Prevalence of Microbial Contaminants in Shallow Aquifers of Abakaliki Semi -Urban Areas, South-eastern Nigeria.

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Abstract

Over 80% of the semi- urban population of Abakaliki depends on shallow wells as their main source of water supply (Obasi et al, 2022). These wells are recharged by shallow aquifers of the fractured shales because of the Santonian epeirogeny which characterizes the area. The population is composed of middle-class low-income earners and students who cannot afford the luxury of potable water supply. Due to increasing complaints from students on the condition of their well water sources, this study was carried out to examine the prevalence of microbial contaminants of wells in the areas of Kpirikpiri, Presco and Nkaliki all in Abakaliki, Ebonyi State. This is a way of safeguarding public health against water borne diseases. Eighty (80) water samples were collected from eighty hand dug wells and were assessed for bacteriological quality using the coliform count most probable number and filter membrane methods. The result of the study revealed that most of the wells (over 92%) were grossly contaminated with bacteria coliforms. Comparatively, wells in Kpirikpiri were more contaminated. Only seven water samples are within the standard limit of 10cfu per 100 ml set by the World Health Organization. This result highlights the fact that most well water sources in the areas are not safe microbiologically for drinking and could lead to outbreak of water borne diseases. Proper well construction practice, good environmental and personal hygiene must be advocated, especially by the users of these wells to prevent their contamination with bacterial coliforms.

Keywords: Shallow aquifers; Hand dug wells; Microbial; Contaminants

INTRODUCTION

Shallow wells are wells that are less than 15 m in depth (Mahajan, 2011, Olivia, 2022). They are being recharged by shallow aquifers. Such wells are very important in areas where water shortage is experienced, especially in the tropical countries where they serve as alternatives to surface water (Stevens, *et al*, 2003). Mirza *et al*, (2017) noted that the domestic, agricultural, and industrial use of water, which has been on the increase, has led to the deterioration and exhaustion of surface water in many parts of the world. Consequently, groundwater sources (boreholes and hand dug wells) are being harnessed for agroeconomic sustainability. Nevertheless, potable water is not commonly found, and its provision limits the setting up of villages and towns to places where supply exists (Todd, 1980). All over the world, villages and cities have the history of emanating from points of water supplies. Hence, the quality of drinking water in developing countries is of great concern, especially where there are rapid urban

expansions and growth in the country's population. Geology and anthropogenic activities have strong control on the quality of groundwater (Ekanem et al, 2011). Industrial, mining, and municipal wastes can result to contamination and deterioration of shallow aquifers. Such contamination can be physical, chemical, or biological which includes microbiological (Obasi, 2017; Obasi and Akudinobi, 2019b). Microbial contamination of water sources used for drinking, recreation, and fish farming remains a serious health risk to humans (Ekanem *et al*, 2011). The occurrence of microorganisms as the largest population on earth and with the ability to live in different associations makes them significant in the ecological system (Stevens *et al*; 2003). Yusuf (2007) noted that bacteria are one of the microbial contaminants that are frequently found in groundwater. Bacterial contaminated in drinking water and poor sanitation has been enumerated among factors responsible for over a million deaths per year (Akpor and Muchie, 2011; Kabir *et al*., 2011). Bacterial quality is probably the most important consideration in assessing drinking water (Leclerc *et al*, 2001, 2002; Craun, 2010; Maluski *et al*, 1995), but this is most times neglected by both the pathologists and the water sanitation agencies. According to Okafor, (1985); Okpokwasili and Akujobi, (1996), the presence of faecal coliform in water is an indicator of the presence of faecal contamination of the water body. Faecal coliform is a group of bacteria found in the faeces of warm-blooded animals such as humans, livestock, pets, and wildlife (Olajubu, *et al*., 2014, Okafor, 1985). Poor management of on-site septic systems, livestock waste and pet waste are sources of microbial contaminants in wells. These pathogens can be accidentally swallowed with water or eaten in contaminated aquatic foods. Though coliform bacteria do not generally cause disease, its presence in the well water means that contamination has occurred in the well (Althus, 1983). Coliform bacteria can originate in the intestines of animals and humans.

Microbial examination of water is used routinely to confirm that water is safe for human consumption such as bathing and recreational activities (Moore *et al.*, 2014). This is necessary as groundwater quality can be influenced directly or indirectly by microbiological processes, which can transform both inorganic and organic constituents of groundwater. Microbial decomposition has been demonstrated for a whole range or organic compounds, including hydrocarbons, chlorinated solvents, and pesticides (Moore *et al*, 2014). Abdelmonem *et al*., (2012) assessed the microbial load of drinking water in Al-Butana, Sudan; Chidavaenzi (1997) also used this method to study the lateral travel time of coliforms from pit latrines in Zimbabwe. Ibe and Okpelenye (2005) also assessed the microbial contamination of drinking water in Uli, Nigeria while Ingrid *et al* (2004) assessed the contamination of drinking water from septic wastes in Eastern Nebraku. Gleeson and Gray (1997) emphasized that of the four types of pathogens (viruses, bacteria, protozoa, and parasite) contained in human excreta, only bacteria and viruses are likely to be small enough to be transmitted through the soil and aquifer matrix to groundwater bodies (Naggy and Oslo, 1985; Fong and Lipp, 2005). Microbial contamination of groundwater remains a major concern; especially where many dispersed shallow dug wells or boreholes provides unprotected and untreated domestic water supplies for the users. Groundwater is susceptible to faecal contamination and may contain harmful viruses, bacteria, parasites, protozoa, and helminths which may cause some diseases (Fecham *et al*., 1983).Viral protozoa found in groundwater system may include enteric viruses such as *Echovirus, Hepatitis* A and E, *Rotavirus and Norovirus,* enteric bacteria

pathogen such as *Escherichia coli (E. coli), Salmonella spp, Shigella spp,* and *vibrio cholera,* parasite protozoa such as *Cryptosporidium, Cyclospora cayetanensis, Entamoeba histolytica, Giardia intestinalis* and *helminths* (parasite worm) such as *Ascaris lumbricoides, Trichuris trichura, Ancylostoma duodenale* (Hookworm), *Schistosomiasis spp,* (Tyring *et al*. 2006). Ingestion of these pathogens can cause gastroenteritis or in certain rare cases, serious illness such as meningitis, hepatitis, or myocarditis (Moore *et al*. 2014). WHO, (2011) noted that infectious diseases caused by pathogenic bacteria, viruses, and parasites (proto- zoa and helminths) are the most common and widespread health risk associated with drinking-water.

