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PHYSICOCHEMICAL ANALYSIS AND HEAVY METAL ASSESSMENT OF SACHET WATER SOLD IN GASHUA METROPOLIS OF YOBE STATE, NIGERIA

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ABSTRACT

This study aims at assessing the quality of sachet water sold in Gashua, Bade L.G.A. of Yobe State, Nigeria. Sachet water were obtained from five different factories, named: A, B, C, D and E. Heavy metals' concentrations were analysed using Atomic Absorption Spectrophotometry and standard analytical procedures were used to assay for the physicochemical parameters. The results obtained from this study revealed that the concentrations of lead (0.12± 0.01, 0.12± 0.01, 0.18± 0.01, 0.05± 0.01 and 0.13± 0.01), cadmium (0.01±0.01, 0.02±0.01, 0.02±0.01, 0.03±0.01, 0.03±0.01) and arsenic (0.11±0.00, 0.14±0.01, 0.22±0.00, 0.09±0.01, 0.13±0.01) for samples A, B, C, D and E were significantly higher than the WHO permissible values of 0.02±0.00, 0.003±0.00 and 0.01±0.00 respectively. Zinc was not detected in any of the samples but iron was detected at significantly lower value of 0.002±0.00, 0.03±0.01, 0.05±0.01, 0.03±0.00 and 0.03±0.00 for samples of A, B, C, D and E respectively, when compared with the WHO standard value of 3.00±0.00. Chromium showed higher concentration in samples A, C and E but samples B and C fall within the WHO permissible limit of 0.05±0.00. Conductivity, TDS and sulphate for samples A, B, C, D and E were seen to be significantly lower than the WHO standard value. Turbidity and total suspended solids were found to be above the WHO limit. In conclusion, the results of this study have shown that some metals of the various branded sachet water do not meet the recommended standard due to high concentration of heavy metals and physicochemical parameters beyond the WHO permissible level.

Keywords: Branded water, physicochemical, sachet water, assessment, assayed, heavy metals

INTRODUCTION

Water is one of the essentials that supports all forms of plant and animal life (Vanloon & Duffy, 2005) and it is generally obtained from two principal natural sources; Surface water such as fresh water lakes, rivers, streams, etc. and Ground water such as borehole water and well water (Mendie, 2005). Toxic chemicals and heavy metals enter rivers through industrial and anthropogenic activities of urban settlement around the drainage basin of rivers (Ibukun *et al.*, 2018).

The main anthropogenic sources of heavy metal contamination are mining and smelting activities, disposal of untreated and partially treated effluents, metal chelates from different industries and indiscriminate use of heavy metal-containing fertilizers and pesticides in agricultural field (Reza & Singh, 2010). Some of the metals are essential to sustain life-calcium, magnesium, potassium and sodium must be present for normal body functions. Also, cobalt, copper, iron, manganese, molybdenum and zinc are needed at low levels as catalyst for enzyme activities (Adepoju-Bello, 2009). However, excess exposure to heavy metals can result in toxicity.

Pollution of water bodies are usually caused by chemical and microbial contaminants which leads to water- borne infections and diseases (United States Environmental Protection Agency, 2001). Improper dispersal of industrial effluents which is most common in major African urban and rural center has led to heavy contamination of available fresh water sources reducing the volume of safe agriculture, domestic, irrigation and drinking water (Ezeh *et al.*, 2019).

The packaging of sachet water (packaged groundwater), popularly known as "pure water," has become a booming business in Nigeria. In the view of the Nigerian government, whose preoccupation is poverty eradication, the sachet water industry is seen as a poverty alleviation industry for many Nigerians without jobs (Orish *et al.*, 2006). Sachet water packaging materials contributed to the leaching of some undesirable heavy metals into the water sources which when in high concentration can be toxic and can cause acute or chronic health effect.

