# Parasitological evaluation of some vended sachet water in Southwestern Nigeria

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**Abstract:** The sale and consumption of sachet water continues to grow rapidly in most countries of the world. A parasitological evaluation of some vended sachet water in Southwestern Nigeria was carried out to determine the safety of sachet water and recommend ways of improving the quality of such drinking water. One hundred (100) brands of 500ml sachet water samples were purchased from roadside and market hawkers and examined using wet preparation and Modified Ziehl Nelson techniques. The result obtained from this study showed that almost all the sample contains debris, while 22.0% (n=22) of them harboured parasites and the water were found to be very slimy and had objectionable odour. Infective stages of six common protozoan and helminthes pathogens were identified. Of the 6 incriminating parasites, *Entamoeba species* 7(31.8%) was most predominant. This was closely followed by *Isospora belli* 6(27.2%) and *Balantidium coli* 6(27.2%) while *Cryptosporidium parvum* 1(4.5%), Hookworm 1(4.5%), and *Taenia species* 1(4.5%) was least prevalent. The parasitic load found in the various samples differed markedly, 86.4% of the positive samples examined contained single parasitic infection, while 13.6% contained mixed infection of two or three types of parasites (*C. parvum* with *Entamoeba species*, while hookworm also had *I. belli* and *Taenia species* as a second contaminant). Location-dependent prevalence showed that samples from Ojoo/UI had the highest prevalence of parasites 4(66.7%). This was followed by Gate Motor Park 3(42.9%), Oja Oba 2(40.0%), Bodija Market 2(25.0%), Oje/Yemetu Market 2(25.0%), Ogunpa Market 2(25.0%), Gbagi/Alakia Motor Park 2(25.0%), Iwo Road Motor Park 3(18.0%), and Challenge/New Garage 1 (14.3%). Those from Owo 1(8.3%) and Akure 1(6.7%) had the least prevalence. No parasite was detected in samples from Ijebu-ode and Lagos. Oocyst of *C. parvum* was found in sample from Iwo Road Motor Park only, mixed infected with *Entamoeba species*. Ova of Hookworm and Ova of *Taenia species* in water from Gate Motor Park only, mixed infected with *I. belli*. Of all the samples examined, only 4.0% of them had NAFDAC approval, while the remaining 96.0% were listed. Of these 4.0% NAFDAC approved and 96.0% NAFDAC listed water, 2(50.0%) and 20(20.8%) were also positive for parasites respectively. However, there was statistical significant relationship (F=10.953; P=0.000) between method of identification of parasite (wet preparation method and modified Ziehl Nelson techniques respectively) and parasite recovery. The organisms detected in these water samples were mainly pathogens of faecal and zoonotic origin. Our observation suggests the existence of a significant level of faecal contaminants in some of our sachet water. Thus, implementation of measures and regulations that would critically minimize and control the spread of waterborne diseases is highly advocated.

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**Keywords:** Modified Ziehl Nelson techniques, *Cryptosporidium parvum*, *Taenia species*, *Isospora belli*, *Balantidium coli* and *Entamoeba species*, Wet preparation

## 1.0. Introduction

Over the recent years however, concerns have been raised over the microbial quality of drinking water (Fewtrell et al., 1997; Rosenberg, 2003; Khaniki et al., 2010). Recently in Nigeria, drinking water is commercially available in easy-to-open 50 – 60 ml polyethylene sacks known as satchet/pure water (Umeh et al., 2005; Okonko et al., 2008b). Sachet drinking water popularly called "pure water" in Nigeria is presently a lucrative business, with many people involved in the production and marketing of the product (Ekwunife et al., 2010). Many people in rural and urban communities rely on sachet water and/or borehole water as the source(s) of their drinking water supply. The integrity of these sachet waters before is doubtful, in fact, unconfirmed report abounds that most of the vendors do not treat their sachet waters before selling to the public (Oladipo et al., 2009). This become a concern for public health workers and any right-thinking individual when one consider the fact that public including nursing mothers patronize these vendors to procure water for their small children (Oladipo et al., 2009). These sachet drinking water and food - drinks though beautifully packaged, well labelled and advertised are not necessarily free of contaminants, to which they are exposed (Ekwunife et al., 2010). Food - drinks contamination in Nigeria are well documented (Omemu *et al*., 2005; Taura *et al*., 2005). Food - drinks and water occasionally get