Abakaliki semi-urban is composed of a teaming population of about 79,280 (NPC, 2006). This population is made up of over 80% of the middle- and lower-class earners who cannot afford the luxuries of a good life including potable water supply. Before the recent development in the area, the area has been associated with the scourge of guinea worm in Nigeria (Abolarin, 1981; WHO, 1980). Odoh, *et al*; (2012) maintained that groundwater has strategically remained a valuable resource in the area, due to the lack of surface water reservoirs. Also, the economic, political, and educational development in the area has led to consequent increase in population, which has eventually increased the demand for water. This demand has however, subjected the populace to alternative sources of water supply. Boreholes, hand dug wells, stagnant ponds and even abandoned mine pond waters have recently served as these alternatives (Obasi, 2017, Obasi and Akudinobi, 2019b; 2020). There is hand dug wells in almost every compound amongst the middle- and lower-class earners. Factors such as high population growth and poor development plan can affect the use of hand dug wells. More importantly, seepage from septic tanks, pit latrine, open waste dumps, poor hygiene and high erosion are recipes for environmental pollution in hand dug wells (Reynoid and Bareth, 2003, Gerba and Smith, 2005; Arnone and Walling, 2007). WHO, (2012) recommended that wells should be located at least 30m away from latrines and 17m from septic tanks to prevent groundwater contamination. These shallow groundwater aquifers are therefore susceptible to faecal contamination and may contain harmful viruses, bacteria, parasites, protozoa, and helminths which may cause some diseases. Moreso, infectious diseases caused by pathogenic bacteria, viruses and parasites are the most common and widespread health risk associated with domestic uses of water. It is against this background, that this study is necessitated. It centres on the middle- and lower-class population areas like Nkaliki, Kpirikpiri and Presco where over 90% of the populace depend on hand-dug wells as their major source of water supply. The Nkaliki areas represent a medium class population while Kpirikpiri and Presco areas have very high demography of undergraduate population of Ebonyi State University. This population cannot afford potable water supply. Hence, the need of this study to determine the microbial load of hand dug wells which serve this population of semi urban areas of Abakaliki.

SITE DESCRIPTION, GEOLOGY AND PHYSIOGRAPHY

The Abakaliki area of Ebonyi State has been characterized with fast growing urban population due to recent socio -economic and political developments in the area. The area is the seat of the Ebonyi State University and the center of political and economic activities in the state. Geologically, the area is underlain by the Asu River Group (Fig 1). The lithology of the area consists mainly of well-indurated fractured shales, argillaceous

sandstones, siltstones, and mudstones. The sandstones and siltstones are exposed at the hills and ridges while the shales and mudstones occupy the lowlands. The deposits are the oldest sedimentary rocks in south-eastern Nigeria (Kogbe, 1976). It is exposed variously in the Abakaliki area where they are often referred to as the Abakaliki Shales. These shales differ in their physical characteristics. Some are fissile while others are indurated. The occurrence of intrusions of pyroclastic rocks in the area is obvious in many places (Olade, 1979). The Abakaliki area has been renowned for its high tectonic activities which occurred in the Santonian orogenic times (Kogbe, 1976). This has led to the fracturing of the shales, and hydrothermal inclusion of mineral deposits in the area. These fractures now form the basis for groundwater development and solid mineral exploration in the area (Odoh, *et al*; 2012; Obasi. 2017).

The geomorphology of the area is controlled by the prevalent structural, lithologic, and physico-chemical factors. The topography could be described as comprising irregular ridges and gentle sloping hills. The elevation of the highlands ranges from 45m to 65m above mean sea level, while the lowlands rise to an average of about 30m. The area is characterized by a uniform sloping drainage slightly tilted eastward. This is due to the Basement complex rocks of the Oban massif, Obudu hills and Mamfe Embayment, which bound the area to the east (Chukwu and Obiora, 2014). These topographic features are controlled by the bedrock geology.

MATERIALS AND METHODS

Water sample collection

A total of eighty (80) water samples were collected from hand-dug wells in the areas of interest i.e., Nkaliki (n=30), Kpiripkiri (n=30) and Presco (n= 20). All wells were georeferenced. Clean and sterile bijou bottles were used. These bottles were sterilized in autoclave at 121^{o}c for 20 minutes. At each point of collection, the pre-sampled bottle was opened and the bailer(fetcher) of the well was used to fetch the water of the well and poured into the bijou bottle. The samples were not totally filled to allow for any biological or chemical process. They were tightly sealed and immediately put in ice-chest under 4^{0}C before transportation to the laboratory for analysis (APHA, 2005). All samples were collected in a day as the areas are near and within the town. Coliform count analysis using the spread plate method was done. The results were analysed and compared with the World Health Organization (WHO, standards for water quality. The analysis of the water sample was performed according to standard method (APHA 2005). One hundred millilitre (100ml) aliquots of the water samples were measured with a sterile measuring cylinder. After setting up the membrane filtration apparatus with a membrane filter of 90mm diameter 0.45µm pore size and the vacuum pump.

