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Microbiological Assessment of the Quality of Domestic Water Consumed in Southern Edo State, Nigeria

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Abstract

Water is a critical global resource, its quality paramount for our health. This study evaluated domestic water quality in southern Edo State, Nigeria. Samples (Rain, Bottled, Borehole) were gathered from five communities in Egor, Ikpoba-Okha, Ovia South-west, Orhionmwon, and Oredo LGAs. Parasitological, bacterial, and fungal analyses were conducted. The results showed that heterotrophic bacterial and fungal counts for borehole water collected were all within the WHO/NSCWQ standard for water quality while for feacal coliforms, highest counts ($9x10^3$- $15x10^3$) cfu/ml were seen in borehole water samples collected in some communities in Egor Local Government Area and lowest in Ovia South-West Local Government area For rain water samples, heterotrophic bacterial and fungal counts were also within the standard limits used while faecal coliform counts were highest from samples collected from Ikpoba-Okha Local Government Area ranging between ($9x10^3$-$28x10^3$)cfu/ml and lowest (4.00-18.00) $x10^3$cfu/ml counts were observed also in Orhionmwon Local Government Area. The heterotrophic bacteria, fungi and faecal coliform counts were all within WHO/NSCWQ standards for bottled water samples analyzed. Parasitic contamination was found in all samples (prevalence: 50.67%), including Ascaris species (25.45%), hookworm ova (36.36%), Giardia lambia cysts (14.54%), and Cryptosporidium parvum oocysts (18.18%). Bacteria isolated included Staphylococcus aureus (36%, 48%, 40%), Enterobacter sp (20% 32%, 12%), Escherichia coli (35%, 40%, 15%), and Pseudomonas spp (36.0%, 32.0%, 13%) from borehole, rainwater, and bottled water, respectively. Contamination sources may include collection media, hygiene practices, and proximity to septic tanks. Stringent hygiene measures are imperative to mitigate pathogenic risks.

Keywords: Water, Protozoans, Faecal coliform, Heterotrophic Fungi, Hygiene.

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INTRODUCTION

Water is a vital resources needed for the sustenance of life (Anake *et al.,* 2013). Water in its pure form should be colourless, odourless, tasteless and sparkling in nature (Egereonu, 2006). Like other developing countries, the issue of access to healthy water is very significant in Nigeria, where 48% (about 67 million Nigerians) depend on surface water source for domestic use, 57% (79 million) use hand dug wells, 20% (27.8 million) harvested rain, 14% (19.5 million) have access to pipe borne water, and 14% have access to borehole water sources (FGN, 2007). An estimate of over 2 billion people live in water-stressed countries, which is expected to be exacerbated in some regions as a result of climate change and population growth. At least 2 billion people use a drinking water source contaminated with faeces. Also, some 829 000 people are estimated to die each year from diarrhoea as a result of unsafe drinking water, sanitation and hand hygiene (WHO, 2022). This situation is worse in developing countries, where 60% of their population do not have access to healthy drinking water (Karanis, 2006;). In the context of international regulations, the contamination of water bodies by organic micro-pollutants is the subject of constant interest and is always under investigation. Studies have shown the enormous roles played by water in the transmission of enteric and other waterborne diseases from one point to another **(**Nnadozie and Abu, 2015).

Basically, microorganisms play a major role in determining water quality. Some of the microorganisms that are concerned with waterborne diseases include: Salmonella *spp,* Shigella *spp*, *Escherichia coli*, Klebsella and *Vibrio cholera* **(**Adetunde and Glover, 2010). All these cause diseases like typhoid fever, diarrhoea, dysentery, gastroenteritis and cholera. Similarly, the consumption of water containing parasites has been attributed to be a major source of *Giardia lamblia, Crysptosporidium parvum, Entamoeba histolytica, Isospora beli and Microsporidium* spp infections in various outbreaks or epidemics (Odikamnoro *et al.,* 2014). Common water-related diseases caused by parasites include schistosomiasis, amoebiasis, cryptosporidiosis and giardiasis. People become infected with these diseases when they drink or have contact with water that has been contaminated with the causative parasites. For example, individuals drinking water contaminated with fecal matter containing the amoeba, *Entamoeba histolytica* can get amoebic dysentery (amebiasis). An individual can get Guinea worm disease when they drink water that contains the parasite *Dracunculus medinensis.*