Cadmium and lead are toxic heavy metals with long retention times; they can accumulate to a significant extent in human tissue. Cadmium may have a half-life in bone of 38 years and it has carcinogenic properties. Its intake in relatively high amounts can be detrimental to human health. Over a long period of intake, cadmium may accumulate in the kidneys and liver and, because of its long biological half-life, may lead to kidney damage (Lauwerys, 1979).

Chromium found in water is usually in the hexavalent form which is carcinogenic and highly toxic (WHO, 2004).

Lead has no essential function in man and it can be found occurring as metallic lead, lead salts and lead inorganic ions. Food and water are some of the major sources of lead exposure. Once in the blood stream, lead is distributed among the soft tissue, mineralizing tissue and blood. Children are more sensitive to lead because of their rapid growth rate and metabolism (Agency for Toxic Substances and Disease Registry, 2008).

According to Yashim and Abdullahi, 2023, determination of heavy metals in food items has a great health implication on humans. Heavy metals are indestructible and most have toxic effects on aquatic organisms, animals and humans (Aladesanmi *et al.*, 2014). Heavy metal can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested (Adepoju & Alabi, 2005).

They produce their toxicity by forming complexes with proteins, in which carboxylic acid (–COOH), amine (–NH2), and thiol (–SH) groups are involved. These modified biological molecules lose their ability to function properly and result in the malfunction or death of the cells. When metals bind to these groups, they inactivate important enzyme systems or affect protein structure, which is linked to the catalytic properties of enzymes. This type of toxin may also cause the formation of radicals which are dangerous chemicals that cause the oxidation of biological molecules (Bakare, 2005).

The growing incidence of kidney disease and other organs damage in Gashua had become alarming, hence, the need for urgent search and remedies. The analysis of the physicochemical parameters as well as toxic heavy metals is an urgent concern to individual, government and the society. This study assesses the physicochemical parameters and toxic heavy metals of sachet water in Gashua metropolis, Yobe State. At this point, the present research should be able educate the masses and give an informed recommendation on the consumption of such water and more so put forward a proposal to the Government on the urgent need to set up portable water in such a community.

MATERIALS AND METHODS

Study Area

Gashua is a community in Yobe State in North-eastern Nigeria, on the Yobe River a few miles below the convergence of the Hadejia River and the Jama'are River. Average elevation is about 299 m. The population in 2006 was about 125,000. The hottest months are March and April with temperature ranges of 38-40^o Celsius. In the rainy season, June-September, temperatures fall to 23-28^o Celsius, with rainfall of 500 to 1000mm.

Collection of Sample

Samples (sachet water) for the study were obtained from the various sachet water factories in Gashua, Bade Local Government Area, Yobe State. They are kept in the refrigerator at 25^{0}C for onward laboratory analyses.

Analyses of Physicochemical Parameters of Water Samples

The analytical tests of the water samples collected were carried out and the pH was determined using Test-2 pH meter. The temperature, total dissolved solid (TDS) and conductivity were estimated using electrical conductivity/TDS/Temperature meter (HM-Digital COM-100). Sulphate, nitrate, phosphate and turbidity of each water sample was measured using spectrophotometer (HACH-DR-2000). The turbidity was estimated against deionized water as a blank at a wavelength of 450nm. Alkalinity was determined using titrimetric method. Total suspended solid (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO) and total organic carbon (TOC) were determined as described by (American Public Health Association, 1992).

Analyses of Heavy Metals

All the heavy metals concentrations were assayed using Flame Atomic Absorption Spectrophotometer (FAAS), PerkinElmer Analyst 400 AA Spectrometer.

RESULTS AND DISCUSSION

Results

The results of some heavy metals and physicochemical parameters analyse are presented in Table 1 and 2 below.

