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Elemental Analysis of Bottled and Sachet Water Commercially Available in Abuja Metropolis Nigeria

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ABSTRACT

Background: Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and depletion of aquatic biota. Drinking water that contain high amount of heavy metals is a serious threat to the health of humans. People are exposed primarily to heavy metals through water consumption; however, few heavy metals can bioaccumulate in the body and may induce cancer and other risks. The objectives of this study are to assess the quality of packaged water marketed in Abuja metropolis and to compare the level of conformance to quality standards based on different processing technologies employed by packaged water manufacturers in the treatment of raw water.

Methods: Different samples of both sachet and bottled water along with their raw water were randomly collected from different water production companies, coded and analyzed using the flame system of the atomic absorption spectrophotometer (AAS) for elemental contents and also compare results based on production processes from the different companies.

Results: The results obtained showed that 13.3% of the raw water sample were contaminated with lead, 46.7% of the samples contain nickel above WHO limit, while 40% of the sample had concentration of cadmium above the WHO limit.

Conclusion: The study showed that the reverse osmosis and activated carbon filtration technique are highly efficient in removing unwanted particles/ contaminants. The study further revealed that some of the finish product had substantial amount of metals which are above WHO and NAFDAC limit for drinking water.

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Introduction

Water is one of the most important compounds that profoundly influence life [1]. The quality of water is usually described according to its physical, chemical biological characteristics. Drinking water that contain high amount of heavy metals is a serious threat to the health of humans. People are exposed primarily to heavy metals through water consumption; however, few heavy metals can bioaccumulate in the body and may induce cancer and other risks [2]. Publications on various aspects of heavy metals in drinking water are few. Many developing countries are faced with the challenge of reducing human exposure to heavy metals, mainly due to their limited economic capacities to use advanced technologies for heavy metal removal.

Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and depletion of aquatic biota. According to a World Health Organization report, 1.1 billion people lack access to an improved drinking water supply, 88 percent of the 4 billion annual cases of diarrheal disease are attributed to unsafe water and inadequate sanitation and hygiene, while 1.8 million people die from diarrheal diseases each year. The WHO estimates that 94 percent of these diarrheal cases are preventable through modifications to the environment, including access to safe water [3]. Simple techniques for treating water at home, such as chlorination, filters, and solar disinfection, and storing it in safe containers could save a huge number of lives each year [4]. Reducing deaths from waterborne diseases is a major public health goal in developing countries.

Water purification is defined as the sum total of the various processes or techniques applied to raw water for the sole purpose of effecting the removal of all contaminants in order to produce a final product of desired quality [5]. It is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from contaminated water. The goal is to produce water fit for a specific purpose. Most water is disinfected for human consumption (drinking water), but water purification may also be designed for a variety of other purposes, including fulfilling the requirements of medical, pharmacological, chemical and industrial applications. The methods used include physical processes such as filtration, sedimentation, and distillation; biological processes such as slow sand filters or biologically active carbon; chemical processes such as flocculation and chlorination and the use of electromagnetic radiation such as ultraviolet light.

Purifying water may reduce the concentration of particulate matter including suspended particles, parasites, bacteria, algae, viruses, fungi, as well as reducing the amount of a range of dissolved and particulate material derived from the surfaces that come from runoff due to rain.

Visual inspection cannot determine if water is of appropriate quality. Simple procedures such as boiling or the use of a household activated carbon filter are not sufficient for treating all the possible contaminants that may be present in water from an unknown source. Even natural spring water – considered safe for all practical purposes in the 19th century – must now be tested before determining what kind of treatment, if any, is needed. Chemical and microbiological analysis, while expensive, are the only way to obtain the information necessary for deciding on the appropriate method of purification.

Every chemical agent in water may be hazardous to health except confirmed. The inorganic chemicals are less hazardous than organic ones but excessive levels are toxic. Instrumental analysis of water chemicals usually gives more reliable results. Potable water that complies with WHO and NAFDAC standards of physiological acceptability will be satisfactory for drinking. For each parameter, the maximum permissible limit refers to the limit that should not be exceeded, and which will cause rejection of the water. However, the highest desirable level is one likely to be objectionable to an appreciable number of people and is intended for toxicants such as Arsenic, Barium, Cadmium, Chromium, Cyanide, Lead, Selenium, and Silver [5]. The objectives of this study are to assess the quality of packaged water marketed in Abuja metropolis and to compare the level of conformance to quality standards based on different processing technologies employed by packaged water manufacturers in the treatment of raw water.

