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Microbiological risk assessment of groundwater sources in Ikorodu- a peri-urban Lagos settlement

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More than three quarters of the residents of Lagos peri-urban communities rely solely on the private underground water sources without concerns on public health implications. The aim of the study was to determine the microbiological quality of a large spectrum of underground water available for the residents of the rapidly developing peri-urban community of Ikorodu, Lagos, Nigeria. Water samples were collected from a total of one hundred and fifty underground water sources including wells and boreholes in a randomly stratified manner covering five sub-communities of Ibeshe, Odonguyan, Igbogbo, Haruna (Lowa area) and Lambo Lasuwon. A total of thirty samples were collected from each of the sub-locations in similarly stratified manner. The samples were analyzed microbiologically for the presence of Faecal Indicator Bacteria (FIB) using vacuum membrane filtration techniques and pre-prepared selective medium for coliform detection. The results showed high FIB concentration above WHO standard in more than 85% of underground water assessed indicating a high risk of pathogen presence which may lead to water borne infections.

Key words: Coliform, Faecal Indicator Bacteria (FIB), pathogens, peri-urban, underground water.

INTRODUCTION

There is an emerging fact that not many low and middle income countries will be able to meet the Millennium Development Goals (Goal 7 and Target 10) of providing adequate water supply to the people as the timeline draws near. This is particularly so for residents in the peri- urban communities (Allen et al., 2006).). Many residents of peri-urban communities in low and middle income countries have relied majorly on groundwater sources particularly where the governments have been unable to provide adequate and safe water (Ruet et al., 2007).

Ikorodu area is not an exception to this assertion, with an ever increasing population as a peri-urban settlement adjoining the Lagos metropolitan area. Ikorodu local government area lies in the Lagos East Senatorial district with population of 527,917 as at the 2006 census covering 396.488 square kilometer area of land (Nigerian Population Commission, 2010) Figure 1.

The housing development pattern in Lagos state and indeed Nigeria, contributed immensely to the current situation, where provision of accommodation is largely that of self built, from land acquisition to completion as well as to the provision of waste water treatment units, internal and external drainage, security and even groundwater abstraction, treatment and distribution. This concern is the case in all peri-urban areas of Lagos such as Ikorodu due to the ever increasing housing challenges in the metropolis. Groundwater sources are very important resource for drinking purpose because it has been found to contain over 90% of the fresh water recharge over the world (Sabahi, 2009), and it is partially or severely polluted depending on the level of vulnerability to pollution sources (Papiya and Sunil, 2012). Groundwater being the most predominant source of water by residents in peri-urban areas (Ruet et al., 2007), it is not surprising that it constitutes the major drinking water supply source for residents of Ikorodu.

This source is also one of the safest means outside treated water supply from government water supply sources. However, the microbiological quality of shallow

Figure 1. Map showing location of Ikorodu Area, Lagos, Nigeria.

groundwater or well water is usually compromised due to several factors such as run-offs, rapid recharge after rainfall, on-site sanitation etc, which are prevalent in peri-urban communities of low income countries as indicated by studies conducted in Kampala, Uganda (Howard et al., 2003).

Findings from a review of microbiological contamination between source and point of use water carried out by Wright et al. (2004), shows that the microbiological quality of water from groundwater sources in developing countries is of concern and this quality declines at point of use. Recently conducted studies in other low income countries of the world revealed the incessant microbial contamination of groundwater sources in peri-urban communities (Razzolini et al., 2011; Moyo, 2013; Lavanya & Ravichandran, 2013).

The Nigerian Standard for Drinking Water Quality (NSDWQ) stipulates maximum limits for physical, chemical, disinfectants, radio-nuclides and microbiological parameters. It stipulates that an average of one sample shall be taken per 5,000 populations for 0cfu/100ml *Escherichia coli or* thermo tolerant coliform at 95% compliance over a year period. The standard encourages routine monitoring, increased sampling frequency for water sources with high risk of faecal or chemical contamination, depending on the population (Nigerian Standard for Drinking Water Quality, 2007). This research is aimed to determine the microbiological quality of groundwater sources available for the residents of the rapidly developing peri-urban community of Ikorodu area of Lagos to fulfil the NSDWQ regulation for the peri-urban community.

METHODOLOGY

Methods

Water sampling process

Water samples were collected from a total of one hundred and fifty (150) groundwater sources including wells and boreholes in a randomly stratified manner covering five sub-communities of Ibeshe, Odonguyan, Igbogbo, Haruna (Lowa area) and Lambo Lasunwon Community (First-Gate, Lagos State Polytechnic) in Ikorodu area.

Coliform evaluation in water samples

A total of thirty samples were collected from each of the sub-locations in similarly stratified manner. The samples were analyzed microbiologically for the presence of Faecal Indicator Bacteria (FIB) using vacuum membrane filtration techniques and pre-prepared selective medium

Table 1. Samples collection areas in Ikorodu and reliance on groundwater sources.

Location area in Ikorodu	No of Samples	Reliance on groundwater for drinking	Available alternatives
Ibeshe	30	Very High	None*, Commercial packed water
Odonguyan	30	High	None*, Commercial packed water
Igbogbo	30	High	None*, Commercial packed water
Haruna, Lowa	30	Medium	None*, Commercial packed water
Lambo Lasunwon	30	High	None*, Commercial packed water

None*: Means no government treated water supply (mini or major water works plant)

for faecal coliform in the form of *Escherichia coli*.