Table 1: Results of Some Heavy Metal Analyses of Sachet Water

Sample	(mg/L) Pb	(mg/L) Zn	(mg/L) Fe	(mg/L) Cr	(mg/L) Cd	(mg/L) As
WHO	0.02±0.00	5.00±0.00	3.00±0.00	0.05±0.00	0.003±0.00	0.01±0.00
A	0.12 ±0.01^a	N.D	0.002±0.00^a	0.15 ±0.01^a	0.01±0.01^a	0.11±0.00^a
B	0.12±0.01^a	N.D	0.03±0.01^a	0.04±0.00^b	0.02±0.01^a	0.14±0.01^a
C	0.18±0.01^a	N.D	0.05±0.01^a	0.13±0.00^a	0.02±0.00^a	0.22±0.00^a
D	0.05±0.01^a	N.D	0.03±0.00^a	0.09±0.03^b	0.03±0.01^a	0.09±0.01^a
E	0.13±0.01^a	N.D	0.03±0.00^a	0.11±0.00^a	0.03±0.01^a	0.13±0.01^a
P-VALUE	<0.0001	NILL	<0.0001	<0.0001	0.0550	<0.0001

Result is presented in mean± standard deviation (n=3). Superscript ^{a}Values on the same column differ significantly (P<0.05) when compared with the control, Superscript ^{b}Values on the same column are not significantly different (P>0.05) when compared with the control. One-way ANOVA was used to analyse the results and mean differences were sorted out based on Tukey-Kramer's Multiple Comparisons Test using InStat3 Software, 2022.

ND - Denotes" Not Detectable, Lead=Pb, Zinc= Zn, Iron=Fe, Chromium=Cr, Cadmium=Cd, Arsenic=As

Table 2: Results of Physicochemical Parameters Analysis of Sachet Water

Parameters	WHO	Different Water Samples					P-VALUE
		A	B	C	D	E	
(μs-cm^{-3}) Conductivity	500	2.31±0.11^a	2.00±0.10^a	2.81±0.04^a	1.89±0.04^a	2.45±0.05^a	<0.0001
(^{0}C) Temperature	30-32	27.20±0.34^b	27.50±0.30^b	27.27±0.35^b	27.23±0.30^b	27.60±0.20^b	0.4319
(mg/L) TDS	259	1.14±0.02^a	1.05±0.05^a	1.33±0.12^a	0.97 ±0.26^a	1.23±0.14^a	0.0027
pH	6.5- 8.50	7.51±0.21^b	7.53±0.15^b	7.69±0.10^b	7.45±0.23^b	7.72±0.20^b	0.3494
(NTU) Turbidity	5.00	10.71±1.23^a	7.56±0.30^a	8.71±0.39^a	9.33±0.65^a	10.34±0.73^a	<0.0001

(mg/L) TSS	50.00	52.26±0.95[a]	52.39±1.13[a]	52.68±0.38[a]	50.80±0.53[b]	50.73±0.83[b]	0.0034
(mg/L) Total Alkalinity	20-200	50.00±0.00[b]	75.00±0.00[b]	25.00±0.00[b]	80.00±0.00[b]	40.00±0.00[b]	0.0005
(mg/L) BOD	50.00	50.25±0.13[b]	48.45±0.10[a]	50.10±0.10[b]	49.50±0.10[a]	50.25±0.10[b]	<0.0001
(mg/L) COD	50.00	50.20±0.10[b]	50.55±0.10[a]	50.10±0.10[b]	50.50±0.10[a]	50.25±0.20[b]	<0.0001
(mg/L) DO	7.50	8.17±0.21[a]	7.80±0.20[b]	11.22±0.06[a]	10.97±0.06[a]	9.53±0.31[a]	<0.0001
(%) TOC	2.00	2.15±0.10[b]	2.10±0.18[b]	2.50±0.20[a]	2.20±0.20[b]	2.10±0.10[b]	0.0221
(mg/L) Sulphate	200	185.50±1.75[a]	180.30±3.36[a]	190.50±0.25[a]	190.20±4.90[a]	190.20±0.20[a]	<0.0001
(mg/L) Nitrate	45.00	43.30±0.26[b]	45.30±4.04[b]	40.10±0.10[b]	42.40±2.19[b]	45.10±0.10[b]	0.0340
(mg/L) Phosphate	5.00	4.30±0.52[b]	4.50±0.10[b]	5.30±0.27[b]	5.30±0.82[b]	5.55±1.55[b]	0.3553

