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Survey of Parasitic Contamination of Sachet Water Sold in Jos-North Local Government Area of Plateau State, Nigeria

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Abstract

Sachet water, commonly referred to as "pure water", is a primary source of drinking water for low- and middle-income populations in Nigeria. While regulatory frameworks emphasize in-package microbiological safety, parasitic contamination during production and distribution remains underexplored. This study investigates both internal and external contamination of sachet water to assess public health risks and inform quality control interventions. A total of 179 sachet water samples, representing nine commercial brands, were randomly collected from nine districts across Jos, Plateau State. Each sample underwent macroscopic inspection and pH measurement. Under sterile conditions, 10 mL of water was aseptically extracted from each sachet, centrifuged at 10,000 rpm for 5 minutes, and examined for parasitic ova and cysts using wet mount, iodine staining, and modified Ziehl-Neelsen techniques. A subset of sachets—primarily obtained from street vendors—was further assessed through external surface washes using the same microscopic protocols. Eighty-nine percent of samples conformed to WHO standards for appearance and pH (colorless, odorless, tasteless; mean pH = 6.93). However, 2.2% of sachets (n = 4) were internally contaminated with intestinal parasites: *Entamoeba histolytica (n = 1) and Cryptosporidium parvum (n = 3).* Statistical analysis revealed no significant association between contamination and brand type (Chi-square test; p = 0.423). External surface analyses from sachets sold by hawkers identified *E. histolytica, C. parvum,* and *Ascaris lumbricoides,* suggesting poor handling and storage practices contribute to secondary contamination. The detection of protozoan and helminth parasites within sachet water underscores a residual health threat, despite compliance with basic physicochemical standards. External contamination from improper handling further elevates consumer risk. These findings support the urgent need for enhanced parasitological surveillance, stricter regulatory enforcement across the water distribution chain, and targeted public education to promote safe handling and storage of sachet water in informal settings.

Keywords: Sachet Water, Parasitic Contamination, *Cryptosporidium Parvum, Entamoeba Histolytica,* Water Quality, Public Health, Nigeria, Informal Water Distribution, Street Hawkers, Waterborne Diseases

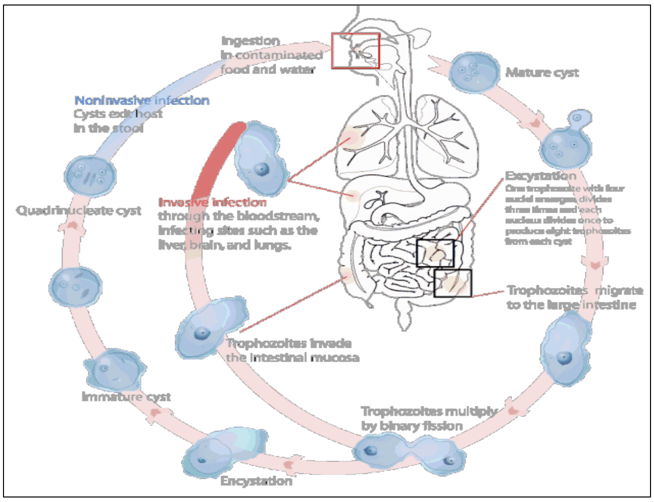
Introduction

A parasite is an organism that is entirely dependent on another organism, referred to as its host, for all or part of its life cycle and metabolic requirement. Strictly speaking, the term parasite can be applied to any infectious agent but, by convention, it is generally restricted to protozoa and helminths and excludes the viruses, bacteria and fungi [1].

Parasitism is a relationship between two organisms, the parasite which is always the beneficiary and the host which is always the provider [2]. Many of these parasitic associations produce pathological changes in the host that may result in disease [3]. Parasitic disease(s) have been with mankind since time immemorial and remains a common cause of morbidity and mortality worldwide. It also serves as a hindrance to the development of economically less advanced countries [4].