contaminated either during processing, while transporting them or by hawkers and handlers. Apart from the health implications, drinking contaminated water also have serious socio - economic and political implications (Mukhtar and Oyeye, 2005).

Water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability (Lamikanra, 1999; Okonko et al., 2008a,b). Water related diseases continue to be one of the major health problems globally (Oladipo et al., 2009). Unsafe water is a global public health threat, placing persons at risk for a host of diarrheal and other diseases as well as chemical intoxication (Hughes and Koplan, 2005; Prasanna and Reddy, 2009). Biological contaminants such as bacteria, viruses, fungi, protozoa and helminthes constitute the major cause of food-borne and water-borne diseases with varying degrees of severity, ranging from mild indisposition to chronic or life-threatening illness, or both (Okonko et al., 2009b). A review of 28 studies carried out by the World Bank gives the evidence that incidence of certain water borne, water washed, water-based and water sanitation associated diseases are related to the quality and quantity of water and sanitation available to users (Prasanna and Reddy, 2009). An estimated 1.1 billion persons (one sixth of the world's population) lack access to clean water and 2.6 billion to adequate sanitation (WHO, 2005; Hughes and Koplan, 2005; Okonko et al., 2008b, 2009b).

One of the strategies for tackling this problem is the provision of protected sources such as boreholes, standpipes, protected wells and springs. However, such facilities are located some distances requiring transportation to homes (Taulo et al., 2008). During transportation, water gets contaminated with bacteria which grow and proliferate during storage in the homes (Hoque et al., 2006). This contamination may lessen the health benefits of water source improvements (Wright et al., 2004; Okonko et al., 2009a). The overall treatment of source water is dependent in the quality of source water, type of sachet water being manufactured and location (Wartburton et al., 1998; Khaniki et al., 2010). Earlier investigation conducted on the safety of drinking water has show that water on the market is of good microbiological quality while the quality of some factory bagged sachet and hand-filled polythene bagged drinking water was noted to be doubtful (Obiri-Danso et al., 2003).

This observation was based on studies carried out on water sample to ascertain the presence of heterotrophic bacteria, indicators of fecal contamination (total coliform, fecal coliforms and *Enterococci*) and for lead, manganese and iron (Oladipo et al., 2009). Lack of information on pathogenic and parasitic microorganisms in sachet water on our market creates some uncertainties in our understanding of the overall quality of drinking water on our markets (Oladipo et al., 2009).

To bridge this information gap, there is an urgent need for the determination of protozoan and helminthes organisms associated with drinking water in our communities (Steiner et al., 1997). A good knowledge of the microbial qualities of raw water is necessary so as to guide its suitability for use. Thus, regular physico-chemical, microbiological and parasitological evaluation of water at source must be carried out to determine or check the effectiveness of treatment process (Okonko et al., 2008a,b, 2009a,b). Therefore, this study aimed at determining the parasitological status/quality of vended sachet in southwestern Nigeria in order to provide information that could improve public health of the populace and prevent disease outbreak in Nigeria. The study will also afford opportunity to implore Government at various levels to improve on the concerted efforts to supply water suitable for human consumption and easily made available to the masses.