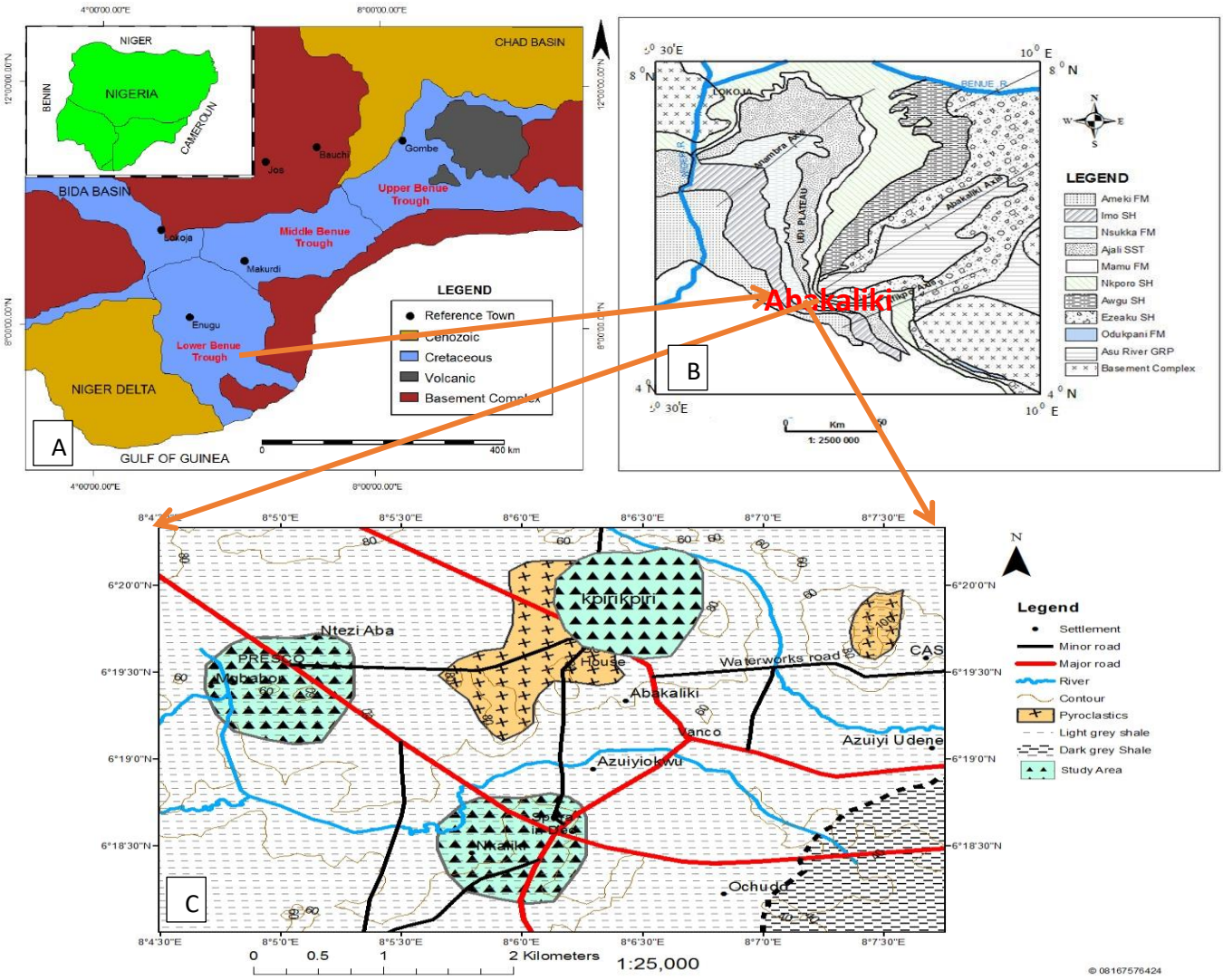


Figure 1: (A) Geologic Map of the Lower Benue Trough (LBT) Zaborski, 1998) (B) Stratigraphic Settings of the LBT (Nwajide, 2013) (C) Geological map the study area showing dominant rock types and sample locations.

The measured 100ml water samples were filtered through the membrane filter (Millipore fitter 0.45µm). Mackonkay and Eosine Methylene Blue agar were used to culture the samples. Mackonkay agar was used for samples from the Nkaliki area and Eosine Methylene Blue agar were used for samples from the Kpirikpiri and Presco areas. The filters were inoculated into plates containing solidified sterile agars and the plates were labelled accordingly. The agar plates were then incubated overnight at 35^0C – 44.5^0C. After 22 – 24 hours of incubation, the plates were observed for growth of coliform and the colony forming units were counted using colony counter machine as shown below:

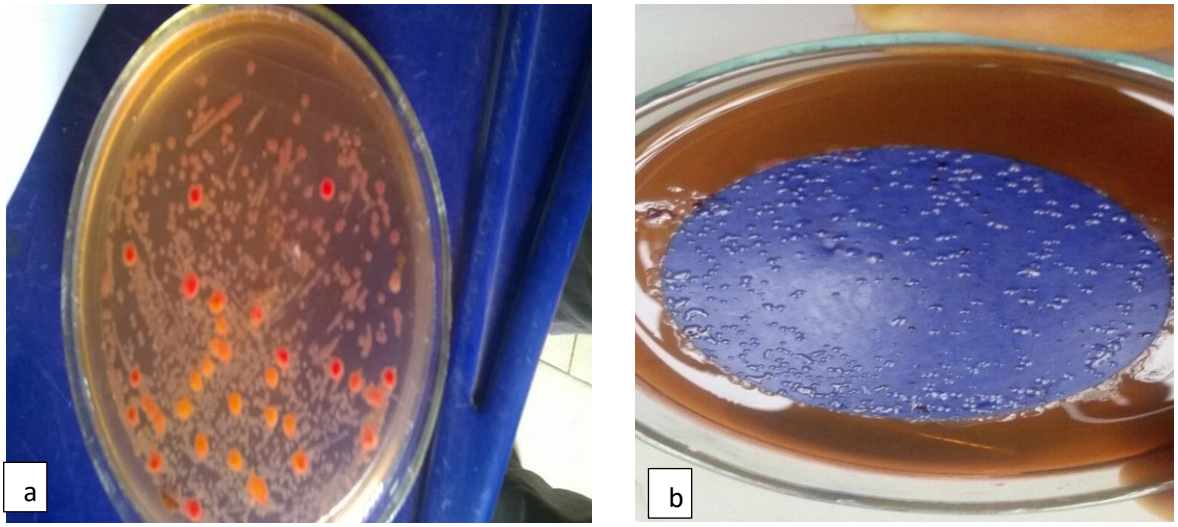


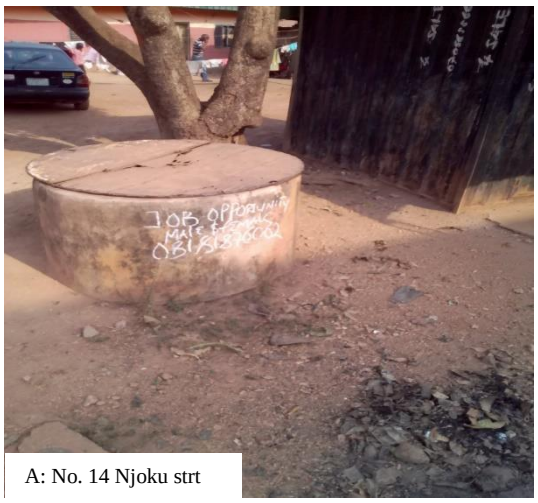
Plate 1: Bacterial colonies in agars. (a): Pinkish colonies indicating the presence of coliform bacteria in Mackonkay agar, (b): Bluish colonies indicating the presence of coliform bacteria Eosine Methylene Blue agar.