Globally, about 80% of all diseases and death in third world are water-related due to pollution of water sources (Aderibigbe *et al.,* 2008; Ayeni *et al.,* 2011). The numbers of outbreaks of water-related diseases that have been reported in Nigeria indicate that transmission of pathogens by drinking water constitutes a major cause of illnesses (Nwidu *et al.,* 2008). A number of studies pointed out that the lack of awareness as regards the significance of maintaining clean and hygienic stored water contributes to increasing waterborne diseases (Bello *et al.,* 2017; Andersson *et al.,* 2018; Mark *et al.,* 2019; Rubino *et al.,* 2019).

MATERIALS AND METHODS

Study Area

Edo state is located in the heart of the tropical rain forest. The state lies within the geographical coordinates of longitude 005°04′ East and 006°43′ East and latitude 05°44′ North and 07°34′ North. To the north, it is bounded by Kogi State; to the east, it is bounded by Anambra State; to the south, by Delta State and to the west, by Ondo state. The population of Edo State based on 2006 Census is 3,233,366 (Ojeifo and Eseigbe 2012). The State is also characterised by high rainfall with July having the highest mean rainfall (403.0mm) while the month of January recorded the lowest (17mm) (Iseghosimhe, 2005).

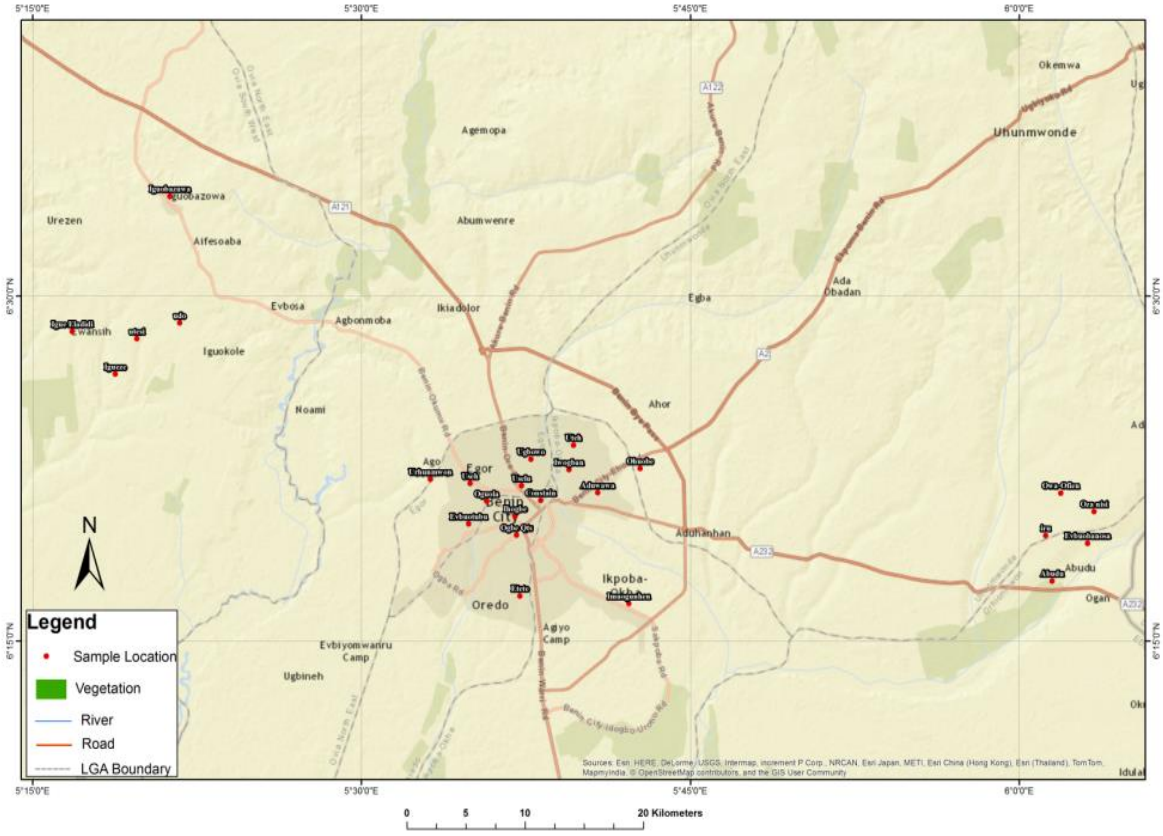

Fig. 1: Map of the study area.

