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Research Article

Packaging Characteristics, Lead and Zinc Levels of Sachet Water in Ibadan, Nigeria

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Abstract

Nylon packaged water, popularly called sachet water, is a common source of drinking water in many developing countries. We report the sachet water characteristics and chemical analysis (lead and zinc content) of 25 randomly purchased brands of sachet water sold within Ibadan Metropolis, a major city in Nigeria. The study was conducted in dry season (October and November 2015). Different brands of sachet water were purchased from vendors within Bodija market and around the main campus of the University of Ibadan, Nigeria. Sachet water with fine finishing (edges) and labeling that could be clearly read were graded as good while all others were graded as poor. Heavy metals (lead and zinc) were analyzed using Atomic Absorption Spectrophotometry (AAS). Samples had label titles in accordance with recommendations of the National Food and Drug Administration and Control (NAFDAC). The labelling of 10 (40%) of the products was good while 15 (60%) was poor. The expiry (best before) date was indeterminable in all the brands. Zinc was not detected in any of the brands. Lead was detected in nine (36%) of the brands, with seven of them having lead concentrations of 0.02 to 0.07 mg/L which are above the National and World health Organization (WHO) allowable limits. This finding is of public health importance as some of the sachets of water with lead levels above allowable limits may be contributing to chronic lead toxicity in people who consume them regularly. Stringent water quality control and monitoring measures are recommended. Adding Zinc in tolerable amounts to sachet water in resource-limited countries may be beneficial

Keywords: Water quality, sachet water, Lead, Zink, Ibadan, Nigeria

INTRODUCTION

Packaged drinking water, in form of sachet or bottled water, is a common source of drinking water in many developing countries (Stoler et al. 2012). The safety of drinking water in the community needs to be continuously monitored and regulated to safeguard public health. Lead and zinc are two common metals that are present in many natural substances (Kabir et al. 2012). While lead is recognized to be toxic in humans, zinc is an essential trace metal in many metabolic processes (Plum et al. 2010). Accumulation of lead in humans poses significant health hazards. Until recently, lead was a significant exhaust from automobiles worldwide (Landrigan 2002). The degree to which the heavy metal continues to be emitted into the environment in developing countries like Nigeria remains largely speculative. Lead and zinc are components of old lead pipes, old paints and decaying roofing sheets, which are common in many areas of Ibadan where old buildings are found.

Portable water is scarce in many developing nations and a significant proportion of the population purchase water for drinking. In Ibadan, a common source of drinking water is sachet water. Different brands of sachet water are widely sold in the metropolis. Sachet water is cheap, conveniently packaged, widely and regularly consumed. The purity of such water needs to be regularly verified, more so that the sources of water for the sachets are usually from wells and boreholes, which are reservoirs of percolated rainwater (Mayomi and Elisha 2011). Rainwater may have washed down old paints, car exhausts, industrial chemicals, and zinc containing roofing sheets. Thus, such water sources may be contaminated by heavy metals that percolate into the soil and into the ground water used to produce sachet water.

We conducted a study of commonly purchased sachet water in Ibadan and analyzed the contents for zinc and lead levels. We set out to determine if quality of the sachets had any relationship with the likelihood of the water containing lead and zinc above recommended concentrations. We have used this study to highlight the need for tertiary institutions complementing the roles of regulatory bodies such as NAFDAC in safeguarding the health of the consumers.

MATERIAL AND METHODS

Study period, sites and sample collection: The study was conducted during dry season between the months of October and November 2015. Different brands of sachet water were purchased from sellers within Bodija market and around the University of Ibadan campus and its environs. Effort was made to obtain all available brands of sachet water from these locations. We documented the information on the sachets, which included the manufactured and expiry dates. Each of the

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sachet water was inspected visually for sediments and cloudiness. Approximately 10 mL of water from each sachet was taken in plastic bottles and preserved properly for analysis of lead and zinc levels. Quality control was done to ensure that other liquids or solids do not contaminate the samples during the process of collection, storage, and analysis.

Characterization of product plastics, labeling, and other information on sachet water: The purchased sachets of water were closely examined for neatness of the packaging and information printed on them. These were documented and presented in the results section. Sachets with fine finishing (edges) and labeling that could be clearly read were graded as good while all others were graded as poor. The analysis was based on package recommendations from the National Agency for Food, Drug Administration and Control (NAFDAC), described below. Gross eye examination was also done to determine cloudiness of water and presence of sediments.