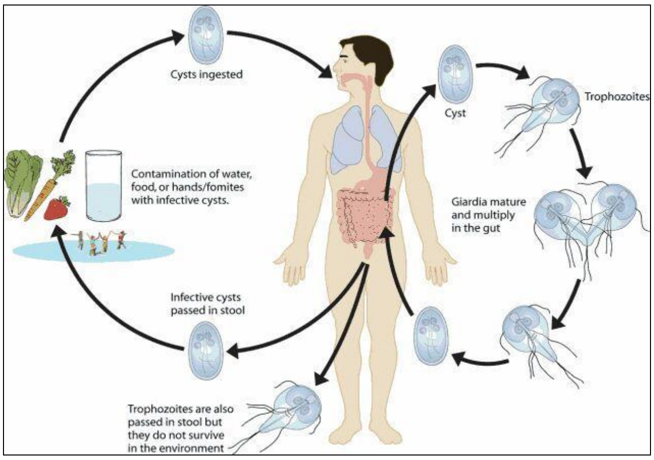
Parasites are classified into; protozoa and helminths based on medical importance. The protozoa are unicellular eukaryotic microorganisms capable of growing or multiplying in their host by binary fission and these includes; Amoebae, flagellates, ciliates, microsporidia and coccidia, while helminths are multicellular organisms, which when mature can generally be seen with the unaided eye and they include; the plathelminths (cestodes and trematodes) and nemathelminths (nematodes), [5, 6].These parasites inhabit different sites in or on the host body such as the intestinal tract, the red blood cells, visceral organs as well as the skin. The mode of transmission of intestinal parasites is mostly through the "fecal-oral route" where the infective stage is ingested from food, water, vegetables or hands contaminated with human feces [7].

Water as an indispensable element of the universe is required by all living organisms and water in its "quality form'' water contains no pathogenic organism [Figures 1 and 2]. It is not only clear and colorless but has no objectionable taste and odor. It does not contain concentrations of chemicals that may be physiologically harmful or economically damaging. Water may be sourced naturally or man-made. Natural sources include; rain, lakes, rivers, streams or springs while man-made sources include; boreholes, wells and pipe-borne water common in urban settings [8].



Source: CDC

Fig 1: Life Cycle of *Entamoeba histolytica*



Source: CDC

Fig 2: Diagram of the Life Cycle of *Giardia lamblia*

Urbanization (a global trend), has resulted in shortage of portable water especially in the emerging economies of the world of which Nigeria is one. This has led to the development of packed sachet water to meet the water needs of people. Pipe-borne water and boreholes are the major sources of portable water especially within the major cities in Nigeria but unfortunately, its circulation is grossly limited. In Jos, Plateau State Nigeria, sachet water is common and is distributed by commercial companies to local hawkers or stores for sell to prospective customers who drink this water or cook with it due to scarcity of safe and hygienic water. The sources of these sachet water ranges from tap water to boreholes and in some cases wells before they undergo any water treatment by these water companies. Purified water is water from any source that is has been processed to remove impurities. Parasitic cysts may be present at any time and are potential cause of illness or death. They may be contained in the sachet water due to poor handling during packaging and the intake of unwholesome water could have devastating effects on the health of the public as unsafe drinking water is a key determinant of many parasitic diseases with serious complication especially in immunocompromised individuals [9].

Biological contaminants largely parasites, bacteria, and viruses constitute the major cause of foodborne and/or waterborne diseases. In developing countries like Nigeria, such parasitic contaminants are responsible for a wide range of diseases such as; cholera, amoebiasis, cryptosporidiosis, cyclosporiasis, schistosomiasis, as well as diarrhea. Diarrheal diseases especially infant diarrhea are the dominant foodborne and/or waterborne disease problem(s) in most developing nations. Various factors such as the general sanitary standard of the house, the proper use of sanitary facilities like; latrines, and refuse management systems affects water safety in developing nations. Sachet water handling in terms of production and treatment, storage and distribution can affect the safety (quality) of water. This study was to determine the prevalence of parasitic contamination of sachet water sold within Jos, Plateau state, Nigeria.

Materials and Methods

Study Area

The study was carried out in Jos metropolis, Plateau state. Jos is a city in the middle belt of Nigeria. The city has a population of about 900,000 based on the 2006 census. The city is located on the Jos Plateau of about 1,238 meters high above sea level with the coordinates: 9° 56'N 8° 53' E/ 9.933°N 8.883°. Samples of sachet water were collected from Photo-tech, British-America, Dadin Kowa, Angwa Rukuba, Tudun wada, Bauchi/Ring road, Katako junction, Rikkos and Farin gada all located in Jos, Plateau state Nigeria. These areas consists of populations of speakers of various tribes amongst which includes; Birom, Tarok, Hausa, Ibo and Yoruba. Their occupations includes mostly; peasant farmers, traders, local dry cleaners, artisans, mechanics, commercial motorist and civil servants.