Sample Collection

Seventy five (75) water samples (25 each for borehole water, bottled water and rainwater) were collected with clean and well labeled bottles from five communities in the selected five Local Government Areas in Edo State namely: Egor (Uselu, Ugbowo, Evbuotubu, Useh, Urunmwom); Ikpoba-Okha (Iwogban, Uteh, Aduwawa, Imuogunhen, Ohuovbe); Oredo (Costain, Ogbe, Oguola, Etete, Ihogbe); Orhionmwon (Abudu, Iru, Oza-nisi, Evbuobanosa, Owa-Ofien) and Ovia South West (Udo, Utesi, Igueze, Igue-Eladidi, Iguobazua).

Each of the communities mentioned accounted for three (3) water samples: one (1) each from harvested rainwater, bottled water consumed in the area and stored borehole water. Water samples collected were transported immediately to microbiology laboratory University of Benin for microbial analysis.

Laboratory procedures

Enumeration of total heterotrophic bacteria and feacal coliform counts

Enumeration of total viable bacteria and *E. coli* count by plate count method was carried out for each water samples, using nutrient agar, mannitol salt agar and macConkey agar . Aliquots of 1ml serially diluted samples were poured on sterilized plate and 15-20ml molten agar mentioned above was poured into each plate and swirled gently to mix the inoculated water and agar properly. Duplicate plates and inoculated plates were incubated at a temperature of 37^0C for 24hours for mesophillic bacteria plates and MacConkey agar plates for *E. coli* (Cheesbrough, 2000).

Enumeration of total heterotrophic fungal counts

Total fungal analysis was carried out on treatments by weighing 10 ml of soil sample into 90 ml of distilled water and serially diluted to obtain a ten-fold diluent. From dilution 10^{-4} and 10^{-6}, aliquot of was plated unto Potato Dextrose Agar (PDA), amended with chloramphenicol (0.02-1 µg/ml) and used for the isolation of fungi. The plates were prepared and inoculated in duplicates and incubated at room temperature for 5 days. After incubation, the colonies of the isolates were counted and expressed in cfu/ml; isolated colonies were further purified by sub-culturing and identified by comparing growth with standard manual and microscopy (Barnett and Hunter, 1998).

Parasitological Examination of the Water Samples

This study utilized saline gradient sedimentation technique for examination of water samples for enumeration of ova, cysts and oocysts of helminthes, *Giardia lamblia* and C*ryptosporidium* spp. The Direct Smear Method was used as an adjunct test for identification of cysts, eggs and oocysts of these parasites. Water samples were analyzed following the method described by Abbaszadegan *et al*. (1991) and Campbell *et al.* (1992).

RESULTS

Microbial contamination of public drinking water supplies poses a serious threat to human health (Musa *et al*., 2014). The bacteria isolated from drinking water sources from communities in the five local government area investigated were *Staphylococcus aureus* (36%, 48%, 40%), *Enterobacter sp* (20% 32%, 12%), *Escherichia coli* (35%, 40%, 15%), and *Pseudomonas* spp (36.0%, 32.0%, 13%) from borehole, rainwater, and bottled water, respectively. The fungi isolated were *Aspergillus niger* and *Penicillinum. Aspergillus niger* had percentage frequency of occurrence as 40% in borehole water, 44% in rainwater and 16.7% in bottled water. *Penicillinum notatun* had percentage frequencies of occurrence as 22% in borehole water, 45% in rainwater and 10.7% in bottled water. The mean heterotrophic bacterial counts analyzed for borehole water, rainwater and bottled water ranged between (1.00- 5.50) x 10^3cfu/ml, (1.00- 5.00) x 10^3cfu/ml and (0.00- 1.50) x 10^3cfu/ml respectively for all the communities sampled in the five (5) Local Government Area examined. The highest range for borehole water, (3.00-5.50) x10^3cfu/ml was observed in Orhionmwon local government while the lowest range (1.00-3.00) x 10^3cfu/ml was seen in Oredo local Government area. The highest range, (3.00-5.50) x10^3cfu/ml for rainwater was seen also in Orhionmwon local government area and the lowest value, (1.00-3.00) x10^3cfu/ml was observed also in Oredo local Government area , The mean heterotrophic bacterial counts for bottled water was minimal for all water samples analyzed across the five local government areas.