## 2.0. MATERIALS AND METHODS

### 2.1. Study area

The study areas include Ibadan in Oyo State, Lagos State, Ijebu-ode in Ogun State, Akure and Owo in Ondo State. Ibadan shares common boundaries with Lagos and Ijebu-ode. Ibadan is geographically situated at an area lying between the longitude 758 EAST and the 722 North of Oyo empires. Ibadan is said to be the second largest in Africa and the largest in West Africa. As the largest city, Ibadan municipal area has five (5) local Government area, they are Ibadan North, Ibadan South, Ibadan South-West, Ibadan North-East, Ibadan North-West, and Ibadan South-East. Ibadan gets its water supply from two(2) main sources, the Asejire Dam along Ife road which is the boundary between Oyo state and Osun state. The second place is Eleyele water works nearer to a hill called Oke-Ibadan.

### 2.2. Collection of samples

One hundred (100) brand of 500ml vended sachet water were randomly purchase from market hawkers at the various study locations in southwestern Nigeria. These include Ibadan, Akure, Owo, Lagos and Ijebu-ode and examined. Table 1 show the summary of vended sachet water from different locations in southwestern Nigeria. It showed the area of collection and the frequency of sample collected respectively.

**Table 1: Summary of vended sachet water from different locations in southwestern Nigeria**

| Location | No. Tested |
|---|---|
| Gate Motor Park | 07 |
| Iwo Road Motor Park | 16 |
| Bodija Market | 08 |
| Challenge New Garage | 07 |

| | |
|---|---|
| Oje/Yemetu Market | 08 |
| Oja Oba | 05 |
| Ogunpa Market | 04 |
| Ojoo/UI Area | 06 |
| Gbagi/Alakia Motor Park | 08 |
| Akure | 15 |
| Owo | 12 |
| Lagos | 03 |
| Ijebu-ode | 01 |
| **Total** | **100** |

**2.3. Wet mount preparation**

A drop of suspended sediment was placed on a clean glass slide; it was cover with cover slip and examined microscopically using x10 and x40 objective lenses. A drop of suspended sediments was placed on a drop of iodine solution using Pasteur pipette. The mixture was cover with cover slip and examined microscopically using x10 and x40 objective lenses (Cheesbrough, 2005).

**2.4. Modified Ziehl Nelsen techniques**

A drop of each sediment was placed on a labelled slide and spread in a thin uniform smear using a Pasteur pipette. It was fixed in methanol for two minutes. The slides were stain with cold carbol fuschin for fifteen minutes and wash off with water. Slides were decolorized with 1% acid alcohol for 10 s, it was rinsed with water. Slides were counterstained with methylene blue for 5mins and rinsed with water. Slides were examined using high power objective lens (x100) according to Cheesbrough (2005).

**3.0. RESULTS ANALYSIS**

The parasitological examination of 100 different brands of sachet water samples purchased from different markets and motor parks showed that almost all the samples contain debris. Of the 100 different brands of sachet water examined, 22.0% (n=22) of them harboured parasites and the water were found to be very slimy and had objectionable odour.

Table 2 shows the frequency of occurrence of protozoan and helminthes organisms detected in vended sachet water from different location in southwestern Nigeria. Infective stages of six common protozoan pathogens were identified. Of these common parasites, *Entamoeba species* 7(31.8%) was most predominant. This was closely followed by *Isospora belli* 6(27.2%) and *Balantidium coli* 6(27.2%) while *Cryptosporidium parvum* 1(4.5%), Hookworm 1(4.5%), and *Taenia species* 1(4.5%) was least prevalent. The parasitic load found in the various samples differed markedly, 86.4% of the positive samples examined had single parasitic infection, while 13.6% contained mixed infection of two or three types of parasites. The sample detected with *Cryptosporidium parvum* was also found to contain *Entamoeba species*, while the sample detected with hookworm also contain *Isospora belli* and *Taenia species* as a second contaminant (Table 2).