RESULTS AND DISCUSSION

The summary of results of the microbial analysis is presented in appendix 1

Discussion

High concentrations of coliform (up to 29.0 $x10^4$cfu/ml) were recorded in the shallow aquifers of semi- urban areas of Abakaliki. The World Health Organization recommends a zero per colony number of E. coli and coliform count in safe water. In the Nkaliki area, only wells OP1, OP11, OP16 and OP 17 has 0 cfu/ml concentration of E. coli in line with WHO stipulation. The 0 cfu/ml of these wells is due to the good hygiene and proper construction of the well. This protects the wells from runoffs which would introduce contaminants into the wells (Plates 2a-d). Wells with poor hygienic and environmental conditions showed high concentration of microbial coliforms (plate3).



A: No. 14 Njoku strt

B: No. 57 Nkaliki road

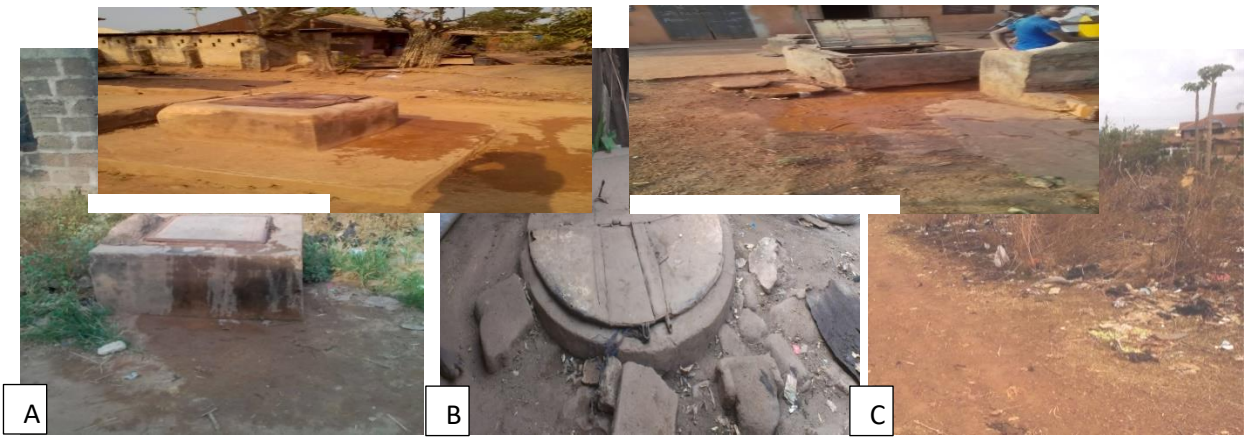


Plate 3: Poorly located wells: a: located in a nearby bush and uncompleted building where people defecate. b: Unhygienic and low-lying well (OP20); c: well, cited in the bush and low-lying in Nkaliki (OP 22)

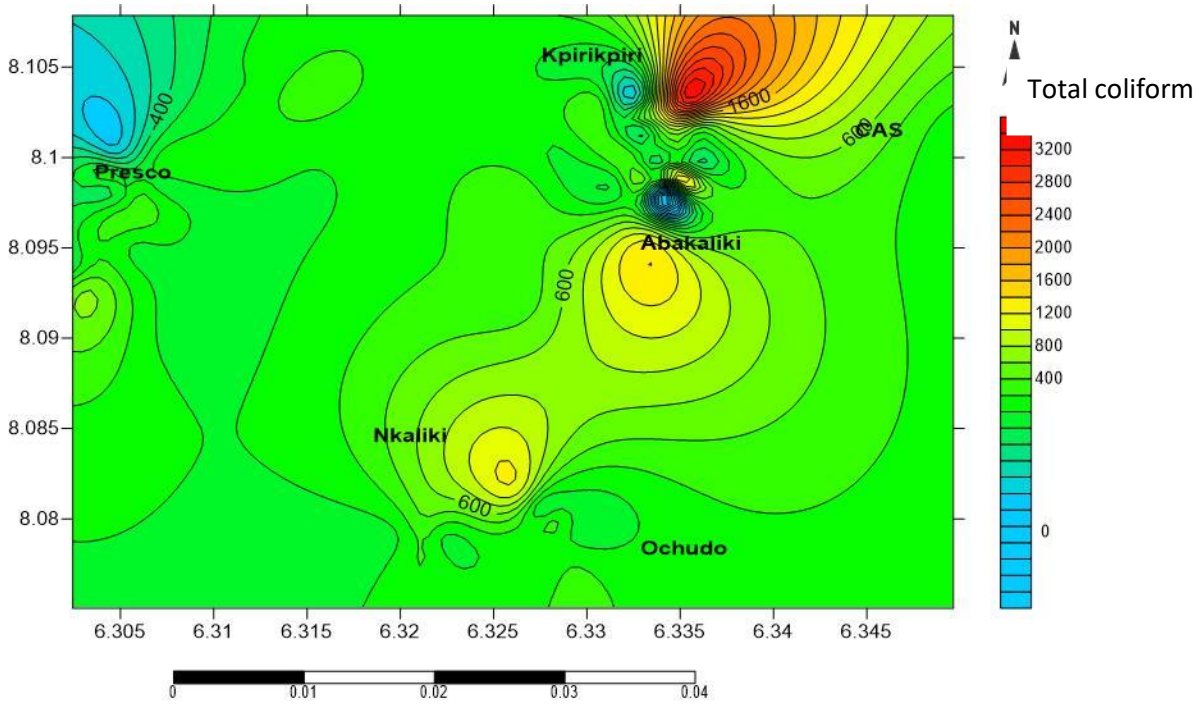


Figure 2: Contoured distribution map of total coliform in the Abakaliki area.