The feacal coliform counts for borehole water, rainwater and bottled water ranges are (7.00-15.00) x 10^3cfu/ml, (4.00- 28.00) x 10^3cfu/ml and (0.00- 6.-00) x 10^3cfu/ml for all the communities sampled in the five (5) Local Government Area examined. The highest range of feacal coliform for borehole water, (9.00-15.00) x10^3cfu/ml was observed in Egor local government while the lowest range (7.00-12.00) x 10^3cfu/ml was seen in Ovia South West Local Government Area. The highest range, (9.00-28.00) x10^3cfu/ml for rainwater was seen also in Ikphoba-Okha local government area and the lowest value, (4.00-18.00) x10^3cfu/ml was observed also in Orhionmwon Local Government Area

The result of the heterotrophic fungal counts for borehole water, rainwater and bottled water sampled analyzed in the various communities in five local government areas revealed their ranges as (0.00- 7.-00) x 10^3cfu/ml. The highest (1.00- 5.50) x 10^3cfu/ml for borehole water was seen in Orhionmwon Local Government Area and lowest range of value (1.00- 5.50) x 10^3cfu/ml seen in Egor Local Government Area. For rainwater, the highest value (3.00- 7.00)

x 10^3cfu/ml in Oredo Local government area while the lowest value, (0.00- 2.00) x 10^3cfu/ml is seen in Egor Local Government Area

		BOREHORE			RAINWATER			BOTTLED WATER		
LGAs	**COMMUNITIES**	**Total Heterotrophic Bacteria Count (cfu/ml) (×10³)**	**Faecal Coliform (cfu/ml) (×10³)**	**Total fungal count (cfu/ml) (×10³)**	**Total Heterotrophic Bacteria Count (cfu/ml) (×10³)**	**Faecal Coliform (cfu/ml) (×10³)**	**Total fungal count (cfu/ml) (×10³)**	**Total Heterotrophic Bacteria Count (cfu/ml) (×10³)**	**Faecal Coliform (cfu/ml) (×10³)**	**Total fungal count (cfu/ml) (×10³)**
EGOR	Uselu	4.00	9.00	0.00	3.00	14.00	2.00	0.00	1.00	1.00
	Useh	3.00	15.00	0.00	2.00	9.00	1.00	1.00	0.00	1.00
	Urunmwon	2.00	12.00	0.00	1.50	8.00	0.00	1.00	1.00	2.00
	Evbuotubu	1.00	10.00	0.00	1.00	10.00	1.00	0.00	1.00	0.00
	Ugbowo	4.00	12.00	1.00	1.00	2.00	1.00	1.00	3.00	1.00
IKPOBA-OKHA	Iwogban	4 00	11.00	1 00	2 00	20.00	2 00	0 00	0.00	0 00
	Uteh	3.00	13.00	2.00	1.00	28.00	1.00	1.00	5.00	1.00
	Ohuovbe	2.00	9.00	1.00	2.00	24.00	2.00	1.00	0.00	1.00
	Aduwawa	2.00	7.00	1.00	1.00	17.00	3.00	0.00	1.00	1.00
	Umogunhen	1.00	15.00	2.00	2.50	9.00	2.50	1.00	6.00	2.00
OREDO	Costain	2.00	7.00	3.00	1.00	9.00	3.00	1-00	6.00	2-00
	Ogbe	1.00	7.00	1.50	1.00	8.00	5.00	1.00	1.00	1.00
	Ihogbe	2 00	12.00	2 00	2.00	10.00	7 00	1.00	1.00	1 00
	Oguola	3 00	10.00	3 00	1 00	7.00	4 00	1 50	0.00	1 00
	Etete	2.00	11.00	3.00	2 00	10.00	4.50	1 00	5.00	2.00
ORHIONMWON	Abudu	5.50	10.00	5.50	3.50	18.00	4.00	1.00	5.00	1.00
	Owa-Ofien	4.00	10.00	4.00	5.00	9.00	3.00	1.00	5.00	0.00
	Evbuobanosa	4.00	12.00	2.00	5.00	5.00	2.00	0.00	0.00	1.00
	Iru	5.00	9.00	1.00	3.00	6.00	3.00	0.00	0.00	1.00
	Oza-Nisi	3.00	7.00	2.00	4.00	4.00	1.00	0.00	1.00	1.00
OVIA SOUTH-WEST	Udo	2.00	7.00	3.00	2.00	21.00	3.00	1.00	5.00	1.00
	Utesi	3.50	11.00	3.00	3.50	19.00	2.00	1.00	0.00	0.00
	Igueze	4.50	9.00	1.50	4.00	7.00	1.50	1.00	0.00	1.00
	Igue-Eladidi	4 .00	12.00	1.00	3.00	7.00	1.00	1.00	1.00	1.00
	Iguobazua	3.00	7.00	1.00	2.50	6.00	1.00	1.00	3.00	1.00