Materials and Methods

Sampling and Samples Collection

Bottled and sachet water that were randomly selected from available brands in Nigeria, based on willingness of the manufacturers to disclose the major water treatment and method they deploy in manufacturing packaged water and allow collection of raw water. Eight different brands of bottled coded as BW001, BW002, BW003, BW004, BW005, BW006, BW007, BW008 and five sachet water brands coded as SW001, SW002, SW003, SW004, SW005 were anonymously and randomly purchased from different shops within Abuja municipal area council and environs in their original sealed package as supplied by manufacturers and raw water they use in production were voluntarily given by the manufacturers as well which are also coded as RW001, RW002, RW003, RW004, RW005, RW006, RW007, RW008, RW009 and RW010. Two popular and remarkably known brands were purchased and coded BW009 and BW010, which were used as gold standard in the study.

Elemental Analysis

Flame atomic Absorption Spectroscopy (FAAS) technique was used for the determination of the elements in the samples. The samples were analyzed based on the equipment operating conditions using Air-acetylene and at different wavelength for each element after calibration with reference standard solution of the selected elements. The data generated were processed using relation:

$$\text{Metal } (\mu g/g) = \frac{C \times V \times d.f}{W\ (g)}$$

Where; C is the concentration obtained from the AAS machine (mg/L); V is the volume of the undiluted sample solutions in mL; W is the sample's weight in grams and d.f is the dilution factor, where applicable and converted into mg/g.

Results

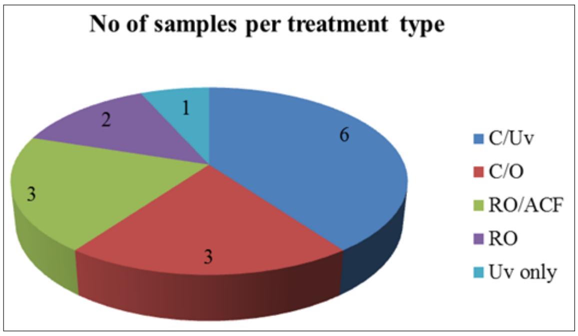

Figure 1: Showing number of sample per treatment type

C/Uv = Cartridge filtration and UV; C/O = Cartridge filtration and Ozonation; RO/ACF= Reverse Osmosis and activated charcoal filtration; RO = Reverse osmosis only; Uv = Uv only

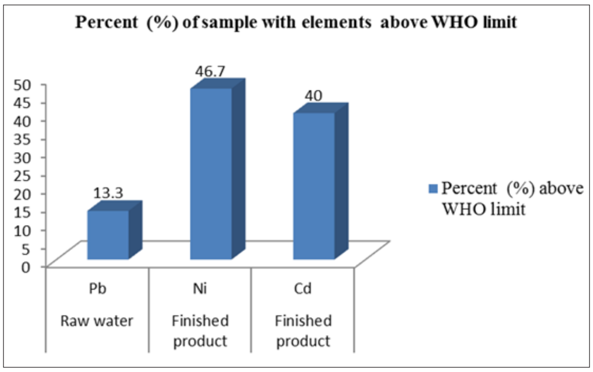

Figure 2: Percentage of sample with Cd, Ni and Pb above the WHO permissible limit of 0.03mg/L, 0.02mg/L and 0.01mg/L respectively

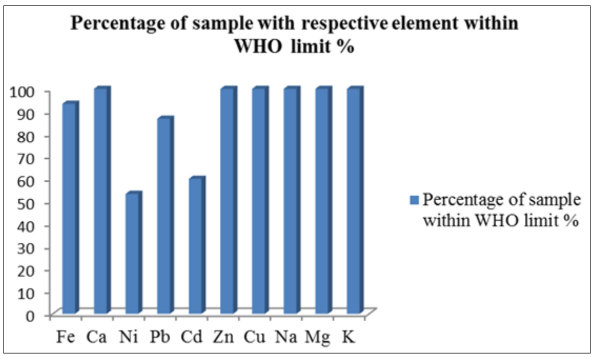

Figure 3: Percentage of elements that levels is within the WHO permissible limit in the analysed samples

The results obtained showed that 13.3% of the raw water sample were contaminated with lead, 46.7% of the samples contain nickel that was above WHO limit, 40% of the sample had concentration of Cadmium above WHO limit a shown in Figure 2. Figure 3 depicts the percentage of each element in the samples that are within the permissible WHO limit with some having high level of Ni, Pb and Cd.