In the Kpirikpiri area, only wells OP35, OP36 and OP40 has 0 cfu/ml concentration of coliform in line with WHO stipulation meanwhile, 90% of the samples shows coliform concentration exceeding the permissible limit. This is very high especially in wells OP50 (25.0 x 10^4 cfu/ml; 7, Awufia str); OP51 (12.5 x 10^3 cfu/ml; 8, Awufia str); OP53 (11.2 x 10^4 cfu/ml; 4, Igweogbofia str); OP55 (25.0 x 10^4 cfu/ml; 3a, Okorowokoro str); OP59 (29.0 x 10^4 cfu/ml; 10, Nri str); OP60 (28.0 x 10^4 cfu/ml 28, Igweogbofia). This high concentration of coliform could be because of not only humans and animal's

faeces from surrounding bushes which has migrated into the wells but the use of unhygienic buckets and bails for bailing water from the wells (see plate 4). Obasi *et al*., 2022 noted that the fracture systems in the Abakaliki area can aid contaminant migration in the shales. Also, faeces can migrate through fractures in the shales from improperly constructed pit latrines and septic tanks. During precipitation, faecal contaminants from the surrounding bushes are carried along with surface runoffs and are deposited into the poorly constructed well and as such contaminating the water and making it unsafe for domestic use.

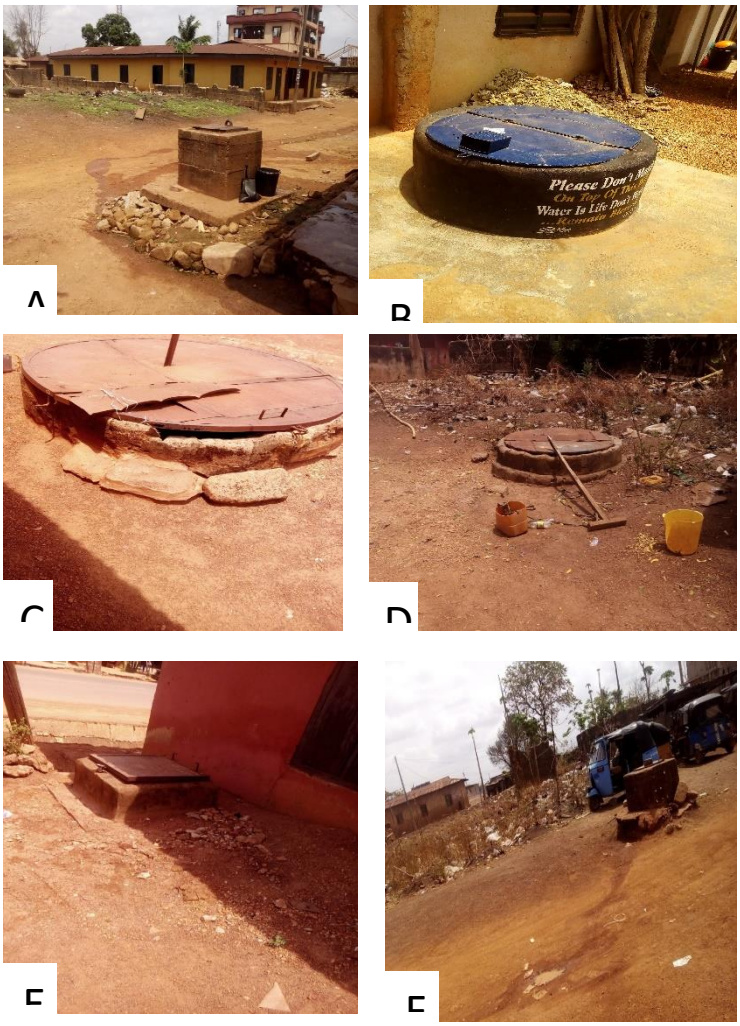


Plate 4: Hand-dug wells in Kpirikpiri area. (A and B are well constructed with nil coliform). (C, D and E are badly constructed, almost the same height with ground level). (F is in an unhygienic environment).

In Presco area, the highest coliform count (CFU/100ml) was observed from wells OP68 (Oversea Lodge, 2.27 x 10^5 CFU/ml); and OP73(Gist Lodge 2.16 x10^5 cfu/ml). The least counts were obtained in wells OP71 (Power Base Lodge 0.22 X10^5) and OP80 (St. Luke Catholic Church 0.32 X 10^5). Nwachukwu, *et al* 2013 observed high counts of bacterial pathogens in most wells in Aba. Similarly, unacceptably high bacterial counts

have been reported from several hand–dug wells in Nigeria (Olajubu and Ogunika, 2014; Obi, 2011; Ibe, and Okplenye, 2005). Apart from human or animal faecal matter emanating from surface water runoffs, and seepages from broken septic tanks, it was observed that the unhygienic practices of undergraduate students who inhabit this area has contributed to the high coliform concentration of these wells. Most of the wells are uncovered, and the bailers (fetchers) look dirty and untidy. Faecal contaminants from nearby bushes and gutters and seepage from sewage or septic tank which are near wells could also contribute to such contamination (plate 5).

The bacterial pathogens isolated from the various water samples in this study are of public health importance because these microbes are implicated in a plethora of human infections (Table 1). The presence of these microbes in water (especially above the acceptable limits) also signifies that these water sources are not potable and thus could not be used for drinking purposes and other domestic processes. Yet the student and lower-class population solely depends on this water for their daily uses. High number of total coliform and the presence of *E coli* in the water sources is an indication of faecal contamination from pit latrines, leakage from septic tanks and run off from nearby bushes which are often used as off-site for open defecation (Agwu *et al*., 2013, Craun, *et al*. 2010, Adekoyeni and Salako, 2012). These organisms may not be dangerous in themselves, but their presence signifies that these household water sources are being contaminated with fresh faecal matter of either human or animal sources or both. This is also an indication that other faeco-orally transmitted organisms including protozoans such as *Balantidium coli, Giardia lamblia, Entamoeba histolytica* and *Cryptosporidium parvum*, in addition to intestinal helminth parasites may be present in these water sources. These are indicated by the most common symptoms of waterborne illness like nausea, vomiting, and diarrhoea (Nwachukwu and Gerba, 2006; Moore *et al*, 2014). In facts, the elderly, and those with compromised immune systems may suffer more severe effects, this is because their immune system cannot fight diseases as supposed. In extreme cases, some pathogens may infect the lungs, skin, eyes, nervous system, kidneys, or liver and the effects may be more severe, chronic, or even fatal. The various hazards that can be presented in water can have very different health outcomes (Ashbolt, 2004). Some outcomes are mild (diarrhoea), whereas others can be severe (cholera, haemolytic uraemic syndrome associated with Escherichia coli or cancer). Some are acute (diarrhoea), whereas others are delayed (infectious hepatitis or cancer).