**Table 2: Frequency of occurrence of protozoan and helminthes organisms detected in vended sachet water from different location in southwestern Nigeria**

| **Parasites** | **No. (%)** |
|---|---|
| *Entamoeba species* | 7(31.8) |
| *Isospora belli* | 6(27.2) |
| *Balantidium coli* | 6(27.2) |
| *Cryptosporidium parvum* | 1(04.5) |
| Hookworm | 1(04.5) |
| *Taenia species* | 1(04.5) |
| **Pattern of infection** | |
| Single infections | 19(86.4) |
| Mixed infections of *Cryptosporidium parvum* and *Entamoeba species* as well as of *Isospora belli,* Hookworm and *Taenia species* | 03(13.6) |
| **Total** | **22(100.0)** |

Table 3 shows the distribution of protozoan and helminthes organisms detected in vended sachet water in relation to locations. It showed that water samples from Ojoo/UI Area had the highest prevalence of parasites detected 4(66.7%). This was followed by those from Gate Motor Park 3(42.9%), Oja Oba 2(40.0%), Bodija Market 2(25.0%), Oje/Yemetu Market 2(25.0%), Ogunpa Market 2(25.0%), Gbagi/Alakia Motor Park 2(25.0%), Iwo Road Motor Park 3(18.0%), Challenge New Garage 1(14.3%). Those from Owo 1(8.3%) and Akure 1(6.7%) had the least prevalence. However, no parasite was detected in samples from Ijebu-ode and Lagos. In the same vein, cyst of *Entamoeba species* was detected only in samples from Iwo Road Motor Park, Ogunpa Market, Ojoo/UI Area, Owo and Akure. Oocyst of *Isospora belli* was detected in samples from Gate Motor Park, Iwo Road Motor Park, Ojoo/UI Area, Bodija Market, Challenge New Garage and Oje/Yemetu Market. Oocyst of *Balantidium coli* was detected in samples from Bodija Market, Oje/Yemetu Market, Oja Oba, and Gbagi/Alakia Motor Park only. Oocyst of *Cryptosporidium parvum* was found in water sample from Iwo Road Motor Park only, mixed infected with *Entamoeba species*. Ova of Hookworm and Ova of *Taenia species* in water from Gate Motor Park only, mixed infected with *I. belli* (Table 3). No protozoan and helminthes organisms were detected in sachet water from Ijebu-ode and Lagos (Table 3).

**Table 3: Distribution of protozoan and helminthes organisms detected in vended sachet water in relation to locations**

| Study area | No. Tested (%) | No. Positive (%) | Parasites detected | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Ova of *Taenia species* | Oocyst of *I. beli* | Ova of Hook worm | Cyst of *Entamoeba species* | Oocyst of *C. parvum* | Cyst of *B. coli* |
| Gate Motor Park | 07(07.0) | 3(42.9) | 1(33.4) | 1(33.3) | 1(33.3) | 0 (00.0) | 0 (00.0) | 0 (00.0) |
| Iwo Road Motor Park | 16(16.0) | 3(18.8) | 0 (00.0) | 1(33.4) | 0 (00.0) | 1(33.3) | 1(33.3) | 0 (00.0) |
| Bodija Market | 08(08.0) | 2(25.0) | 0 (00.0) | 1(50.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 1(50.0) |
| Challenge New Garage | 07(07.0) | 1(14.3) | 0 (00.0) | 1(100.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) |
| Oje/Yemetu Market | 08(08.0) | 2(25.0) | 0 (00.0) | 1(50.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 1(50.0) |
| Oja Oba | 05(05.0) | 2(40.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 2(100.0) |
| Ogunpa Market | 04(04.0) | 1(25.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 1(100.0) | 0 (00.0) | 0 (00.0) |
| Ojoo/UI Area | 06(06.0) | 4(66.7) | 0 (00.0) | 1(25.0) | 0 (00.0) | 3(75.0) | 0 (00.0) | 0 (00.0) |
| Gbagi/Alakia Motor Park | 08 (08.0) | 2(25.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 2(100.0) |
| Akure | 15(15.0) | 1(06.7) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 1(100.0) | 0 (00.0) | 0 (00.0) |
| Owo | 12(12.0) | 1(08.3) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 1(100.0) | 0 (00.0) | 0 (00.0) |
| Lagos | 03(03.0) | 0(00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) |
| Ijebu-ode | 01(01.0) | 0(00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) | 0 (00.0) |
| **Total** | **100(100.0)** | **22 (22.0)** | **1(04.5)** | **6(27.3)** | **1(04.5)** | **7(31.8)** | **1(04.5)** | **6(27.3)** |

