DETERMINATION OF HEAVY METAL CONCENTRATION IN SACHET WATER SOLD IN GOMBE METROPOLIS

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ABSTRACT

Background : Water is a very essential constituent of life, and the availability of good quality water is an indispensable feature for preventing diseases and improving quality life.

Objective: The study was conducted to ascertain the wholesomeness in terms of presence and concentration of heavy metals in sachet water sold in Gombe metropolis.

Methodology: A total of 20 brands of sachet water were randomly selected from 25 brands sold in Gombe. These were obtained from water vendors in the markets and motor parks in Gombe town. Physico-chemical analysis was conducted on the collected water samples, and data analysed using SPSS 13.

Results: The heavy metal concentration in sachet water studied revealed that, all samples were within World health organisation (WHO) standard. Iron concentration ranged from (0.00-0.29mg/l), Zinc and chromium ranged from 0.001-1.40 and 0.00-0.04mg/l respectively. Similarly concentration for lead, copper and magnesium were 0.00-0.04mg/l, 0.00-0.05mg/l and 2.00-3.40mg/l respectively. However, manganese and chloride concentration ranges from 0.00-0.06mg/l and 11.5-16.32mg/l. the colour, taste, odour and alkalinity were all within the standards of WHO.

Conclusion: The physico-chemical parameters analyzed and the heavy metals concentration in the sachet water sampled in Gombe had values within the acceptable limits as prescribed by WHO standards for quality of drinking water. The study provides guidance to help water processors in collaboration with public health authorities to identify those chemicals that are likely to be present in water sold which may present potential public health risk on a long term exposure.

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Keywords: Sachet water, physico-chemical, Heavy metals, Gombe metropolis

INTRODUCTION

Water is one of the abundantly available substances in nature and is essential to sustain life. Safe drinking water is a basic need for human development, health and well-being; it is an internationally accepted human right [1]. It is an essential constituent of all animal and vegetable matter and forms about 75% of the matter of Earth's crust. It is also an essential ingredient of animal and plant life. Water is distributed in nature in different forms, such as rain water, river water, spring water, and mineral water. Rain water is the purest form of naturally occurring water. Since rain water is produced by a process of distillation, it is considered to be the purest form of water. Rain water, however, is associated with dissolved gasses such as CO_2 SO_2, NH_3, etc. from the atmosphere. Water obtained from different sources is associated with a large number of impurities. For example, water gets impurities of various kinds from ground or soil which it comes into contact with. Water also gets contaminated with sewage and industrial waste or effluents when these are allowed to flow into running water or by percolation through the ground[2]. Inadequate water, sanitation and hygiene continue to pose a major threat to human health. These risk factors contribute to millions of unnecessary death each year[3].

Heavy metals in water refer to heavy, dense, metallic elements that occur in trace levels, but are very toxic and tend to accumulate. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb)[4,5,6]. Most heavy metals are too rarely found in water to justify government regulation, but a few have been given an MCL (maximum contaminant limit) by the EPA (environmental protection agency)[7].

In human body water is of utmost physiological importance and has specific functions to perform. It acts as a solvent for the secretory and excretory products. It also acts as a carrier of nutritive elements to tissues and organs and removes waste materials from them.

The source of trace metals is associated with both human activities, such as mining and manufacturing, natural processes of chemical weathering and soil leaching. Corrosion in distribution piping and plumbing can also add trace metals to tap water. Cadmium, chromium, mercury, nikel, selenium, lead etc are toxic metals affecting the internal organs of the human body[4,5].