Plate 5: Poorly sited and constructed hand-dug wells in Presco. (A and B are located close to public gutter). (C and F are constructed the same height with ground level). (D and E located at unhygienic environment).

Table 1: pathogens found in groundwater (adapted from Ashbolt, 2004; Chakrabarti and Chakrabarti, 2009)

PATHOGENS	**MAJOR DISEASES**	**SOURCES**
Bacteria		
Escherichia coli	Gastroenteritis haemolytic Uraemic syndrome (enterotoxin E. coli)	Human faeces
Salmonella spp.	Enterocolitis, endocarditis, meningitis, pericarditis, reactive arthritis, pneumonia.	Human and animal faeces
Shigella spp.	Gastroenteritis dysentery, reactive arthritis	Human faeces
Campylobacter jejuni	Gastroenteritis, guillain-Barre syndrome	Human and animal faeces
Yersinia spp.	Diarrheal, reactive arthritis	Human and animal faeces
Vibrio cholera	Cholera	Human faeces and freshwater zooplankton
Legionella spp.	Pneumonia (legionnaires' disease)	Thermally enriched water
Pseudomonas aeruginosa	Pneumonia, urinary tract infections, bacteraemia	Soil and water
Mycobacterium spp.	Pulmonary disease, skin, and soft tissue disease.	Soil and water
Viruses		
Poliovirus	Poliomyelitis	Human faeces
Coxsackievirus	Fever, pharyngitis, rash, respiratory disease, diarrhoea, haemorrhagic conjunctivitis, myocarditis, pericarditis, aseptic, meningitis, encephalitis, reactive insulin-dependent diabetes	Human faeces
Echovirus	Respiratory disease, aseptic meningitis, rash, fever.	Human faeces
Enteroviruses 68-71	Polio-like illness, aseptic meningitis, hand foot and mouth (E71), epidemic conjunctivitis (E70)	Human faeces
Hepatitis A	Fever, nausea, jaundice, liver failure	Human faeces
Hepatitis E	Hepatitis E fever, nausea, jaundice	Human faeces
Norovirus (Norwalk virus)	Gastroenteritis	Human faeces
Calicivirus	Gastroenteritis	Human faeces
Astrovirus	Gastroenteritis	Human faeces
Sapovirus	Gastroenteritis	Human faeces
Orthoreovirus	Gastrointestinal and upper respiratory disease	Human faeces
Rotavirus A and C	Gastroenteritis	Human faeces
Coronavirus	Gastroenteritis	Human faeces
Adenovirus	Respiratory disease, gastroenteritis	Human faeces
Protozoa		
Cryptosporidium parvum	Cryptosporidiosis (gastroenteritis)	Water, human and other mammal faeces

CONCLUSION

The assessment of the prevalence of microbial contaminants in hand dug wells in semi- urban areas of Abakaliki was carried out. These wells are recharged by shallow aquifers and have been a major source of groundwater supply for the domestic and agricultural uses of the lower-class

populations in the area. These population classes are specifically located at Nkaliki, Kpirikpiri and Presco with high population undergraduate who cannot afford the luxuries of pipe-borne water, which is mostly non available. Eighty (80) water samples from hand dug wells were collected and analysed using the Most Probable Number Technique. Over 90% of water samples analysed showed coliform concentrations above the WHO standard for drinking water. Especially in the Kpirikpiri and Nkaliki areas where colonies of E. coli, salmonella and shigella were observed, and total coliform counts recorded up to 29.0 x 10^5 CFU/ml and 26.8 x 10^3 CFU/ml respectively. The high concentration of coliform gives an indication of faecal contamination in the shallow aquifers of the area. This might be originated from plant debris, animal and human faeces, legumes and the atmosphere and are washed down into the wells. The utilization of such water without proper treatment poses grave danger to human and animals' health. This is because the ingestion of contaminated water poses serious health risk.

RECOMMENDATION

Since water quality is as important as its quantity and shallow aquifers of the Abakaliki area contains coliform bacteria which are high and indicate high level of faecal contamination, the following recommendation are necessary:

Proper sewage disposal system should be provided and upheld in the study area. This will minimize the rate and distribution of coliform pathogens in shallow groundwater aquifers. Good hand dug well construction practices should be upheld. Wells should be constructed with aprons that will serve as a barrier for external water that leaches down from around the entrance of the well. It should cover at least a 1.5m radius extending from the well opening and should include a channel that diverts the wastewater to a soak away tank that is at least 15m away from the apron. Microbial investigation should be carried out periodically, this is to reduce incidence of consumption of highly contaminated water. Also, there is need to increase awareness among the people in the study area of the danger associated with the use of water with high coliform concentration. The construction of pit latrines and septic tank near wells should be discouraged; this is a major cause of high coliform, especially in the Kpirikpiri area.

Conflict of Interest: On behalf of other authors, the corresponding author states that there is no conflict of interest.

Data Availability Statement: Data is available on request.

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Appendix 1: Results of bacteriological analysis of waters analysed in the area.