Table 4 shows distribution of protozoan and helminthes organisms in relation to NAFDAC approved and NAFDAC listed sachet water companies. In all the sachet water examined only 4.0% of the sachet water company have been approved by NAFDAC, while the remaining 96.0% are still been listed (Table 4). Of the 4 NAFDAC approved sachets water, 2 (50.0%) were positive for parasites, while 20.8% (n=20) of the NAFDAC listed were also positive for parasites (Table 4).

**Table 4: Distribution of protozoan and helminthes organisms in relation to NAFDAC approved and NAFDAC listed sachet water companies**

| Category | No. Tested (%) | No. Positive (%) |
|---|---|---|
| Approved Sachet Water Company | 04(04.0) | 02(50.0) |
| Listed Sachet Water Company | 96(96.0) | 20(20.8) |
| **Total** | **100(100.0)** | **22(22.0)** |

Table 5 shows the distribution of protozoan and helminthes organisms detected in vended sachet water according techniques used. It showed a statistical significant relationship (F=10.953; P=0.000) between method of identification of parasite (wet preparation method and modified Ziehl Nelson techniques respectively) and parasite detection.

**Table 5: Distribution of protozoan and helminthes organisms detected in vended sachet water according techniques used**

| Parasites | No. (%) | Wet preparation (%) | Ziehl Neelson (%) |
|---|---|---|---|
| Ova of *Taenia spp.* | 01(04.5) | 01(100.0) | 00(00.0) |
| Cyst of *Entamoeba spp.* | 07(31.8) | 07(100.0) | 00(00.0) |
| *B. coli* | 06(27.2) | 06(100.0) | 00(00.0) |
| Oocyst of *Isospora belli* | 06(27.2) | 00(00.0) | 06(100.0) |
| Ova of Hookworm | 01(04.5) | 01(100.0) | 00(00.0) |
| Oocyst of *Cryptosporidium* | 01(04.5) | 00(00.0) | 01(100.0) |
| **Total** | **22(22.0)** | **15(68.2)** | **07(31.8)** |

## 4.0. DISCUSSION

Continuous increase in the sale and indiscriminate consumption of packaged drinking waters in Nigeria is of public health significance (Oyedeji et al., 2010). The sale and consumption of packaged water continues to grow rapidly in most countries of the world. In Nigeria particularly, there is an astronomical increase in the consumption of packaged waters especially bottled and sachet drinking water (Oyedeji et al., 2010). The increased demand for these drinking water products is attributed largely to factors such as inadequate or non availability of reliable, safe municipal water in urban areas; impression that high quality natural spring water and drinking water offer a healthy, refreshing and great tasting alternative to high calorie soft drinks and ordinary tap water; and convenience which has made the products meet the requirements of any lifestyle when needed (Gardner, 2004; Oyedeji et al., 2010).

Of the 100 different brands of sachet water examined, 22.0% of them harboured parasites. The study showed that *Entamoeba species* (31.8%) was the most predominant of the 6 incriminating parasites, followed by *Isospora belli* (27.2%) and *Balantidium coli* (27.2%) while *Cryptosporidium parvum* (4.5%), Hookworm (4.5%), and *Taenia species* (4.5%) was least prevalent. The organisms detected in these water samples were mainly pathogens of faecal and zoonotic origin. Our observation suggests the existence of a significant level of faecal contaminants in some of our sachet water. This is in line with the findings of Kwakye-Nuako *et al.* (2007) study in Ghana, where some protozoan parasites were detected in sachet drinking water. However, the occurrence of parasites in the sampled sachet water is in contrast with Ekwunife et al. (2010) study in Awka, Southeastern Nigeria,