Lead exposure occurs through air, soil, dust, paint, food and drinking water. Epidemiological studies have indicated strong association between the occurrence of several diseases in humans, particularly cardiovascular diseases, kidney- related disorders, neurocognitive effects and various forms of cancer and presence of many metals such as cadmium, mercury and lead[8, 9]. Lead toxicity affects the red blood cells, nervous system, and kidneys with young children, infants and fetuses being most vulnerable[2]. Chromium, content in natural waters is extremely low, acute poisoning can result from high exposures to hexavalent chromium from industrial wastes, while a trivalent metal is relatively innocuous[10]. Copper in a large oral dose causes gastrointestinal distress with nausea and vomiting within 60 minutes of ingestion, nevertheless, it causes no apparent chronic health effects. As an indicator of corrosiveness, copper in first- flush samples of tap water from service connections of copper piping should not exceed 1.3mg/l[11]. Mineral substances can be removed from water by alkalizing with lime or by filtration through roasted dolominte. This method is used to remove Pb, Cu, Zn, Ti, V, Mo, Ni, and Hg. Arsenic contamination of ground water has been found in many other countries, including Argentina, Chile, China, India, Mexico, Taiwan, Thailand and the United States, and it is a global problem[12]. Arsenic, inorganic compounds form can be removed from water by chlorination and coagulation alkaline medium, and by aeration[13]. Iron and manganese can also be removed from water by method of oxidation of Fe^{2+} to Fe^{3+} metal and its precipitates as $Fe(OH)_3$. If iron is present in water as hydrocarbonate, it can be removed by aeration. This salt is hydrolyzed in the following way.

$$Fe(HCO_3)_2 + 2H_2) \rightarrow Fe(OH)_2 + 2\,H_2CO_3$$

$$H_2(CO_3 \leftrightarrows H_2O + Co_2$$

Co_2 is removed from water by aeration and therefore, hydrolysis can be completed to the end. Ferrous hydroxide is oxidized by atmospheric oxygen to $Fe(OH)_3$.

$4Fe(OH)_2 + 2H_2O + O_2 \rightarrow 4Fe(OH)_3$. This method can be used to reduce the iron content up to 0.1 to 0.3mg/litres[12].

The quality of drinking-water is a powerful environmental determinant of health, as the majority of diseases that cause morbidity and mortality in population are water related[14]. Drinking-water quality management has been a key pillar of primary prevention for over one-and-a-half centuries and it continues to be the foundation for the prevention and control of water borne diseases [15].

The production of sachet water in large volumes in areas of questionable hygienic environment and sources, has been responsible for wide range of source of contamination of drinking water. Activated carbon is an extremely porous material that attracts and holds harmful contaminants in the water through a process known as adsorption[4]. Satisfactory analysis is yet to be carried out on the quality of some Sachet water sold in Gombe metropolis, hence there is the need to investigate samples of these sachet water, in order to ascertain the concentration of heavy metals in them.

Thus raw or impure water should be subjected to a purification process by which the suspended impurities, examples colour, odour , dissolved heavy metals and bacteria are removed. This study is therefore trying to establish the wholesomeness in terms of the concentration of heavy metals in sachet water sold in Gombe metropolis.

MATERIALS AND METHODS

Sample Collection

A total of 20 brands of sachet water were randomly selected from 25 brand sold in Gombe. These were obtained from water vendors in the markets and motor parks in Gombe town. The samples were Victory, Rahama, Vagarta, Nasab, Uneck, chimed, Savannah, Gombawa, Doma, Proper, Gaskiya, Arfat, Miyetti, Almukhtar, Alfadir, Ikhilas, Godiya, Nasara, Capital and Envic sachet water respectively.

Analysis: Physical parameters

Colour : Colour was determined using a digital colorimeter.[16]

Taste and odour: This was determined according to the method described by Sharma[13]

Total dissolved solids: It was determined using a dist conductivity/ TDS meter.[13]

Turbidity: This was determined by using Labtech digital turbidity meter.[16]

Chemical parameters

pH of the samples was measured using DIST pH meter[13].

Total hardness: This was done by titration method[13].

Conductivity: The conductivity of the samples was determined using a DIST conductivity meter[13].

Metal concentration: This was determined using a digital colorimeter, Zn, Mn, Cu, Cr, Pb, and Mg. All the metals were determined using an atomic absorption spectrophotometer[17].

Alkalinity: Alkalinity of the samples was determined according to the standard method[13].

RESULTS

Table 1 shows that the pH of the samples was within the WHO range for drinking water (6.69-7.54). The temperature and turbidity of the samples were founded to be ranging from 29.7 -31.9 and 0.0-4.0 NTU respectively. Conductivity ranges from 129-345$\mu c/cm^3$ and 41-77 mg/l respectively.

Table 2 depicts the physical characteristics of pure water sold in Gombe. All samples had acceptable physical characteristics.