Analysis of lead and zinc levels: Water analysis for heavy metals was done at the Multi-Center Laboratory of the University of Ibadan, Nigeria. The analysis was carried out within one week of purchasing the samples. Heavy metals (Lead and Zinc) were analyzed using Atomic Absorption Spectrophotometry (AAS) Alpha 4 Chem tech Analytical model (APHA, 1992). Calibration curves ranging from 0.00 to 1.60 mg/dL for the two metals (Pb and Zn) were prepared using laboratory standards. Distilled water was used as the negative control. A volume of 10 mL of each water sample was injected into the machine for the analysis.

National Agency for Food, Drug Administration and Control (NAFDAC) recommendations for packaged water**.** Documents specifying recommendations for packaging of commercially sold sachet water were obtained from the National Agency for Food, Drug Administration and Control (NAFDAC) office at the Federal Secretariat at Ibadan. The NAFDAC recommends that the packaging should be done under hygienic conditions and that products should bear name of product, full location address of manufacturer, batch number, production date, best before date, NAFDAC certification number, and volume of water. For packaged water, label is any writing printed or graphic matter relating or accompanying the packaged water or a package of it. Labels are printed on the plastic bags of sachet water. The NAFDAC numbering system uses alphanumeric codes in the format An-xxxx (n is the code for the particular registered of listed product and xxxx the product number). The numbers for food products are prefixed by 01 or A1 or B1, or C1 etc. followed by four digits e.g. 01-0001 L.

Allowable limits of lead and zinc in drinking water

The national standards for lead and zinc in drinking water are similar to the recommendations of the World Health Organization (NIS 2007; WHO 2008). The allowable value for lead (Pb) in portable water is 10 µg/L (0.01 mg/L). The maximum allowable limit for zinc by the Nigerian industrial standard is 3mg/L (SON 2007).

Data analysis

Neatness of the plastic sachets and appropriateness of labelling were coded and used to determine if there was any relationship between packaging and the number of water samples containing heavy metal contents above recommended values. The World Health Organization recommended levels of Pb and Zn, which correspond with National recommendations, were used for comparisons. Chi square test was used to assess relationship between the number of brands of sachet water evaluated and the quality of their packaging as described above. For ethical reasons brand names of the water samples analyzed have been kept confidential and are not used in this report.

RESULTS

Physical and label characteristics

The results of the physical and label characteristics in 25 brands of sachet water examined in this study are presented in figure 1. The gross eye examination revealed that about 12/25 (48%) of them had poor quality nylon packages with difficult-to-read labelling. Only 4% of the sachets had visible particles in the water content while the others were clear and without sediments. Also, 4% of the sachets had illegible brand name and details of the product.

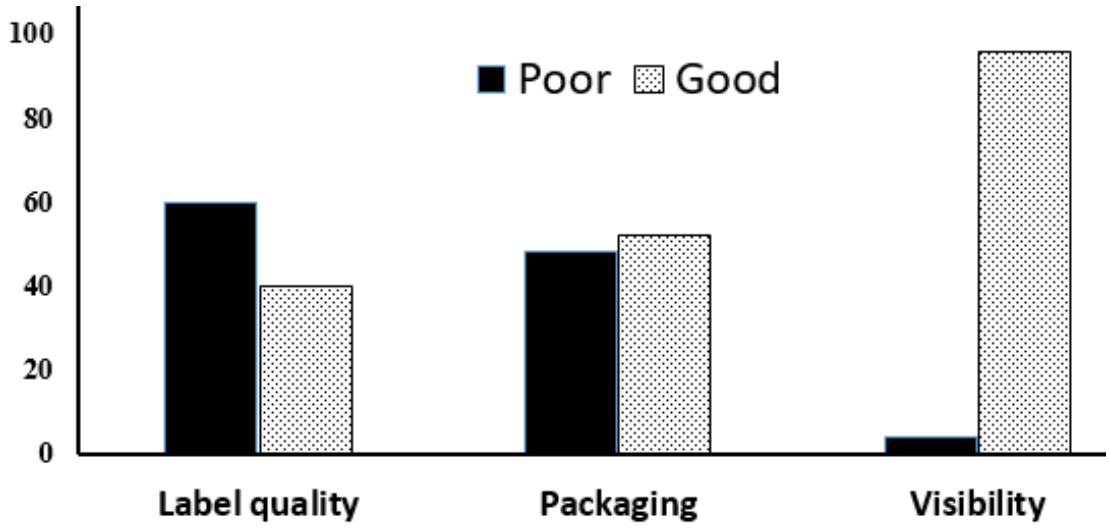

Figure 1

Packaging and labelling characteristics of twenty-five brands of sachet water in Ibadan, Nigeria. Each bar represents a percentage of brand size