Discussion

Comparative Evaluation of Different Water Processing Methods and Different Water types

The results of elemental analysis for the samples showed 13.3% of samples had their raw water with significant concentration of lead, but none detectable level in their final product. This implies that the reverse osmosis and activated carbon filtration technique are highly efficient in removing unwanted particles/contaminants. The concentration of Nickel in 46.7% of samples were above the WHO limit of 0.02mg/l. These samples belong to the group processed by cartridge filtration, ozonation and UV-sterilization, which depicts the limitation of these methods in removing all unwanted inorganic elements and particles from the raw water in contrast to the reverse osmosis and activated carbon filters method. The results also revealed that, there was no significant difference between levels of heavy metals in both the bottled and sachet water, except in the case of Nickel. The study further showed that there was substantial reduction in the concentration levels of most elements due to the treatment processes carried out on the raw water to produce the packaged water. This reemphasizes the need to treat raw water from any source so as to make it adequate and suitable for drinking.

Comparative Analysis of all Samples Based on Different Elements

Iron (Fe) in mg/l

Iron causes brownish or reddish coloration of water purification systems and imparts metallic taste to water. Iron concentration ranged from 0.0189mg/l to 0.332mg/l. 60% of samples had none detectable levels, 33.3% had values within WHO limit and only one sample had value slightly above the WHO prescribed limit. Iron can cause slight toxicity, but excessive intake can lead to siderosis and damage to organs through excessive iron storage [6].

Calcium (Ca^{2+}) in mg/l

Calcium is directly related to temporary hardness in water. Excessive intake leads to urolithiasis and cardiovascular illness. Calcium concentration ranged between 0.0694 mg/L to 32.7911 mg/L and found all within permissible limit of NAFDAC. Also, 60% of samples had none detectable level of Calcium. This implies the ease of its removal by simple boiling.

Nickel (Ni) in mg/l

Nickel is one of the heavy metal contaminants that have deleterious effect to human health. It presence in potable drinking water is not expected. The concentration of Nickel ranged from 0.0084mg/l to 0.0771mg/l. 46.7% of samples had values above the WHO limit (Figure 2).

Lead (Pb) in mg/l

Lead is also one of the heavy metals that accumulate in the body over time manifesting systemic toxicities and organ damage. The concentration of lead in the samples ranged from 0.3630mg/l to 0.3906mg/l. 86.7% of samples had none detectable values, 13.3% had values higher than the WHO limit (Fig.2). Another 13.3% of brands had their raw water with significant concentration of lead, but none detectable level in their final product. This further implies that the reverse osmosis and activated carbon filtration technique is highly efficient in removing unwanted particles/contaminants. Lead in high doses has been recognized for centuries, as a cumulative general metabolic poison [7].

Cadmium (Cd) in mg/l

Cadmium causes cadmium poisoning leading to hypertension, renal disease and bronchitis. The concentration in samples varied between 0.0046mg/l to 0.1157mg/l. 40% of samples had Cadmium concentration higher than the prescribed WHO permissible limit.

Zinc (Zn) in mg/l

Zinc imparts astringent taste to water and causes acute systemic poisoning at excessive concentrations in the body. The concentration in samples ranged from 0.0039mg/l to 0.0307mg/l. All samples had values within the WHO allowable limit for potable drinking water. It is necessary for functioning of various enzyme systems, including alkaline phosphatase; carbonic anhydrase and alcohol dehydrogenize [8]. Symptoms of zinc toxicity in human beings include vomiting, dehydration, electrolyte imbalances, abdominal pains, etc.

Copper (Cu) in mg/l

Copper concentration in the samples ranged from 0.0087mg/l to 0.1744mg/l. All samples had values within the WHO permissible limits.

Sodium (Na+) in mg/l

Sodium imparts saline taste to water and causes hypertension, cerebral and pulmonary oedema. Sodium concentrations in samples were found in between 10.366 mg/L to 18.591mg/L. All values were within the WHO prescribed limits for potable drinking water. 13.3% of samples had none detectable levels of sodium.

Magnesium (Mg2+) in mg/l

Magnesium is directly related to permanent hardness and associated with cardiovascular diseases. Magnesium content in the investigated water samples ranged from 0.0104 mg/L to 2.5089 mg/L. All values were within the WHO prescribed limits for potable drinking water.

Potassium (K+) in mg/l

Potassium content in the water samples varied from 0.2485 mg/L to 0.6518 mg/L. All samples had values within the NAFDAC limit for potable drinking water.

Conclusion

The study showed that the reverse osmosis and activated carbon filtration technique are highly efficient in removing unwanted particles/contaminants. The study further revealed that some of the finished products had substantial amount of metals which were above WHO and NAFDAC limit for drinking water.

Conflicts of interest: There is no conflicts of interest regarding the study and reports

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