Sample Size

The sample size was calculated according to Thrusfield [10]:

$$N= \frac{(1.96)^2 \times Pexp\ (1-Pexp).}{d^2}$$

Where:

n = Sample Size.
Pexp = Expected prevalence.
d = Desired level precision.
Pexp = 13.6% (Alli *et al.,* 2011)
d = 5%

$$N= \frac{(1.96)^2 \times 0.136\ (1- 0.136)}{(0.05)^2}$$

$$N= \frac{3.84 \text{ X } 0.136(0.864)}{0.002}$$

$$N= \frac{3.84 \times 0.118}{0.0025}$$

N=181.

Sample Collection

A total of 179 sachet water samples were collected randomly from nine (9) different water brands/companies in Jos Plateau state from the month of October, 2015 to the month of January, 2016. All samples were collected in clean transparent well sealed sachet for laboratory processing and labeled according to source.

Sample Processing

Using laboratory techniques described by the World Health organization (WHO) the samples will be processed as follows:

1. A gauze filter was placed into a funnel and then placed on top of a centrifuge tube.
2. Water samples in each sachet was shaken and passed through the filter into separate tubes to reach the 10ml mark.
3. The filter was then removed and particulate material(s) present was discarded.
4. The tubes and their contents were centrifuged at 10,000 rpm for 5 minutes.
5. The contents of each tube were pooled after the supernatant fluid has been discarded and re-spun under the same conditions.
6. The supernatant were again discarded.
7. The sediments were examined using x 10 and x 40 objective lenses of the microscope with the iris diaphragm closed and condenser lowered.

Sample Examination

Wet mount preparation

1. A drop of suspended sediments was placed on a clean grease free slide and a drop of normal saline was added.
2. A cover slip was placed and the preparation was examined using x 10 and x 40 objective lenses of the microscope with the iris diaphragm closed and the condenser lowered (WHO).

Iodine preparation

Iodine mount was prepared by the addition of a drop of iodine to a drop of the deposit placed on a clean grease free slide. The preparation was covered with a cover slip and examined using x 10 and x 40 objective lenses of the microscope, with the iris diaphragm closed and the condenser lowered (WHO).

Modified Ziehl-Neelsen method

(a) A smear was prepared from the sediments obtained. The smear was allowed to air-dry.
(b) The smear was fixed with methanol for 3 minutes.
(c) The smear was stained with unheated carbolfuchsin for 15 minutes.
(d) The stain was washed off with water and the smear was decolorized with 1% acid alcohol for 10 seconds.
(e) The smear was counterstained with 0.5% methylene blue for 30 seconds the smear was washed off with water and the slide was left to stand on a draining rack for the smear to air dry. (f) The smear was examined microscopically for oocysts, using a low power magnification to detect the oocysts and oil immersion objective (X 100) to identify them [5].

Statistical analysis

The data was analyzed using SPSS V21 as shown on page 55-56 of the appendix.

Results

A total of 179 sachet water samples of different brands were collected randomly from commercial stores at nine (9) different areas in Jos, Plateau state. Out of the 179 sachet water samples examined, four (4) were positive.

Table 1 titled "Distribution of parasitic contamination of sachet water sold in Jos Plateau state in relation to location" shows the different brands of sachet water obtained from different locations within the study area as well as the number of each brand of water examined. A total of 179 sachet water samples were examined with four (4) positive samples recorded. In terms of location, Dadin Kowa had a prevalence of 8.0%, Farin Gada had a prevalence of 5.9%, while Katako junction had a prevalence of 4.8%. A total prevalence of 2.2% was obtained from the study conducted.

Table 2 which shows the prevalence of parasitic contamination of sachet water sold and in Jos Plateau state relates the individual parasitic organisms identified in the samples with the number of contaminated sachets. *Entamoeba histolytica* was identified in one of the four contaminated samples giving a prevalence of 25% while *Cryptosporidium parvum* found in three out of the four contaminated samples had a prevalence of 75%. Table 2 also showed P> 0.05. This value was obtained by statistical analysis using SPSS V21.

Table 3 shows the frequency and percentage distribution of the different brands of sachet water examined. This was obtained by relating the total number of each brand with the total number of the sachets from different brands examined.