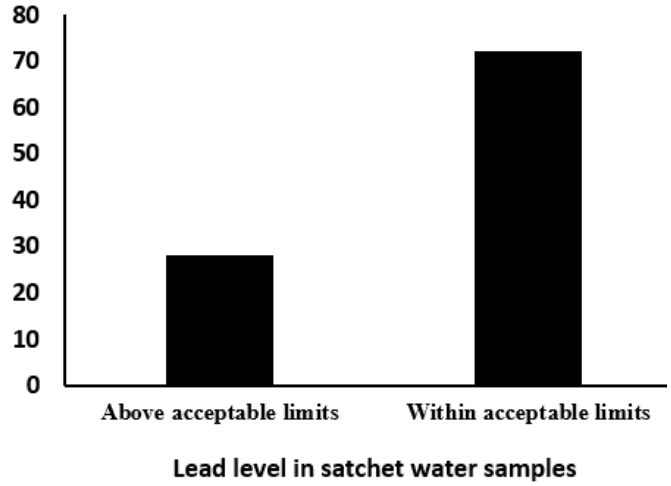

Figure 2
Lead levels categorization in the evaluated satchet water. Each bar represents a percentage of brand

The sachets were labelled in accordance to the requirements of NAFDAC. Information written on them includes Brand Name, NAFDAC registration number, manufacture date, expiry date (best before date), Manufacture address, contact phone number of manufacture place, and in one case chemical component of the water. The brand that listed chemical component wrote the concentrations of Chloride, Calcium, Fluoride, Residual Chloride, Hydrogen sulphide, Iron, Manganese, Magnesium, Nitrite, Zinc, and pH of the water.

All the products purchased for the study, but one, had brand names and table or drinking water written on them. The format of the NAFDAC registration numbers on the products varied. Four formats of NAFDAC numbers were found on the products (x representing numeric characters, while L is used for Listed products); C1-xxxx-L, A1-xxxx-L, B1-xxxx-L, and 131-xxxx-L. Seventeen of the sachets (68%) had C1-xxxx-L format, while six (24%) had A1-xxxx-L, one (4%) had B1-xxxx-L, and one (4%) had 131-xxxx-L formats. The labelling of 12 (48%) of the products was good, while in 13 (52%) the labelling was poor. None of the products had R which is used by NAFDAC for Registered products.

All products examined had manufacture address written on the sachets. However, one of them was illegible. Eleven (44%) of these products were manufactured by companies located within the Ojoo and Akobo areas while the others were from Old Bodija, Iwo road, and the Ibadan-Oyo-Ilorin expressway areas. All brands purchased also had phone numbers of manufacture companies. These numbers were active as staff of the companies received calls to them. All the companies of manufacture of the sachet water evaluated in this project were located within the city or close to roads with high traffic volume.

Analysis for zinc and lead concentrations

Samples from twenty-four of the products were purposively selected and analysed for zinc and lead levels. None of the samples had detectable zinc level (at 0.00 mg/L). Lead was detected in nine (36%) samples. The detected concentrations were 0.06, 0.01, 0.02, 0.03, 0.03, 0.07, 0.06, 0.01, and 0.04 mg/L. Thus, six brands had levels of lead above allowable limits. The quality of labelling and packaging in four of the six brands was good; the other two had poor labelling and packaging quality. There was no association between presence or concentration of Lead and labelling quality (uncorrected chi square 1.00, p-value 0.32).

DISCUSSION

The results obtained from this study suggest the need for closer regulation and surveillance of sachet water in Ibadan metropolis. The project also demonstrates the complimentary role of tertiary institutions in assisting regulatory bodies like NAFDAC in continuous surveillance of commercially sold water products. Over half of the sachet water examined had poor labelling characteristics, none had manufactured dates and thus expiry dates could not be determined. A significant number of them had detectable lead levels with a few of them above the maximum allowable concentration. All of the companies are located in highly populated environments exposed to high traffic. It is not certain if exhaust fumes and other solvents from vehicles and industrial activities contributed to the contamination sources of water used in producing sachet water, however, this is highly probable. Analysis conducted by Odukoya and colleagues in 2009 showed a positive correlation between content of Lead and Zinc in ground water and closeness to major highways (Odukoya et al. 2009). This finding deserves more evaluation as cities such as Ibadan continue to become more industrialized with increasing number of vehicles and major highways. Regulatory bodies and tertiary institutions need to compliment one another in monitoring sources of water used in producing sachet drinking water.