where no protozoan parasites were detected in sachet drinking water. This also contrasted the findings of Egwari *et al*. (2005) in Lagos southwest Nigeria who in their bacteriology study of sachet water found no enteric pathogens and *Entamoeba coli*. Egwari *et al*. (2005) in Lagos, Nigeria also noted that *Entaemoeba coli* and other enteric pathogens formed a significant part of the isolates on the outside sachet surfaces of samples collected from cooling receptacles (pail, basin, wheel barrow, and refrigerator). It was therefore not surprising that some packets analysed in this present study had hook worm eggs on them. Several factors potentially accounted for this observation, notable among these could be improper processing and purification procedures, unhygienic handling after production, the small size of the pathogens which enable them to escape filtration and the resistance of these pathogens to physical water treatment agents and disinfectants (Kwakye-Nuako *et al*., 2005).

Several studies on the microbial quality of bottled and sachet water have reported violations of international quality standards (Oyedeji et al., 2010). In a Canadian study, screening of bottled water for indicator bacteria revealed that 3.7% of the samples had total coliforms and 23.3% of the 3460 samples had more than 100 colonies of heterotrophic bacteria per ml of sample (Warburton et al., 1998). A similar study on brands of bottled water in Trinidad showed that 18 out of the 344 samples checked revealed the presence of total coliforms while five of the samples had *Escherichia coli* and colonies of *Enterococcus faecalis* were occasionally detected in the samples (Bharath et al., 2003). The quality monitoring of sachet water in Nigeria have been documented (Adekunle et al., 2004; Onifade et al., 2008; Dada, 2009; Oyedeji et al., 2010). However, there is little information in scientific literatures on the parasitological quality of the many brands of sachet water produced and marketed by local and multinational companies.

Water borne diseases continue to be one of the major health problems especially in developing nations (Oyedeji et al., 2010). The consumption of drinking water contaminated with pathogenic microbes of faecal origin is a significant risk to human health in the developing world, especially in remote rural areas and industrial areas (Davies-Colley et al., 2001). Over 3 million deaths per year is attributed to water-borne diarrhoeal diseases, especially among infants and young children in poor communities in Africa, Asia and South America (Anon, 1997). The high prevalence of diseases such as diarrhoea, typhoid fever, cholera and bacillary dysentery among the populace has been traced to the consumption of unsafe water and unhygienic drinking water production practices (Mead et al., 1999). The most dangerous form of water pollution occurs when faecal contaminants enter the water supply (Oyedeji et al., 2010).

The study has shown that the protozoan and helminthes organisms detected were widely distributed in Ibadan metropolis than other study locations. No protozoan and helminthes organisms were detected in sachet water from Ijebu-ode and Lagos. Ibadan metropolis, Owo, and Akure city are highly urbanized areas in South Western Nigeria where several brands of bottled and sachet water are vended to the public. Transmission of water borne disease is still a major public health concern despites considerable efforts and modern technology being utilized for the production of safe drinking water (Zamberlan et al., 2008) and it is important to know microbial quality of sachet water (Khaniki et al., 2010). The prevalence of water related diseases in developing countries is determined by the quality of their drinking water. The safety of drinking water in poor and deprived communities has in the last decade been in jeopardy as a result of wanton introduction of refuse and sewage into sources of water supply. The introduction of the sachet drinking water in Nigeria market was a laudable idea but studies suggest that this innovative idea is not risk free. The sachet drinking water was introduced into the Nigerian market as a less expensive means of accessing drinking water than bottled water (Ogundipe 2008; Oyedeji et al., 2010). It also acts as an improvement over the former types of drinking water packaged for sale to consumers in hand filled, hand tied polythene bags (Oyedeji et al., 2010). Today, the easy accessibility to drinking water in packaged forms has resulted in a big and thriving water industry with several hundreds of million litres of these water products consumed every year by Nigerians (Ogundipe, 2008).

