosphate

In this study, phosphate levels ranged from 0.01 to 2.16 mg/L. The levels reported for samples collected from the stream and well exceeded both the WHO and Ministry of Health of Liberia (MOH) limits; thus indicating that the water from both of those sampling points are unsafe for human consumption.

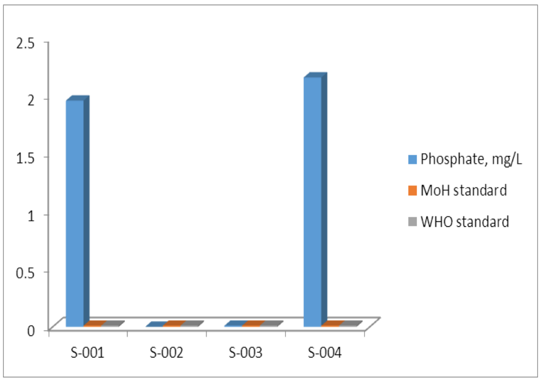

Figure 1-3: Phosphate content of water samples as compared to the WHO and MOH Maximum Permissible Limits

Nitrate and Nitrite

Nitrate is a compound of nitrogen and oxygen that is found in many everyday food items such as spinach, lettuce, beets, and carrots. There are usually low levels of nitrates that occur naturally in water but the majority run-off from, animal feedlots, wastewater and sludge, septic systems, and nitrogen fixation from the atmosphere by legumes, bacteria, and lightning.

Generally, the ground water has high nitrate concentration than surface water because of the percolating sewage, industrial waste, chemical fertilizers, leaches from solid waste landfills, septic tank effluents to the ground water.

Nitrites concentration in the well fell above both WHO and Ministry of Health of Liberia limits (Figure 1.4a). Nitrates levels all the tested samples fell well below both WHO and MOH limits (Figure 1.4b).

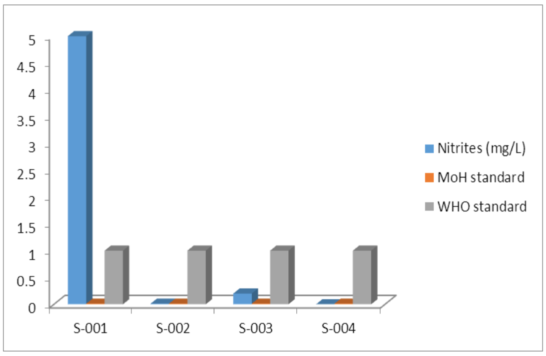

Figure 1-4a: Nitrate content of water samples as compared to the WHO and MOH Maximum Permissible Limits

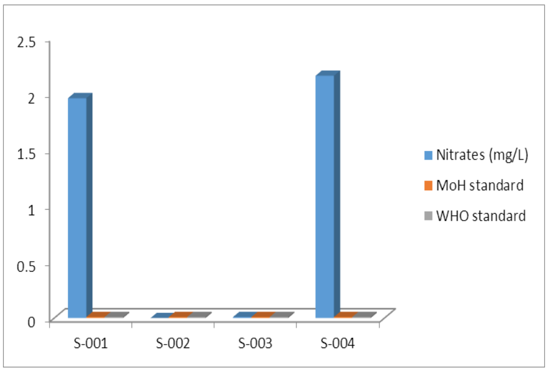

Figure 1-4b: Nitrate content of water samples as compared to the WHO and MOH Maximum Permissible Limits

Levels of cadmium could be higher in areas supplied with soft water of low pH, as this would tend to be more corrosive in plumbing systems containing cadmium (WHO/FAO, 1995).

Cadmium levels were undetected in all but one sample (the stream). The stream recorded cadmium concentration of 0.04mg/L (Figure 1-5), a figure greater than both WHO and Ministry of Health of Libria (MOH) acceptable limits. This indicates that the water from the stream is unsafe for human consumption.

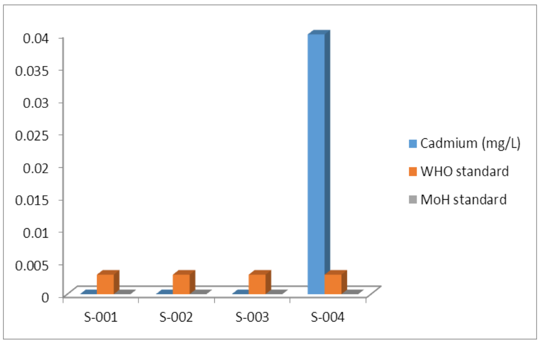

Figure 1-5: Cadmium content of water samples as compared to the WHO and MOH Maximum Permissible Limits

Lead

Lead (Pb) contamination poses a serious threat to the safety of drinking water in most countries. Excessive amounts of lead place adults at higher risk for cancer, stroke, kidney disease, memory problems and high blood pressure. Lead can cause premature birth, reduced birth weight, seizures, hearing loss, behavioral problems, brain damage, learning disabilities, and a lower IQ level in children. (Duruibe et al, 2007)

Lead levels were undetected in all but one sample (the stream). The stream recorded lead (Pb) concentration of 0.08mg/L (Figure 1-6), a figure greater than WHO standard but slightly lower than Ministry of Health of Liberia acceptable limits for drinking water.