Studies evaluating sachet water quality in different regions and states of Nigeria support the need for closer monitoring of portable water in Nigeria. Orisakwe *et. al* in 2006, detected above-normal limits of lead in 12.2 % of sachet water sold in eastern Nigeria (Orisakwe et al. 2006). Olaoye and Olumide in 2009 evaluated sachet water quality in Western Nigeria and concluded that the poor quality of commercial sachet water indicates a need for Nigeria's quality regulatory agency to take appropriate measures in safeguarding public health (Olaoye and Onilude 2009). Studies on analysis of heavy metals content of sachet water in Nigeria are few and a MEDLINE search done while writing this report did not retrieve any study done in the Southwest region. However, studies evaluating lead levels in Nigeria reported that water lead levels have progressively increased in past years, with records of less than 5ug/L (0.005mg/L) in 1993 (omokhodion, 1994) to an estimated increased ranged of 0.01 – 2,16 mg/L in 1997 (Adogame 1997) in Ibadan area (Adogame 1997; Omokhodion 1994). The contribution of increasing industrialization on urban city might be one of the reasons for this trend.

While stringent regulations are adhered to in the assessment of prospective portable water companies before licensing by NAFDAC, the siting of water companies in cities and close to major highways may require re-evaluation. If lead and other heavy metal contents of water is increasing due to increasing industrialization, it may be more appropriate to recommend that portable water companies be sited far away from industrialized cities. Pollutants from vehicles, old buildings, refuse dumps, food and other consumables processing companies may be contributing to increased pollution of ground water, which is the source of portable drinking water.

Lead is a general toxicant that accumulates in the skeleton (Gidlow 2004; Gordon et al. 2002). Infants, children up to six years of age and pregnant women are most susceptible to its adverse effects (Carrington et al. 1993). Placental transfer of lead occurs in humans as early as the 12th week of gestation and continues throughout development (Damstra 1977). Young children absorb 4 – 5 times as much lead as adults and the biological half-life may be considerably longer in children than in adults. Lead accumulates progressively and affects heam synthesis, calcium metabolism, and may result in neurological dysfunction (Damstra 1977). Lead toxicity may result in acute and chronic disease states. These include acute abdominal colic, encephalopathy, headache, hallucination, irritability, convulsions, and rarely coma. Other manifestations include peripheral neuropathies, wrist drop, anaemia, tremors, weight loss, and gastrointestinal symptoms (Papanikolaou et al. 2005). As cumulative toxin, the presence of lead in any source of drinking water is a serious situation that requires all practical measures to reduce exposure to lead be implemented as a matter of urgency.

On the other hand, zinc is an essential trace element. Zinc deficiency caused by malnutrition and foods with low bioavailability, aging, certain diseases, or deregulated homeostasis is a far more common risk to human health than intoxication (Plum et al. 2010). Resource-limited countries of Africa have a high burden of infectious diseases and malnutrition. Thus the presence of the element in portable water may be beneficial to health. Zinc is a component of more than 300 enzymes and it appears to be a critical factor for maintaining DNA integrity in humans (Song et al. 2009). It is active in the metabolism of glucides and proteins, and is required for the synthesis of insulin by the pancreas and for immune processes. Zinc deficiency has been reported to result in growth failure, sexual infantilism in adolescents, loss of taste, and delayed wound healing (Prasad 1988). Zinc supplementation, in combination with oral rehydration therapy, has been shown to significantly reduce the duration and severity of acute and persistent diarrhea (Walker and Black 2010). Adequate zinc intake is essential for maintaining the integrity of the immune system (Delafuente 1991). Suggested daily intake for adults is 15 mg per day for men, 12 mg per day for women, 10 mg/day for children and 5 mg/day for infants (Pennington and Young 1991). Sachet water is a perfect vehicle for providing essential elements and vitamins to the populace. Addition of safe amounts of essential elements like zinc to portable water is a possibility that may be explored for public health benefits.

In conclusion, about one quarter of the samples analysed had concentration of lead above the recommended allowable limits. Zinc was absent in all the samples evaluated. There was a significant proportion of sachet water with poor packaging characteristics; however, there was no relationship between packaging quality and lead or zinc content of water contained in the sachets. Thus, the neatness or attractiveness of sachets did not correlate with the presence or absence of the metals. The presence of lead is of public health importance as some of the sachets with lead concentration above allowable limits may be contributing to chronic lead toxicity in those who consume them regularly. It is also noteworthy that all the manufacturing companies of the brands of sachet water evaluated were located within the city or close to major roads and this may be a source of contamination of ground water used in the production of the products. The regulatory body therefore, may make it necessary for all manufacturing companies to indicate in their products, the levels of heavy metal concentrations that are of public health importance. This will help consumers to make informed choices. In addition, it is advisable for consumers to go the extra step of checking the water they consume for heavy metal contents periodically. This can be done at the laboratory where the analysis reported in this paper was conducted at an affordable cost.

Authors' contributions

The first author conceived the project and wrote the first draft of the manuscript. Other authors participated in conduct of the study and contributed significantly to the development of the manuscript. Authors declare that they have no conflict of interest. The project did not receive any funding.

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