PARASITOLOGICAL CONTENT OF THE WATER SAMPLES

Water samples from borehole, rainwater and bottled water collected and examined indicated presence of parasitic contamination. Out of seventy five (75) water samples examined, 38 of them had parasites giving an overall prevalence of 50.67% in the study area. The results showed that ova of Ascaris species detected in the water samples were 14(25.45%) and hookworm ova were 20(36.36%). Cysts of *Giardia lambia* were 8 (14.54%) while oocysts of *Cryptosporidium parvum* were 10 (18.18%).

Helminths were the most widely distributed representing 61.81% of all the parasites identified in the water samples as shown in (Fig. 1). The presence of parasites showed that water from borehole (25 samples) was the most contaminated with 21 (84.0%) positivity for parasites; 17 (68.0%) of rainwater sources (25 samples) had parasites while all the bottled water (25 samples) examined had no parasites (Fig. 2).

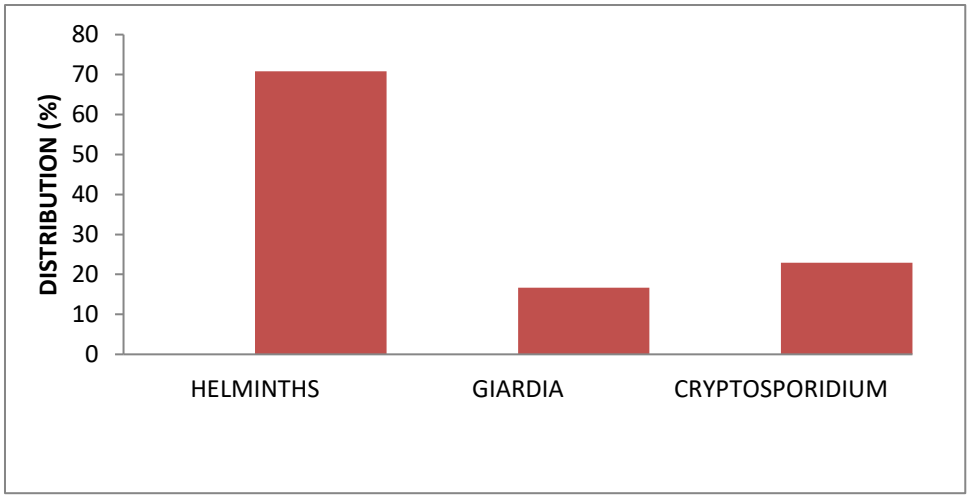

Fig. 1: Spread of parasites in all the water samples investigated

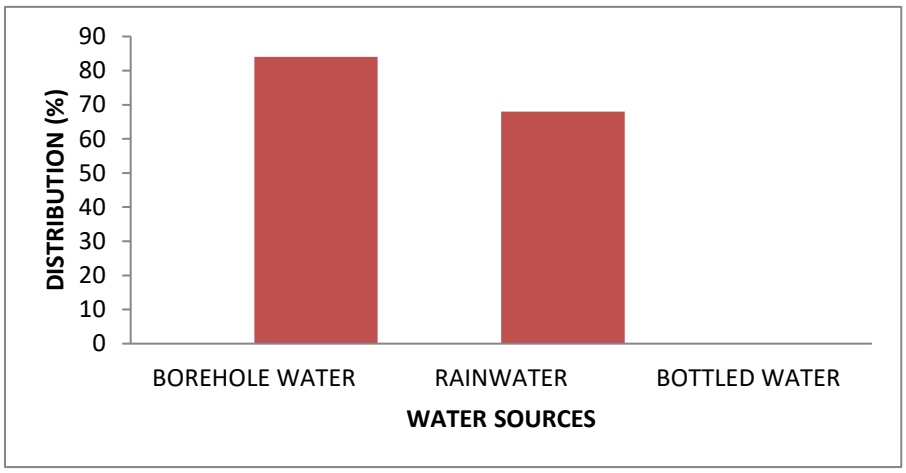

Fig.2: Rate of contamination of water sources by parasites

DISCUSSION

The presence of faecal coliforms in water represents a greater risk of infectious pathogens (Musa *et al*., 2014). Total heterotrophic bacterial and fungal counts for all samples from borehole water, rainwater and bottled water in all the selected communities in the five local government area investigated were within the WHO/NSDWQ standard for water quality (Table 1, 2, 3). Faecal coliform counts from all types of water in question exceeded the WHO/NSDWQ standards and was relatively high in rainwater samples collected from Uteh and Ohovbe communities in Ikpoba-Okha Local Government Area of Edo State. This could be attributed to the fact that these two communities are developing communities and their hygienic practices in terms of collecting harvested rainwater could be poor because the facilities used in channeling rainwater from the roof is usually open. The result also is a pointer to the fact that harvested rainwater were more prone to fecal contamination through the receiving and conveying materials of the water to the storage facilities. This is in line with WaterAid (2013) which reported that rainwater supplies can be contaminated by bird and other animal droppings