The results of the chemical analysis of the samples are presented in Table 3. From the results it shows that the concentration of iron, zinc and chromium ranged from 0.00- 0.29, 0.00-1.40 and 0.00- 0.04 respectively. The concentrations for lead, copper and magnesium in the samples ranged from 0.00-0.04mg/l, 0.00-0.05 and 2.00 -3.40mg/l respectively.

Table 1: Physical parameters

Samples	pH	Temperature (oC)	TDS (mg/l)	Conductivity µS/cm	Turbidity (NTU)
Victory	7.25	31.5	43	130	1.0
Rahama	7.21	31.2	41	149	1.0
Nagarta	6.69	30.0	42	139	0.0
Nasab	7.22	31.2	51	175	2.0
Uneck	7.02	31.2	45	135	1.0
Chimed	7.15	30.7	60	165	2.0
Savannah	7.04	29.9	48	153	1.0
Gombawa	7.54	31.2	54	227	4.0
Doma	7.20	30.2	61	134	2.0
Proper	7.00	31.2	64	131	0.0
Gaskiya	7.48	30.8	70	245	2.0
Arfat	7.46	31.3	57	227	3.0
Miyetti	7.12	30.0	52	189	1.0
Almukhtar	7.03	29.7	50	149	1.0
Alfadir	7.23	31.2	46	142	1.0
Ikhilas	7.19	31.9	48	232	1.0
Godiya	7.02	31.7	42	129	2.0
Nasara	7.54	31.8	77	149	1.0
Capital	7.23	30.2	66	159	2.0
Envic	7.08	30.7	61	136	0.0
Range	6.69-7.54	29.7-31.9	41-77	169-345	0.0-4.0
Mean	7.18	30.9	54.0	169.8	1.4
Standard deviation	0.21	0.67	15.70	52.98	61.18
WHO(1998)[18]	6.65-8.50	-	100	-	5.0

Table 2: Physical Characteristics

Samples	Odour	Taste	Colour
Victory	Inoffensive	Inoffensive	Colourless
Rahama	"	"	"
Nagarta	"	"	"
Nasab	"	"	"
Uneck	"	"	"
Chimed	"	"	"
Savannah	"	"	"
Gombawa	"	"	"
Doma	"	"	"
Proper	"	"	"
Gaskiya	"	"	"
Arfat	"	"	"
Miyetti	"	"	"
Almukhtar	"	"	"
Alfadir	"	"	"

DISCUSSION

Heavy metals are natural components of the Earth's crust. They are harmful and insidious pollutants because of their non-biodegradable nature and their potential to cause adverse effects in human beings beyond certain level of exposure and absorption[8]. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain[3]. Heavy metals are dangerous because they tend to bio-accumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted[4,6]. Heavy metals can enter water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater[4].

PH value within the range of 4.5 to 8 contains no carbonates but contains bicarbonates and carbonic acid[7], natural waters fall under this category. The pH of the samples studied in Gombe was within the World Health Organization (WHO) [18] range for drinking water (6.69-7.54). The temperature and turbidity of the samples were founded to be ranging from 29.7 -31.9 and 0.0-4.0 NTU respectively; these values are also within the WHO specified limits. The conductivity and total dissolved solid (TDS) were also found to be within specified limits

Ikhilas	"	"	"
Godiya	"	"	"
Nasara	"	"	"
Capital	"	"	"
Envic	"	"	"
WHO(1998)18	inoffensive	inoffensive	TCH 15