S/N	Sample code	Address	coordinates		Depth (m)	Ave. No. of Colonies per plate	Colony
1	OP 1	14 Njoku strt. old timber shed Nkaliki	N06º 18 ' 55.9 "	E008º 05' ' 57.6 "	3.9	Nil	No growth
2	OP 2	25 Nkaliki road, Nkaliki	N06º 18 ' 15.9 "	E008º 05 ' 55.6 "	2.9	17	E. coli and others
3	OP 3	20 Nkaliki road, Nkaliki	N06º 18 ' 15.8 "	E008º 05 ' 57.0 "	3.5	78	E. coli
4	OP 4	16 Aguncha str. Nkaliki.	N06º 18 ' 22. "	E008º 05 ' 43.4 "	3.7	6	Others
5	OP 5	15 Aguncha strt. Nkaliki.	N06º 18 ' 23.9 "	E008º 05 ' 23.0 "	3.5	28	E. coli
6	OP 6	26 Nkaliki road, Nkaliki	N06º 18 ' 17.1 "	E008º 05 ' 50.3 "	3.4	55	Salmonella
7	OP 7	1 Okereke str. Nkaliki.	N06º 19 ' 36.0 "	E008º 05" 53.5 ' '	2.8	268	E. coli
8	OP 8	11 Ibagi strt. Nkaliki.	N06º 18 ' 21.1 "	E008º 05 ' 53.8 "	3.6	108	E. coli
9	OP 9	6 Ibagi strt. Nkaliki.	N06º18 ' 23.09 "	E008º 05 ' 54.5 "	2.1	45	Others
10	OP 10	2 Ibagi strt. Nkaliki.	N06º 18 ' 22.8 "	E008º 05 ' 55.2 "	4.2	12	Salmonella
11	OP 11	57 Nkaliki Road, Nkaliki.	N06º 18 ' 10.2 "	E008º 05 ' 42.2 "	4.8	Nil	No growth
12	OP 12	11 Afoezuna str. off Nkaliki road	N06º 18 ' 35.2 "	E008º 05 ' 56.3 "	3.2	24	E. coli
13	OP 13	30 Afoezuna strt. off Nkaliki road.	N06º 18 ' 30.4 "	E008º 05 ' 57.3 "	2.9	52	Shigella
14	OP 14	44 Afoezuna strt. off Nkaliki road.	N06º 18 ' 24.9 "	E008º 05 ' 58.3 "	4.0	38	E. coli
15	OP 15	20 Nkaliki road Nkaliki	N06º 18 ' 19.3 "	E008º 05 ' 54.4 "	3.8	8	E. coli
16	OP 16	21Nkaliki road Nkaliki	N06º 18 ' 18.9 "	E008º 05 ' 54.4 "	5.7	Nil	No growth
17	OP 17	22 Nkaliki road Nkaliki	N06º 18 ' 18.9 "	E008º 05 ' 52.2 "	4.6	Nil	No growth
18	OP 18	26 Nkaliki road Nkaliki	N06º 18 ' 20.6 "	E008º 05 ' 50 "	3.3	300	E. coli
19	OP 19	19 Nzekwe str. Nkaliki	N06º 18 ' 09.3 "	E008º 05 ' 35.9 "	2.3	222	E. coli
20	OP 20	21 Nzekwe str. Nkaliki	N06º 18 ' 08.8 "	E008º05 ' 37 "	2.6	6	E. coli
21	OP 21	14 Njoku str. old timber shed Nkaliki	N06º 18' 15.9"	E008º 05' 57.6"	3.9	Nil	No growth
22	OP 22	24 Nkaliki road Nkaliki	N06º 18' 15.9"	E008º 05' 55.6"	2.9	18	E. coli
23	OP 23	20 Nkaliki road Nkaliki	N06º 18' 15.8"	E008º 05' 57.0"	3.5	232	E. coli
24	OP 24	16 Aguncha str. Nkaliki Abakaliki	N06º 18' 22.1"	E008º 05' 43.4"	3.7	6	shigella
25	OP 25	15 Aguncha str. Nkaliki.	N06º 18' 23.9"	E008º 05' 28.0"	3.5	28	salmonella
26	OP 26	26 Nkaliki road Nkaliki	N06º 18' 17.1"	E008º 05' 50.3"	3.4	55	salmonella
27	OP 27	19 Awgu strt. Azuiyiokwu	N06º 18' 49.0"	E008º 06' 13.9"	2.8	188	E. coli
28	OP 28	14 Awgu strt. Azuiyiokwu	N06º 18' 45.4"	E008º 06' 17.3"	3.6	38	salmonella
29	OP 29	13 Awgu strt. Azuiyiokwu	N06º 18' 46.1"	E008º 06' 16.5"	2.1	45	salmonella
30	OP 30	55 Afikpo road Abakaliki	N06º 18' 44.9"	E008º 06' 22.5"	4.2	42	shigella
31	OP 31	19 Mgbowo str. Kpiri-kpiri	N06º 19' 58.2"	E008º 06' 09.6"	3.2	68	E. coli
32	OP 32	9 Mgbowo str. Kpiri-kpiri	N06º 19' 56.9"	E008º 06' 08.1"	2.9	33	E. coli
33	OP 33	3 Anikpe str. Kpiri-kpiri	N06º 20' 02.0"	E008º 05' 46.9"	4.0	12	salmonella
34	OP 34	19 Igweogbuofia str. Kpiri-kpiri	N06º 19' 59.8"	E008º 06' 12.1"	3.8	8	E. coli
35	OP 35	22 Gilbert stt. Kpiri-kpiri	N06º 19' 45.8"	E008º 06' 15.7"	5.7	Nil	No growth
36	OP 36	7 Nri strt. Kpiri-kpiri	N06º 19' 43.2"	E008º 06' 01.8"	4.6	Nil	No growth
37	OP 37	38 Ogbaga road Kpiri-kpiri	N06º 19' 36.0"	E008º 05' 32.1"	3.3	300	E. coli
38	OP 38	25 Ogbaga road Kpiri-kpiri	N06º 19' 42.3"	E008º 06' 28.3"	2.3	198	E. coli
39	OP 39	4 Igweogbuofia str. Kpiri-kpiri	N06º 19' 52.01"	E008º 06' 10.8"	2.6	6	shigella
40	OP 40	4 Ogbuodudu strt. Kpiri-kpiri	N06º 19' 56.2"	E008º 06' 02.6"	1.8	16	E. coli
41	OP 41	4, Enugukwu str, Kpiri-kpiri	N06º 19' 54.3"	E008º 05' 51.5"	3.2	26	E. coli
42	OP 42	8, Ekwulobia str, Kpiri-kpiri	N06º 19' 54.8"	E008º 05' 54.1"	2.9	28	shigella
43	OP 43	6, Moneke str, Kpiri-kpiri	N06º 20' 01.7"	E008º 05' 57.6"	2.0	10	E. coli
44	OP 44	17, Awkuzu str, Kpiri-kpiri	N06º 19' 59.8"	E008º 05' 55.5"	4.1	297	E. coli
45	OP 45	6, Awkuzu str, Kpiri-kpiri	N06º 20' 05.1"	E008º 05' 54.3"	3.6	20	E. coli
46	OP 46	4, Awkuzu str, Kpiri-kpiri	N06º 20' 06.0"	E008º 05' 53.7"	4.0	51	E. coli
47	OP 47	2, Awkuzu str, Kpiri-kpiri	N06º 20' 06.5"	E008º 05' 53.3"	3.3	68	Salmonella
48	OP 48	14, Okorowokoro str, Kpiri-kpiri	N06º 20' 04.8"	E008º 05' 55.7"	3.3	1110	E. coli
49	OP 49	2, Ogbaga rd, Kpiri-kpiri	N06º 19' 53.7"	E008º 06' 04.6"	2.9	70	E. coli and others
50	OP 50	7, Awufia str, Kpiri-kpiri	N06º 19' 58.2"	E008º 06' 07.7"	2.8	255	E. coli
51	OP 51	8, Awufia str, Kpiri-kpiri	N06º 19' 58.4"	E008º 06' 07.1"	3.9	125	E. coli
52	OP 52	16, Awufia str, Kpiri-kpiri	N06º 20' 58.7"	E008º 06' 05.5"	4.1	80	Shigella
53	OP 53	4, Igweogbofia str, Kpiri-kpiri	N06º 20' 03.5"	E008º 06' 01.9"	3.7	112	E. coli and others
54	OP 54	6, Igweogbofia str, Kpiri-kpiri	N06º 20' 02.0"	E008º 06' 02.3"	3.7	55	E. coli
55	OP 55	3a, Okorowokoro, Kpiri-kpiri	N06º 20' 05.5"	E008º 05' 58.7"	2.5	250	E. coli and others
56	OP 56	30, Ogbaga rd, Kpiri-kpiri	N06º 20' 05.5"	E008º 05' 59.8"	3.4	26	salmonella
57	OP 57	5, Owa str, Kpiri-kpiri	N06º 20' 08.4"	E008º 05' 57.8"	2.9	96	E. coli
58	OP 58	1, Gilbert str, Kpiri-kpiri	N06º 20' 11.1"	E008º 06' 03.8"	3.6	20	salmonella

