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Heavy Metals and Physicochemical Assessment of Some Selected Sachet Water Around Sokoto Metropolis, Nigeria

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Sachet water is commonly consumed as portable water in almost every part of Nigeria including Sokoto state in Northern part. Present study, assessed levels of heavy metals and physicochemical properties in five brands of sachet water. Levels of Lead, Cadmium, Chromium, Iron, Zinc and Manganese were determined using Atomic Absorption Spectrophotometer (AAS). The pH of the samples was measured using pH Meter. Taste, colour and odour were analyzed using senses of taste, sight, and smell respectively. Samples B, C, D and E were found to contained high Cadmium levels (mg/L) 0.0048, 0.0127, 0.0130 and 0.0061 respectively. Samples A, C and E were found to contained high mean levels (mg/L) of Chromium 0.0837±0.0645, 0.1674±0.0171 and 0.1116±0.0214 respectively, compared to WHO and SON limit. samples D and E have high Iron levels (mg/L) of 0.4642±0.0128 and 0.4642±0.0128 respectively compared to WHO and SON limit. All the water samples analyzed in this study have elevated levels of Manganese compared to SON and WHO limit. Similarly. All the water samples analyzed have pH below the SON and WHO recommended limit except sample A. the water samples analyzed were found to be tasteless, odorless and colorless. We found some sachet water to contained heavy metals above the limit set by regulatory bodies, and consumers may be exposed to hazards. Water samples intended for drinking purposes should be treated to reduce the levels of heavy metals present in them to the levels that are not harmful to the human body.

Keywords: Heavy metals, Sachet water, Sokoto, Spectroscopy, and Physicochemical.

1. Introduction

Water is one of the indispensable resources for the continued existence of all living things including man, and adequate supply of fresh and clean drinking water is a basic need for all human beings (Edema *et al.,* 2011). Sachet water is any commercially treated water, manufactured, packaged and distributed for sale in sealed food grade containers and is intended for human consumption. The production of sachet water in Nigeria started in the late 90s and today the advancement in scientific technology has made sachet water production one of the fastest growing industries in the country. Water consumers are frequently unaware of the potential health risks associated with exposure to water borne contaminants which have often led to diseases like diarrhea, cholera, dysentery, typhoid fever, legionnaire's disease and parasitic diseases (Omalu *et al.,* 2010). In nature, all water contains impurities, as water flows in streams, accumulate in lakes and filters through layers of soil and rock in the ground, it dissolves or absorbs substances it comes in contact with, which may be harmful or harmless (Kris and Ekweozor, 2004). Purified raw water where physical, chemical, and microbial contaminants are removed, package into suitable containers with label is known as package water, the quality of package water is said to be governed by its eventual use (WHO, 2008). One of the major and critical problems in most developing countries today is the provision of an adequate and safe drinking water to its populace (Dinka, 2018). In Nigeria, most potable water sources get contaminated through anthropogenic activities. For instance, effluents of manufacturing industries such as mining *(Miller et al.*, 2004). Now efforts are currently being made by Nigerian Government to enhance environmental condition of the country particularly to control the industrial pollution (Ebiare and Zejiao 2010).In Nigeria, rural areas with low income are the most affected with water pollution (Muta'aHellandendu, 2012). One of the leading causes of water-borne diseases is intake of water without proper sanitation. Heavy metals found in several potable water sources are due to the natural and anthropogenic activities and are toxic to both health and environment at certain concentration (Burke *et al.,* 2011; Oehmen *et al.,* 2006) above the permissible guideline set by regulatory bodies. Drinking water that is fit for human consumption is expected to meet the WHO standards and be free from physical and chemical substances and microorganisms in an amount that can be hazardous to health (Yusuf *et al.,* 2015)

Metals with specific gravity of ≥5cm^3 are known as heavy metals (Idris *et al.,* 2013). Heavy metals' inspection in drinking water sources has been a serious concern to environmental scientists in recent times (Muhammad *et al.,* 2011). Frequently occurring heavy metals in effluents are iron, manganese, copper, lead, cadmium, chromium, mercury, cobalt, nickel etc. (Kelepertzis, 2014; Muhammad *et al.,*2011). Heavy metals present in drinking water can accumulate in human body even at a lower concentration (Elinge*et al.,*2011) depending on the type. These heavy metals have some adverse effects on the living beings when they exceed permissible limit in potable water sources. Mercury, lead, zinc, cadmium, iron, cobalt, manganese, and chromium have been quietly studied and reported in some drinking water in Nigeria (Elinge*et al.,* 2011). Exposing humans to heavy metals above the permissible limits, can lead to disease conditions such as skin, internal cancers, cardiovascular, and neurological disorders (Cobbina *et al.,* 2015). Koloand Waziri (2012) reported that, heavy metals have the ability to accumulate in visual and sensory organs this makes them very toxic and mostly carcinogenic. They also have the ability to affect the tissue and other organs and cause various types of diseases including cancer. Accumulation of heavy metals in the human body poses serious health risks and have been the cause of many epidemics particularly in Northern part of Nigeria (Kiyawa *et al.,* 2019)

Therefore, this study evaluates the concentration of heavy metals in some selected sachet water samples commonly consumed within Sokoto metropolis, concentrations of the metals were compared World Health Organization (WHO), 2011)and Standard organization of Nigeria (SON), 2007permissible limit.