Table 3 : Chemical Parameters

Samples	iron (mg/l)	Zinc (Mg/l)	Lead (mg/l)	Copper (mg/l)	Chromium (mg/l)
Victory	0.01	0.00	0.01	0.03	0.01
Rahama	0.29	1.40	0.03	0.02	0.01
Nagarta	0.03	0.00	0.04	0.03	0.02
Nasab	0.20	1.00	0.01	0.01	0.00
Uneck	0.04	0.90	0.03	0.05	0.04
Chimed	0.15	1.20	0.03	0.04	0.01
Savannah	0.00	0.97	0.04	0.02	0.03
Gombawa	0.09	1.00	0.00	0.02	0.02
Doma	0.20	1.04	0.02	0.01	0.03
Proper	0.11	1.00	0.03	0.00	0.02
Gaskiya	0.07	0.88	0.02	0.03	0.02
Arfat	0.22	1.02	0.04	0.03	0.04
Miyetti	0.00	0.02	0.01	0.02	0.00
Almukhtar	0.00	0.04	0.02	0.01	0.02
Alfadir	0.03	1.04	0.04	0.02	0.03
Ikhilas	0.04	1.15	0.03	0.05	0.04
Godiya	0.12	0.95	0.01	0.03	0.01
Nasara	0.00	1.20	0.00	0.01	0.03
Capital	0.00	0.97	0.02	0.02	0.00
Envic	0.01	1.02	0.00	0.01	0.00
Range	0.0-0.29	0.00-1.40	0.00-0.04	0.00-0.05	0.00-0.04
Mean	0.08	0.84	0.02	0.02	0.02
Standard Deviation	0.09	0.43	0.01	0.01	0.01
WHO(1998)[18]	0.30	5.0	0.05	1.00	0.05

Table 3 continued: Chemical Parameters

Samples	Magnesium (mg/l)	Manganese (mg/l)	Total Alkalinity (mg/l)	Total Hardness (mg/l)	Chloride (mg/l)
Victory	2.10	0.02	16.0	41.8	15.37
Rahama	2.80	0.04	25.0	43.5	14.92
Nagarta	3.10	0.02	14.0	47.5	16.05
Nasab	2.20	0.01	16.0	45.6	15.20
Uneck	3.30	0.04	15.0	51.3	30.20
Chimed	3.00	0.03	25.0	45.6	16.25
Savannah	2.00	0.00	12.0	30.4	32.50
Gombawa	3.40	0.06	20.0	43.5	14.70
Doma	2.10	0.01	18.0	51.5	16.05
Proper	2.00	0.02	12.0	43.5	14.70
Gaskiya	2.60	0.04	16.0	47.3	15.37
Arfat	3.20	0.01	12.0	43.7	14.38
Miyetti	2.10	0.00	16.0	42.8	14.93
Almukhtar	2.00	0.01	13.0	50.1	11.50
Alfadir	2.10	0.03	20.0	47.5	14.28
Ikhilas	3.00	0.05	24.0	58.6	15.00
Godiya	2.10	0.03	20.0	47.5	14.28
Nasara	2.20	0.01	18.0	45.6	12.50
Capital	2.20	0.03	14.0	30.5	13.80

of WHO for all the samples.

The concentration of iron, zinc and chromium ranged from 0.00- 0.29, 0.00-1.40 and 0.00-0.04 respectively. These values obtained were within WHO limits for drinking water quality. Zinc at this level is however, beneficial and essential element necessary for body growth. Similarly the concentrations for lead, copper and magnesium in the samples ranged from 0.00-0.04mg/l, 0.00-0.05 and 2.00 -3.40mg/l respectively. These range are also found to be within WHO specified limits. The low concentration of magnesium in the samples is an indication that the natural source of this water samples contain little dissolved magnesium salt, which justified the low total hardness concentration of the samples.

The concentration of manganese was found to range between 0.00-0.06mg/l for the samples. The ranges were within the WHO standard[18]. The total alkalinity concentration for the samples ranged from 12.0-25.0mg/l, this indicate that the low values obtained classify the sources of the water samples as alkaline. Total hardness was found to range from 30.4- 58.6mg/l which is an indication of softness and values are within WHO standards. Chloride concentration for the samples also complies with the WHO standards and ranged from 11.50-32.50mg/l[18].

From the study, it was recorded that the physicochemical and chemical parameters analyzed for the sachet water samples in Gombe had complied with the World Health Organization (WHO) standards for quality of drinking water. However, it is also recommended that other parameters e.g. microbial load should also be investigated. Monitoring and reduction of metals which could have cumulative toxic effects in drinking water is of paramount importance and necessary.

Envic	2.10	0.01	12.0	28.0	14.37
Range	2.00-3.40	0.00-0.06	12.0-25.0	30.4-58.6	11.5-32.5
Mean	2.50	0.02	17.3	44.71	16.32
Standard Deviation	0.51	0.02	4.35	6.51	5.27
WHO(1998)[18]	-	0.30	-	500	250

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