The findings of this study has fulfilled its objective of assessing the quality and safety of vended sachet drinking water for human consumption and the possibility that it could serve as a route of transmission of protozoa parasites. The study has revealed the occurrence of high proportion of pathogenic and non-pathogenic protozoa and helminthes in some of the sachet water in our markets. This supports what was also reported by Arora and Arora (2009). Our result also support the findings of Kwakye-Nuako *et al*. (2005) in a similar study carried out in Accra and Kumasi in Ghana to determine the microbial quality of water on the streets. In addition, house flies can carry eggs and cysts of a variety of protozoa and helminthes for example *Taenia, Ballantidium coli, Hymenolepsis, Diphyllobothrium, Necator, Ancylostoma, Enterobius, Trichurus, Ascaris* etc. into the such water during packaging as reported by Mike (1999).

The high prevalence of protozoan and helminthes organisms reported in this study could be attributed to the environmental conditions of the area where these sachet water were produced, for instant a city like Ibadan where there is compact houses and where septic tanks, pit latrine and refuse dump are made and built very close to the (Wells which are the source of water for some sachet companies) can be a contributory factor for the presence of these protozoa and helminthes organisms. The presence of live Rotifers commonly found in ponds, was a strong indication of the presence of high level of organic material enough to support life and other biological activities of the organisms, this could explain why some of the samples were noted to be slimy with objectionable odour (Current *et al.,* 1991). Studies have shown that most bottled water manufacturers in Nigeria also engage in sachet water packaging and obtain their raw water mostly from local, municipal piped water or well water (Oyedeji et al., 2010). Adherence to production and analytical standards are doubtful as most of the factories are observed to lack the appropriate technology for achieving these. The standards of hygiene in the various stages of production of bottled and sachet water vary among various manufacturers (Oyedeji et al., 2010). While some employ sophisticated techniques such as ozonization and reverse osmosis most use ordinary boiling of well water sources and exclusion of particles by use of unsterilized filtration materials (Oyedeji et al., 2010).

The protozoan and helminthes organisms detected in this study are potential pathogens associated with water-related diarrhea outbreaks in healthy people with devastating presentations in the immunocompromised individuals. Characteristics of these organisms include the low infective dose (1-10oocysts), the infectious nature of the various oocysts of these organisms immediately after excretion in feaces, the stability of these oocysts in our environment and the rapid rate of environmental dispersal (Nime *et al*., 1976). All these factors affect the dynamics of the epidemiology of these infections in our environment. In view of the prevalence of HIV infection in our communities coupled with the devastating consequences of these infection among immunocompromised individuals, it is important to advocate for the general awareness of the public over the need for quality and safe drinking water (Cimerman *et al*., 1990).

The finding of this study has also shown that wet preparation method is good for detection of ova, egg and cyst of protozoa and helminthes organisms while Modified Ziehl Neelson detects acid fast parasite better. Besides, the sources of untreated drinking water could be veritable reservoir of several other opportunistic pathogens of human and chemical poisoning (Oladipo et al., 2009). Vital information required for the protection of consumers were lacking on some of the sachet water examined. None of the brands has batch numbers and all the brands have no records of the dates of manufacture. Contact addresses were however indicated on all the sachet water bag though none had the expiry dates printed on the sachets. In view of these, NAFDAC should make it mandatory for all companies to include this vital information on their sachet water bags. While current regulatory standards used for the assessment of sachet drinking water places emphasis on bacteria testing and seem to be silent on the limits of protozoa and helminthes organisms; we wish to recommend parasitological investigations to be carried out also on sachet water to assess water quality at various levels before production, after production at the factories, and at the point of consumption in order to ensure their quality and safety.