2. Materials and methods

2.1 Samples collection and treatment

A total of five sachet water samples were purchased from five different manufacturers within Sokoto metropolis during hot season (May-June 2019) when sachet water production is high to meet the people demand. Two samples were collected from each manufacturer containing 50cl sachet, the samples were then transferred into polythene bottles. The samples were labelled as sample A, B, C, D and E.

2.2 Heavy metal Analysis

Method: Concentration of heavy metals in water samples were analyzed using Atomic Absorption Spectrophotometer as modified by(Abdeldayem, 2020).

50 mLof each water sample was transferred into evaporating dish, 10mL concentrated nitric acid HNO_3 were added for each sample, which were placed on steam bath to evaporate to 25mL. The samples were transferred to sample bottles, followed by addition of deionized water (distilled water) up to 50mL mark. It was then taken to AAS (AA Model 306) machine for analysis.

2.3 Physicochemical Analysis

The pH of the samples was measured using pH meter (OHAUS, USA), taste, colour and odour were analyzed using senses of taste, sight, and smell respectively. The pH meter was dip into each sample of water to determine the level of pH(AOAC, 2006). Three replicates analysis were used in the study.

2.4 Statistical analysis

Values are presented as mean and Standard deviation and were compared with standardized values for heavy metals and physicochemical parameters in water set by World Health Organization (WHO 2011) and Standard organization of Nigeria (SON, 2007).

3. Results and Discussion

3.1 Levels of heavy metals in sachet water samples

The results of the levels of Cr, Cd, Fe, Pb Mn and Zn in sachet water from five different samples within Sokoto metropolis is presented in (Table 1) below.

Table 1 Levels of heavy metals in five different samples.

Elements	Sample A	Sample B	Sample C	Sample D	Sample E	WHO	SON
Cadmium (mg/L)	0.0012±0.0002	0.0048±0.0041	0.0127±0.0038	0.0130±0.0010	0.0061±0.0014	0.003	0.003
Chromium (mg/L	0.0837±0.0645	0.0225±0.0032	0.1674±0.0171	0.0236±0.0215	0.1116±0.0214	0.5	0.5
Iron (mg/L)	0.0238±0.0165	0.1229±0.0128	0.1027±0.5875	0.4642±0.0128	0.4642±0.0128	0.3	0.3
Lead (mg/L	BDL	BDL	BDL	BDL	BDL	0.03	0.01
Zinc (mg/L)	0.5388±0.1898	0.3429±0.1022	0.3394±0.0208	0.3904±0.1457	0.3194±0.0581	>3.0	0.5
Manganese	1.5045±1.078	0.2912±0.0839	0.8270±0.7848	0.3372±0.3300	0.0562±0.0066	0.05	0.05

Values represents Mean±SD of three replicate analysis

BDL: Bellow Detection Limit; **WHO**: World Health Organization Standard **(WHO**, 2011)

SON: Standard Organization of Nigeria (SON, 2007)

Table 2 Physicochemical parameters in five different water samples

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E	WHO	SON
pH	6.27±0.02	3.48±0.01	3.41±0.01	3.06±0.01	3.12±0.02	6.5-9.5	6.5-8.5
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
Test	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless

Values represents mean±SD of three replicate analyses

Heavy metals enter the environment through natural and anthropogenic means. Such sources include industrial discharges, mining, erosion, sewage discharge water, waste effluents etc. the main route of exposure for most people is through food and water. Consistent exposure to heavy metals at low levels can cause great adverse effects [4,11,19]. From the analysis carried out on the sachet water samples in this study, it was discovered that lead was not detected in all the water samples analyzed Table 1.0. Cadmium concentration in the water samples ranges from 0.0012 to 0.0130 (mg/L). Sample B, C and sample D were found to contained cadmium levels above the WHO and SON permissible limit of 0.003 (Table 1.0), This is in agreement with previous study by (Olatundun and Adelusi, 2017) which reported high levels of cadmium in some bottled and sachet water samples obtained in Lagos Nigeria. Similarly, our study is in line with study conducted by Raji *et al.,* (2015) that shows high levels of cadmium in water samples obtained from River Sokoto. Cadmium has a biological half-life of 15 to 30 years, making cadmium excretion to be nearly impossible, therefore it accumulates in human body and affects some vital organs which include lungs, liver, kidney, brain, central nervous system etc. Other damages include hepatic toxicity, reproductive, hematological and immunological toxicities (Mudgal *et al.*, 2010). Ionic form of cadmium, Cd^{2+} have been reported to induces haem oxygenase, which causes a decline in cytochrome P450 levels (Moore, 2004). Furthermore, cadmium has been shown to induce changes in carbohydrate status and key enzymes of carbohydrate metabolism, glycolysis and pentose phosphates pathways (Devi *et al.,* 2007).