59	OP 59	10, Nri str, Kpiri-kpiri	N06° 20' 09.7"	E008° 06' 05.6"	3.1	290	E. coli and others
60	OP 60	28, Igweogbofia str, Kpiri-kpiri	N06° 20' 07.4"	E008° 06' 10.1"	4.2	2800	E. coli and others
61	OP 61	Mbama lodge, Presco	$N06^0\ 19^1\ 33.911$	$E008^0\ 041^{38}.9^{11}$	2.5	43	Others
62	OP 62	Haget lodge, Presco	$N06^0\ 19^1\ 37.211$	$E008^0\ 041^{42}.7^{11}$	3.7	67	Shigella
63	OP 63	Authentic lodge, Presco	$N06^0\ 19^1\ 37.811$	$E008^0\ 041^{43}.1^{11}$	4.1	85	E. coli
64	OP 64	Oversea hostel road, Mgbabor Echara,	$N06^0\ 19^1\ 21.911$	$E008^0\ 041^{30}.2^{11}$	3.4	121	E. coli and others
65	OP 65	Paddy Express lodge, Presco	$N06^0\ 19^1\ 19.211$	$E008^0\ 041^{40}.9^{11}$	2.4	86	E. coli
66	OP 66	Prestige lodge, Presco	$N06^0\ 19^1\ 18.011$	$E008^0\ 04^{1\ 42}.8^{11}$	4.2	128	E. coli and others
67	OP 67	God's favour house, oversea	$N06^0\ 19^1\ 18.011$	$E008^0\ 04^{1\ 43}.9^{11}$	3.0	130	E. coli
68	OP 68	Oversea lodge, Presco	$N06^0\ 19^1\ 17.11$	$E008^0\ 04^{1\ 44}.9^{11}$	3.8	227	E. coli
69	OP 69	Opposite oversea, Presco	$N06^0\ 19^1\ 14.211$	$E008^0\ 04^{1\ 44}.9^{11}$	3.9	166	salmonella
70	OP 70	Bethel lodge, Presco	$N06^0\ 19^1\ 37.711$	$E008^0\ 04^{1\ 51}.0^{11}$	2.6	122	E. coli and others
71	OP 71	Power-base hostel, Presco	$N06^0\ 19^1\ 38.011$	$E008^0\ 04^{1\ 50}.7^{11}$	2.9	22	E. coli
72	OP 72	82 DIV. lodge, Presco	$N06^0\ 19^1\ 39.711$	$E008^0\ 04^{1\ 46}.3^{11}$	3.0	212	E. coli and others
73	OP 73	Gist lodge, Presco	$N06^0\ 19^1\ 41.411$	$E008^0\ 04^{1\ 47}.6^{11}$	3.9	216	E. coli and others
74	OP 74	Choice lodge, Presco	$N06^0\ 19^1\ 41.411$	$E008^0\ 04^{1\ 49}.1^{11}$	4.0	36	Others
75	OP 75	Bahanus De Royale, Ezza Road.	$N06^0\ 19^1\ 39.411$	$E008^0\ 04^{1\ 44}.7^{11}$	2.9	156	Salmonella
76	OP 76	Destiny lodge	$N06^0\ 19^1\ 39.811$	$E008^0\ 04^{1\ 44}.0^{11}$	3.3	120	E. coli
77	OP 77	74 Ezza Road, Presco	$N06^0\ 19^1\ 40.711$	$E008^0\ 04^{1\ 42}.9^{11}$	2.9	66	E. coli
78	OP 78	70 Ezza Road, Presco	$N06^0\ 19^1\ 41.211$	$E008^0\ 04^{1\ 40}.8^{11}$	2.2	55	E. coli
79	OP 79	N0 I Emmanuel close, Presco	$N06^0\ 19^1\ 44.511$	$E008^0\ 04^{1\ 40}.0^{11}$	3.6	142	E. coli
80	OP 80	St. Luke's catholic church, Ezza Road, Presco	$N06^0\ 19^1\ 44.611$	$E008^0\ 04^{1\ 45}.9^{11}$	3.9	32	E. coli

WHO, 2012 0CFUper 100ml of water?