This study gives belief to the fact that the magnitude of water-related parasitic human diarrhea disease due to the intake of contaminated drinking water in our communities is undoubtedly underestimated. The microbial contaminations of packaged drinking water could be influenced by factors such as their raw water source, treatment process employed and hygienic practices observed in production (Geldreich, 1996; Oyedeji et al., 2010). Most sachet water manufacturers are observed to utilize well water or at best shallow, contaminated boreholes and municipal tap water as raw water source. Well water is usually contaminated by surface waters especially during the rainy season and inadequate attention paid to the environmental sanitary qualities of these wells could result in wild animals and birds constituting natural sources of zoonotic pathogens (Oyedeji et al., 2010). At best raw water is subjected to ordinary boiling and packaging by most producers, which may not produce the desired quality and safe products (Oyedeji et al., 2010). It is advisable that these two sources (river and well) should therefore be avoided as sources of raw water for production. Ground waters such as boreholes when properly constructed and maintained provide a relatively safer source of raw water in terms of microbial load compared to unprotected water sources such as river, spring and well waters (Howard et al., 2003; Oyedeji et al., 2010).

The presence of protozoan and helminthes organisms in this study may also be attributed to improper handling, processing and purification procedures, unhygienic handling after production. Inadequate sanitation and unhygienic practices accounts for the major source of microbial contamination of any potable water (Sahota, 2005). High demand for packaged water for various occasions has led to springing up of small scale entrepreneurs who engage in production of

packaged waters without due regard to hygienic practices in the production processes. The implication of this is lack of guarantee that the products will meet set standards for drinking water quality (Oyedeji et al., 2010). Water with such protozoa and helminthes organisms are not safe for human consumption hence, the water source should be re-examined by the NAFDAC (Tortora et al., 2002; Oladipo et al., 2009). Also, the presence of protozoan and helminthes organisms in sachet drinking water sold in selected areas of South Western Nigeria make the products unfit for human consumption going by WHO and NAFDAC recommendations and guidelines. There is therefore need for NAFDAC to intensify efforts in the routine monitoring of activities in the packaged drinking water industry. The safety of sachet drinking water should be ensured through comprehensive regulatory programs at both the federal and state levels. NAFDAC regulations for packaged waters should be protective of public health and there should be continuous adoption of packaged water quality standards (Oyedeji et al., 2010). Testing of market samples will be a good way of detecting if the water is actually pure as claimed by these producing companies (Oyedeji et al., 2010).

This study has also established the extent to which contaminated drinking water contributes to the overall disease burden of the Nigeria population. The microbiological/parasitological quality of drinking water is of paramount importance and monitoring must be given highest priority, this is so because studies have attributed several disease outbreaks to untreated or poorly treated water containing bacteria pathogen that have been isolated from sachet water (Oladipo et al., 2009). The continuous proliferation of these packaged water products by protozoa and helminthes organisms and their indiscriminate consumption are of public health significance. An understanding of their microbiological/parasitological quality and safety were therefore imperative (DWRF, 2004). To reduce contamination, further investigation on sachet water is recommended. Assessment of water quality at some important stages of production; pre-production, production and postproduction stages at the factories is therefore, suggested in order to ensure their quality and safety. High premium should be placed on ascertaining compliance with Good Manufacturing Practice (GMP) with emphasis on management of raw water source to the consumer product point as recommended by the International Bottled Water Association (Oyedeji et al., 2010).

## 5.0. CONCLUSION

This study shows that some sachet water in our markets could serve as possible routes of transmission of protozoan parasites. Therefore, Infections caused by these parasitic protozoa and helminthes organisms should critically be considered potential waterborne diseases in our environment. In line with the assertions of Prasanna and Reddy (2009), we would also like to recommend the proper sanitary survey, design and implementation of water and or/ sanitation projects; regular disinfections, maintenances and supervisions of water sources, and regular bacteriological assessment of all water sources for drinking should be planned and conducted. Like other countries, we need to implement measures and regulations that would critically minimize and control the spread of waterborne diseases (Current *et al*., 1991). Epidemiological and risk assessment approaches will undoubtedly boost our understanding of the occurrence, survival and transport of these organisms. Regardless of these measures, the possibility of contaminated water causing significant diseases still remains due to problems associated with water purification and distribution.

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