on catchment surfaces and guttering structures. Poorly constructed water jars or containers can suffer from invasion by insects, lizards and rodents. Also, they make use of their streams for bathing defecating purposes, these water form part of the groundwater that they dig up as borehole water. These borehole waters may not even be treated before use. The higher values of faecal coliforms that was generally obtained in all the communities sampled from rainwater than borehole water is consistent with the work of

Shittu *et al.* (2008) in Abeokuta, Nigeria and Omoigberale *et al.* (2013) who indicated that the primary sources of these bacteria in water are animal and human wastes but is contrary to the work of Adetunde *et al.* (2011) where higher values were reported in boreholes.

While the levels detected in the sampled bottled water were lower than those found in rainwater and borehole water, when measured against WHO/NSDWQ standards (0CFU/mL), they still present a potential risk to human health, possibly leading to enteric diseases. The result of this study agrees with Bukar *et al.* (2015) in Maiduguri metropolis, Nigeria, who reported that drinking sachet water was contaminated with *Enterobacteria* spp. The findings of this study is also similar to the work of Kalpana *et al.* (2011) in Kebbi State, Nigeria, who isolated *Staphylococcus aureus* and *Escherichia coli* from drinking water samples. The presence of these pathogens in such water could lead to incidence of diarrhoea, food poisoning and gastroenteritis especially among children (Adamu *et al*., 2016).
The relatively low microbial contaminants in most bottled water could be attributed to better hygienic practices observed in the industry. These include use of protective sealed caps on bottles, improved and hygienic filling system and use of non-returnable plastic containers.
The ability to detect faecal contamination in drinking water is important because pathogenic microorganisms from human and animal faeces in drinking water pose the greatest risk to public health (Mustapha *et al*., 2012). Also, the isolates with high frequency of occurrence are significant human pathogens associated with a variety of infectious diseases such as gastroenteritis, typhoid fever, dysentery, cholera and urinary tract infection (Orji *et al*., 2006; Uzoigwe and Agwa, 2012).