Chromium is highly carcinogenic; hence, minimal intake has been recommended (WHO 2011). Chromium concentration in this study ranges from 0.0225 to 0.1674 (mg/L). Sample A, C and E were found to contained high levels of Chromium compared to WHO and SON limit (Table 1.0). Our finding is in concordance with Raji *et al*., (2015), who reported high levels of Chromium in tap water samples within Sokoto Metropolis. Similarly, High levels of Cr seen in food and drinking water should be a great concern to authorities. Hexavalent form of chromium is the most toxic species of chromium, although other species such as Chromium (III) compounds are less toxic and cause little or no health problems. Chromium (VI) has the ability to be corrosive and it can also lead to allergic reactions in the body. Hence, breathing high levels of chromium (VI) can lead to irritation to the lining of the nose and nose ulcers. It can also cause anemia, irritations and ulcers in the small intestine and stomach, damage sperm and male reproductive system. Extreme redness and swelling of skin are among allergic reaction as a result of chromium. Exposure of extremely high doses of chromium (VI) compounds to humans can result in severe cardiovascular, respiratory, hematological, gastrointestinal, renal, hepatic and neurological effects and possibly death (Engwa *et al.,* 2018).

Iron levels were found to be within permissible limit of SON and WHO (0.3 mg/L) except in samples D and E which have Iron levels above recommended levels. Bello *et al*., (2018) reported a high level of Iron in water samples obtained from Kware lake in Sokoto state. High level of Iron can lead to hemochromatosis, which can lead to liver and pancreatic damage; early symptoms include fatigue, weight loss and joint pain(Mohod & Dhote, 2013). elevated levels of iron in drinking water may change the appearance, taste, odor of water and may even enhance the growth of bacteria in the water system.

Results of the analysis indicate that Zinc contents was within permissible limit of SON and WHO in all the samples analyzed. Zinc concentration between 3 and 5 mg/L is good for healthy living ATSDR (2017). Toxicity of Zinc in human occur when its concentration approaches 400 mg/kg and 3 mg/L in soil and water, respectively. This is characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite and nausea. Zinc have a protective effect against the toxicities of both cadmium and lead (Fergusson, 1990). Toxicity of zinc is influenced by many factors such as the temperature, hardness and pH of the water WHO (2011).

Manganese occurs naturally in food and water; it is an essential element for human and other animals. The analysis shows that manganese levels in all the water samples analyzed is significantly above SON and WHO guideline of 0.05 mg/L. our result is in agreement with previous study by (Oyem *et al.,* 2015) that reported a high content of manganese in groundwater of Agbor and Owa communities of Nigeria. Manganese is regarded as essential element that is beneficial to the body. However, recently it became a metal of global concern when toxic methylcyclopentadienyl manganese tricarbonyl (MMT), was used as a gasoline additive. MMT has been shown to be an occupational manganese hazard and linked with the development of Parkinson's disease-like syndrome of tremor, gait disorder, postural instability and cognitive disorder. Exposure to high levels of manganese can result in neurotoxicity (Njoku *et al.*, 2020).

The results of Physico-chemical analysis showed that all the water samples have pH below the WHO and SON guideline of 6.5-9.5 and 6.5-8.5 respectively except sample A Table 2.0. (Dirisu & Mafiana, 2016) reported a low pH level in drinking water sample of an oil and gas producing community in Nigeria, which is in line with our finding. Health impacts of water with low pH has been by W.H.O/UNICEF (2005). Any substance with a pH below 4 when taking into the oral cavity can cause irritation of the oral mucosa (Kanokvalai *et al.*, 2013). All the water samples analyzed have normal taste, colour and odor Table 2.0.

It is therefore recommended that manufacturers of sachet water to treat the water using iron filters before packaging them WHO (2011). Trace metals are needed by the body in minute quantity for normal metabolic activities but at elevated concentrations, they can lead to adverse effects to the body. Moreover, toxic metals have no beneficial effects in humans. Exposure to them cause toxic human health effects (Buschmann *et al.,* 2008).

4. Conclusion

This study investigated the levels of heavy metals and physicochemical properties of sachet water and their potential health risk. This include five brands of sachet water from different manufacturers in Sokoto metropolis. Some of the water samples were found to contained heavy metals above WHO and SON permissible limit. Therefore, it is advisably that sachet water for drinking purpose should be treated to reduce the levels of heavy metals present in them to a level that is harmless to the body system. Furthermore, From the data collected and analyzed this study reveals that majority (4 out of 5) of the water samples were slightly acidic (low pH). Considering that low pH indicates the presence of element or contaminants, it is recommended that the water be treated to some considerable extent to bring up the pH to the specified level, since the acidity in drinking water can affect human health.

Competing Interests

Authors have declared that no competing interests exist.

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