Table 1: Distribution of Parasitic Contamination of Sachet Water Sold in Jos Plateau State in relation to the Locations

Brand	Location	No. Examined	No. Positive	Prevalence (%)
Elim	Photo-Tech	22	0	0.0
Trust	British-America	20	0	0.0
Our Nation	Dadin Kowa	25	2	8.0
Chain Chris	Angwa Rukuba	19	0	0.0
Medigap	Tudun Wada	20	0	0.0
Gold Care	Bauchi/Ring Road	20	0	0.0
Chimas	Katako Junction	21	1	4.8
Skysun	Rikkos	15	0	0.0
Canon	Farin gada	17	1	5.9
Total		**179**	**4**	**2.2**

Table 2: Prevalence of Parasitic Contamination of Sachet Water Sold in Jos, Plateau State

Parasites	No. Positive	Prevalence (%)	Pvalue
Entamoeba histolytica	1	25.0	0.423
Cryptosporidium parvum	3	75.0	
Total	**4**	**2.2**	

Table 3: Frequency and Percentage distribution of the different brands of sachet water examined in Jos, Plateau state

Brand of water	No. examined	Percentage (%)
Elim	22	12.3
Trust	20	11.2
Our Nation	25	13.9
Chris Chain	19	10.6
Medigap	20	11.2
Gold Care	20	11.2
Chimas	21	11.7
Sky Sun	15	8.4
Canon	17	9.5
Total	**179**	

Discussion

In this study, 75% of the positive samples contained *Cryptosporidium parvum* while 25% of the positive samples contained *Entamoeba histolytica* as seen in Table 2. This observation suggests the existence of contaminants in some sachet water sold within the study area. Although a P value > 0.05 and a total prevalence of 2.2% was obtained, the result of this study supports the findings (the presence of parasitic contaminants in sachet water samples) of a similar study carried out in Southwestern Nigeria titled "Parasitological evaluation of some vended sachet water in Southwestern Nigeria" by Alli *et al.,* conducted in 2011 with a higher prevalence of 13.6%. Even though a lower prevalence was recorded in this study, the indication of the presence of parasitic contaminants in some of the sachet water examined has public health implications.

The study also recorded a prevalence of 8% for samples from Dadin Kowa while samples from Katako junction and Farin gada have a prevalence of 4.8% and 5.9% as reported in Table 1. These organisms encountered are potential pathogens associated with diarrheal diseases in healthy individuals, with devastating presentations in immunocompromised individuals. The possibility of water contamination is largely due to sanitary habits as well as hygiene techniques used in water purification and distribution. Among positive samples examined *Crytosporidium parvum* had the highest prevalence rate of (75%). This may be as a result of underground water contamination (bore hole or well), or in the case of tap water, broken water pipe which most of the time passes through drainage gutters. In most cases, contamination is as a result of domestic sewage and industrial wastes being discarded carelessly as well as poor and maladroit water treatment and processing. Several houses in Jos, Plateau state lack a central sewage disposal system hence, most of them dump refuse at the back of their houses while some dump refuse in drainage gutter and some go as far as relieving themselves on the road side, river banks, on top of rocks or pedestrian bridges. Most of the sewage/waste disposed indiscriminately at different places could be washed along with infective stages of parasites into water bodies with severe implication for the users if this water is not properly treated before use. The 1993 Milwaukee Cryptosporidiosis outbreak was as a result of a significant distribution of the cryptosporidium protozoan in Milwaukee Wisconsin, and the largest waterborne disease outbreak in documented United States history. The Howard avenue water purification plant was contaminated, and treated water showed turbidity levels well above normal. It was one of two water treatment plants for Milwaukee [11]. *Entamoeba histolytica* had a prevalence of 25%. Most likely, this should be a result of poor manufacturer hygiene. The absence of parasites in examined samples from the following brands; Elim, Trust, Chain Chris, Medigap, Gold Care and Skysun is most likely due to proper handling, treatment, as well as hygienic environmental condition. Manufacturers of sachet water play a vital role in the purity of the sachet water and contribute to the prevalence rate of waterborne parasitic diseases as a result of poor personal hygiene, method of handling/processing, and also contamination of equipment. Equipment should be properly decontaminated to maintain an aseptic condition. The aforementioned points suggest reasons for the contamination of sachet water.

Conclusion

The result of this study indicates the presence of parasitic contaminants in some brands of sachet water sold in Jos, Plateau state and this could serve as possible routes for the transmission of protozoan parasites. Therefore, infections caused by these parasitic protozoa and helminthes should be considered as potential waterborne diseases in our environment. The poor are mostly at risk of waterborne infection as they tend to be undernourished, lack proper sanitation and have little access to drugs. It has also been documented by previous studies, and supported by this finding that tropical countries like Nigeria are more prone to waterborne diseases where water supplies or treatment plants are made unsafe by indiscriminate waste and sewage disposal or through careless handling of sachet water by manufacturers. An epidemiological and risk assessment approach will undoubtedly boost the understanding of occurrence, survival, and transmission of these organisms and it is safe to say that the possibility of water contamination is largely due to problems associated with water purification and distribution.

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