The research recorded high parasitic contamination of the different water sources except in the bottled water in some communities in Edo State, Nigeria. The rate of contamination varies between the different sources of water (boreholes, rainwater and bottled water). Researchers in different parts of the country have recorded several high rates of contamination of water with parasites (Challom *et al.,* 2013; Ani and Itiba, 2015; Odikamnoro *et al.,* 2016; Chogbo 2023). The public health significance of this is that pathogenic parasites pose serious risk to human health (Challom *et al.,* 2013). Among these water sources, borehole water recorded the highest prevalence of parasites (84.0%). This could be attributed to the fact that over 60% of the boreholes were not hygienically kept and over 90% were below WHO standard proximity to septic tank (30m). The close proximity to septic tank will allow easy access to boreholes by organisms. This is consistent with the work of Ani and Itiba (2015) which recorded a higher parasitic contamination in borehole than rainwater.

Water samples from rainwater had parasitic prevalence of 68.0%. This is attributed to the fact that rain can wash particles containing cyst of parasites on the roof and channels down to the storing containers. This is in line with the report of WaterAid (2013) which reported that water supplies can be contaminated by bird or animal droppings on catchment surfaces and guttering structures. Similarly, poorly constructed water containers can be invaded by insects, lizards and rodents which can contaminate the water with parasites. They can also act as breeding ground for disease vectors if they are not properly maintained. In this study, no parasite was encountered in all the bottled water examined. This can be attributed to the fact that most parasites can be controlled by simple water treatment methods. Also, microorganisms are generally controlled by better hygienic practices observed in the industry (Oyedeji *et al.,* 2010).

Three parasites, helminths (hookworm and ascaris species), *Giardia lamblia* and *Cryptosporidium pavum* were identified in this study. The identification of these parasites in some of the water samples agreed with the studies carried out by Tanyuksel *et al*. (2001);

Challom *et al.* (2013); Ani and Itiba (2015) in different parts of Nigeria and Kassim *et al.* (2015) on the drinking water sources in Iraq. Apart from the presence of these parasites, most of the water samples (except bottled water) contained dirt and debris, thus, making the water unsafe for drinking. Helminths were the most prevalent of the parasites having occurred 34 times (70.83%) in a total of 75 water samples examined. Hence, there is the tendency of high rate of helminths infection within the study area. This is in agreement with the observation made by Challom *et al*. (2013).

CONCLUSION

This study underscores the critical importance of water quality, particularly in the context of domestic water consumed by communities in southern Edo State, Nigeria. Our findings reveal a concerning level of parasitic contamination across all water sources sampled, with a notable prevalence of Ascaris species, hookworm, *Giardia lambia,* and *Cryptosporidium parvum*. While bacterial and fungal counts generally met WHO/NSCWQ standards, fecal coliform counts, especially in borehole and rainwater samples from specific local government areas, exceeded acceptable limits. The presence of pathogenic microorganisms highlights potential health risks associated with water consumption in these communities.

The identification of *Staphylococcus aureus*, *Enterobacter sp, Escherichia coli*, and *Pseudomonas* spp further accentuates the need for stringent hygiene measures to mitigate contamination sources, including the choice of water collection media and practices around water storage. It is evident that factors such as unhygienic practices and proximity to septic tanks contribute significantly to water contamination.

RECOMMENDATIONS

Moving forward, urgent action is required to implement and enforce strict hygiene protocols aimed at safeguarding water quality. Public health interventions should prioritize education and awareness campaigns to empower communities with knowledge about safe water practices. Additionally, regulatory bodies and local authorities must work collaboratively to monitor and manage water quality effectively. By addressing these challenges comprehensively, we can minimize the adverse health effects of waterborne pathogens and ensure access to safe and clean water for all residents of southern Edo State.

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