Result is presented in mean± standard deviation (n=3). Superscript [a]Values on the same row differ significantly (P<0.05) when compared with the control, Superscript [b]Values on the same row are not significantly different (P>0.05) when compared with the control. One-way ANOVA was used to analyse the results and mean differences were sorted out based on Tukey-Kramer's Multiple Comparisons Test using InStat3 Software, 2022.
TDS=Total Dissolved Solid, TSS=Total Suspended Solid, BOD=Biochemical oxygen demand, COD=Chemical Oxygen Demand, DO=Dissolved Oxygen, TOC=Total organic carbon.

Discussion

This work sought to analyse the physicochemical properties and presence of some heavy metals in commercial sachet water consumed in Gashua, Yobe State, Nigeria. Heavy metals are generally toxic to the human body if detected in food or water sample at a certain concentration beyond what the body can tolerate. The result of this investigation shows that the concentration of lead, cadmium and arsenic in samples A, B, C, D and E were reported to be above the WHO acceptable limit. The present study does not agree with the findings of (Sufyan *et al*., 2022; Orish *et al.*, 2006), though in concordance with the study of (Odunola *et al.,* 2013). A high level of cadmium in drinking water in a population with already high cadmium levels in their commonly sold sachet water may elevate blood levels of cadmium, with obvious health implications. Cadmium intake in relatively high amounts can be harmful to human health. Over a period of long intake, cadmium may accumulate in the kidneys and liver and because of its long biological half-life, may lead to kidney damage (Orish *et al.*, 2006). Chromium concentrations were measured and showed significantly higher values in samples A, C and E while samples B and D were seen to fall within the WHO permissible limits. This result obtained is contrary to the report of (Kingsley *et al.,* 2015). Concentration of iron revealed significantly lower values than the WHO standard while zinc was not detected completely in all samples. This study contradicts what has been reported by (Sufyan *et al*., 2022).

The conductivity, total dissolved solid (TDS) and sulphate were found to be below the WHO permissible limits in all the samples A, B, C, D and E. This finding agrees with the report of (Sawere & Uwagwue, 2016). Temperature, pH, total alkalinity, nitrate and phosphate were measured and all of them were found to fall within the WHO standard value. This result agrees with the findings of (Sawere & Uwagwue, 2016; Halilu *et al.* 2011; Ezeh *et al.*, 2019). The temperature of drinking water is often not a major concern to consumers especially in terms of the quality. The quality of water with respect to temperature is usually left to the individual's taste and preference (Adekola *et al*., 2015). Only turbidity revealed a significantly higher value than the WHO standard. This report is in agreement with the findings of (Raji *et al.,* 2010) but contradicts that of (Halilu *et al.* 2011; Ezeh *et al.*, 2019). The total suspended solid (TSS) was found to be above the WHO standard in samples A, B and C while samples D and E were seen to fall within the tolerable limit. This finding is in discordance with the study of (Odunola *et al.,* 2013). Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were both observed to fall within the WHO standard in samples A, C and E but few exceptions were found in the BOD of samples B and D which were seen to show lower value as well as COD concentration in samples B and D which were also observed to be above the WHO tolerable limits. The present study contradicts the findings of (Orish *et al.,* 2006). The dissolved oxygen (DO) concentration in samples A, C, D and E were found to be significantly higher, only sample B was seen to fall within the WHO standard. Samples A, B, D and E were measured to be within the tolerable limit of WHO with the exception of sample C which revealed higher value.

CONCLUSION

From the result of this investigation, all the randomly obtained sachet water were contaminated with heavy metals like lead, chromium, cadmium and arsenic. Iron was detected at level which is within the permissible level for drinking water while zinc was not detected at all in all the sachet water samples. The physicochemical parameters were detected at a level that is both toxic and non- toxic to the body. All these sachet water should be recommended for proper quality control by the relevant government authorities to reduce the heavy metals to a level that is tolerant and non -toxic to the body before consumption.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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