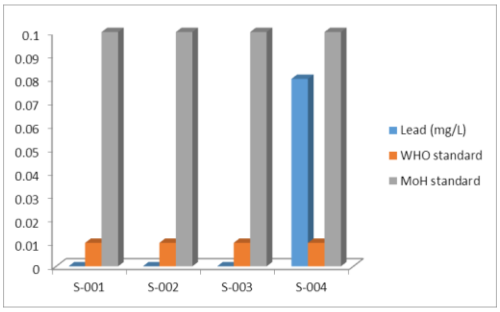

Figure 1-6: Lead content of water samples as compared to the WHO and MH Maximum Permissible Limits

Mercury

Mercury levels in the study ranged from 0.00 to 0.04 mg/L (Table 1.0). Mean mercury concentrations for the well and stream were 0.02 and 0.04 mg/L respectively; far higher than the acceptable WHO and Ministry of Health of Liberia (MOH) limits. These levels could be attributed to background mercury levels in rainwater.

According to WHO/FAO (1996), levels of mercury in rainwater are in the range 5–100 ng/L, but mean levels as low as 1 ng/liter have been reported. Naturally occurring levels of mercury in groundwater and surface water are less than 0.5 µg/L, although local mineral deposits may produce higher levels in groundwater. In 16 groundwaters and 16 shallow wells surveyed in the USA, mercury levels exceeded the maximum contaminant level of 2 µg/L set by the US Environmental Protection Agency for drinking-water. An increase in the mercury concentration up to 5.5 µg/L was reported for wells in Izu Oshima Island (Japan), where volcanic activity is frequent. The concentration range for mercury in drinking-water is the same as in rain, with an average of about 25 ng/liter.

The results in this study (Figure 1-7) indicate that the well and stream water are generally unsafe for drinking due to alleviated mercury levels.

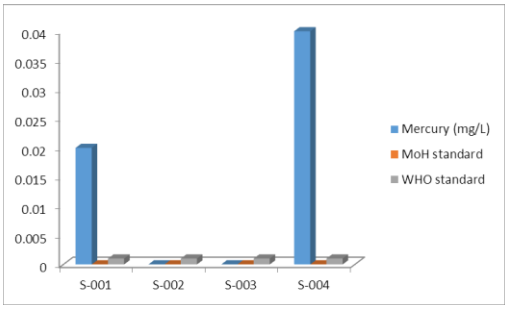

Figure 1-7: Mercury content of water samples as compared to the WHO and MOH Maximum Permissible Limits

Zinc.

Zinc levels reported in the present study (0.03 to 0.13 mg/L) were below both WHO and MOH acceptable limits (Table O-1). Zinc levels in the current study were generally lower than those reported in other studies. In natural surface waters, the concentration of zinc is usually below 10 µg/L, and in ground waters, 10– 40 µg/L . In tap water, the zinc concentration can be much higher as a result of the leaching of zinc from piping and fittings. The most corrosive waters are those of low pH, high carbon dioxide content, and low mineral salts content. In a Finnish survey of 67% of public water supplies, the median zinc content in water samples taken upstream and downstream of the waterworks was below 20 µg/L; much higher concentrations were found in tap water, the highest being 1.1 mg/L . Even higher zinc concentrations (up to 24 mg/L) were reported in a Finnish survey of water from almost 6000 wells (WHO/FAO, 1996).

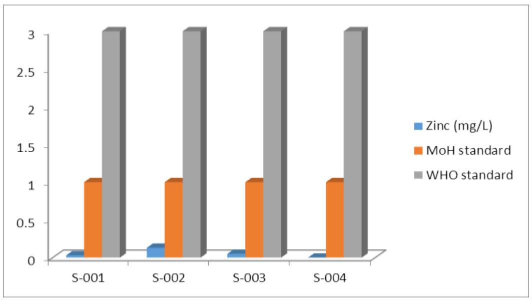

Figure 1-8: Zinc content of water samples as compared to the WHO and MoH Maximum Permissible Limits

Chromium hexavalent

Chromium levels reported in the study ranged from 0.02 to 0.52 mg/L. The well and stream recorded hexavalent chromium levels of 0.32 and 0.52 respectively; far above both WHO and Ministry of Health of Liberia (MOH) acceptable limits (Table 4-1); suggesting that both the well and stream water samples are unsafe with respect to chromium. The elevated levels of hexavalent chromium may be attributed to corrosion from car wash stations, welding shops and residues from construction activities in the area.

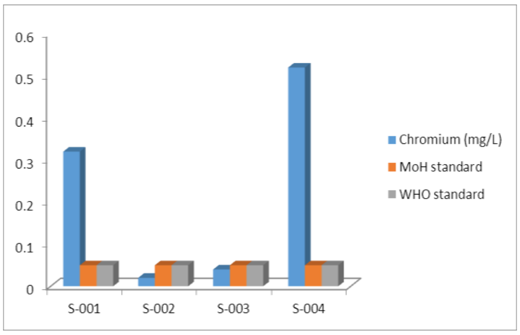

Figure 1-9: Chromium content of water samples as compared to the WHO and MOH Maximum Permissible Limits

CONCLUSIONS

This study determined the levels of selected physical and chemical parameters (mercury, lead, cadmium, zinc, nitrates, nitrites, sulfates, phosphates, pH and turbidity) in a bid to assess the quality of the drinking water consumed by residents of Cotton Tree.

The research made the following findings: The levels of pH, turbidity, zinc, nitrates and sulfates were all within WHO and MoH permissible limits, mercury, chromium and phosphate levels in the stream and well were above both WHO and MoH limits., nitrites concentration in the well was above both WHO and MoH limits, and Cadmium concentration in the stream was above both WHO and MoH limits. Based on these findings it can be concluded that water from both the stream and well are unsafe for hum an consumption and may pose potential health risks to consumers.

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