Physical assessment of water samples

The samples collected were also observed visually for colour, odour and taste. The temperature and the pH were taken with the thermometer and the pH meter respectively.

RESULTS AND DISCUSSION

Table 1 below displays the location of water sources in Ikorodu area, the level of reliance on ground water sources for drinking water supply and the available alternatives, it is evident in all these locations that there is no Government water supply in existence or in the nearest future plan, either by the Local Council Development Area (LCDA), the Local Government Are (LGA) or the Lagos State Water Corporation (LSWC). Averagely there is high reliance on groundwater sources for drinking water, particularly from boreholes.

Considering the physical parameters examined in the samples, pH value range of 4.76 – 5.0 accounts for 10%, 5.1 – 6.0 for 50% and 6.0 – 7.9 has 40%, this implies that slightly less than 40% of groundwater sources satisfies the World Health Organization (WHO) and the Nigerian Standard for Drinking water Quality of pH value range of 6.5 – 8.5. The temperature of samples tested fall within the standards of 22^oC – 30^oC, with 95% of samples having minimum and maximum values of 26.1^oC and 30^oC, while the extreme hits 32^oC. All the samples were tasteless and colourless in compliance to standards. The analysis of the microbiological faecal indicator in the groundwater samples collected from the various locations were all considered and categorized using the WHO Disease Risk level and Action Priority and the *Medicines Sans Frontiers* (MSF) Action for the presence of *Escherichia coli* detection in the water majorly used for drinking water supply in these areas sampled as seen in Table 2.

In a similar study in Zimbabwe an analysis of the microbiological quality of ground water from boreholes and shallow wells showed that boreholes were free of microbial contamination but with severe microbial contamination in well water (Moyo, 2013). The results showed in Table 3 indicates high risk of *Escherichia coli* above WHO standard, the high risk contamination section is so highlighted with 78 and 47 groundwater sources (total = 125) out of 150 samples with 1-10cfu in 10ml and 1-10cfu in 1ml of water sample indicating a moderate and high risk level as shown in Table 3 respectively.

The results is similar to the survey of the microbiological quality of water from privately owned and communal boreholes in the rural Thitale-Hlanganani area of the Limpopo Province, South Africa where the levels of average counts for total coliforms, faecal coliforms, faecal enterococci and *Clostridium perfringes* also exceeded the South African recommended guideline limits of 0-10cfu/100ml (Potgieter, 2006).

Similarly too, the microbiological analysis of boreholes in rural areas and peri-urban areas of Mpumalanga in South Africa, near the borders of Mozambique and Swaziland reveals that 78% of samples did not comply with the South Africa standard of 0cfu/100ml for faecal and 0-5cfu/100ml for total coliform (Mpenyana-Monyatsi, 2012).

Comparison between groundwater sources from different continents of the world confirms the similarity of the results. Monitoring and validation evaluation exercise carried out on groundwater microbiological quality in Canadian drinking water municipal wells in 3 provinces, with multiple sampling analysis of 2 wells with confirmed contamination in 23 wells with good historical bacteriological data over a year. The result was validated that the 23 wells were free of faecal indicators bacteria (*Escherichia coli*, enterococci etc) except for one well with positive detection of enterococci, but *Escherichia coli* was found in 20/38 samples and enterococci in 12/38 samples of the 2 contaminated wells. The water quality indicator of total coliform was rarely present in the free wells but confirmed in the contaminated wells (Locas et al., 2008).

There are no documented statistics of water and sanitation coverage of the communities under study however the authors perceptive observation suggests that a high percentage of the residents have access to water, though through the private sector supply systems due to the inadequacy of government water supply

Table 2. Correlation of *Escherichia coli* levels with WHO disease risk categories.

Level of *Escherichia coli* (cfu/ml)	WHO Disease Risk Level	WHO Action Priority	MSF Action
<1 in 100ml	Very Low	None	None
<1 in 10ml	Low	Low	Consume as is
1-10 in 10ml	Moderate	Higher	Treat if possible
1-10 in 1ml	High	Urgent	Must be treated
>1-10 in 100ml	Very High	Urgent	Reject or thoroughly treat

Table 3. Risk Assessment of *Escherichia coli* levels in Boreholes and Wells.

No of wells/boreholes	No of *Escherichia coli* (cfu/ml)	Risk Level	Authors Assessment
7	<1 in 100ml	Very Low	Low Risk of pathogen
16	<1 in 10ml	Low	contamination
78	1-10 in 10ml	Moderate	High risk of pathogen
47	1-10 in 1ml	High	contamination
2	>1-10 in 100ml	Very High	Very high risk of contamination

systems to provide water for the communities. On the other hand, access of the residents to sanitary facilities is much lower than water supply, as no statistics are also available, thus making open defecation inevitable in some of the communities such as Ibeshe, Odonguyan and Igbogbo. Large percentage of the areas are not adequately covered by the government established Private Sector Participation (PSP) for waste collection system, leaving some residents to dump their waste indiscriminately in drains, bushes or by open burning and open surfaces.

This situation is of a major concern to public health in the communities, and this could be responsible for frequent treatment of infections related diseases and probable resistance of some common anti-biotic due to the high prevalence of exposure.

Conclusion

The situation of the high risk of contamination can be explained in various ways; first the probable source of the *Escherichia coli* in groundwater sources could largely be due to poor point source protection from the multi-users which was observed during the research in some places. Secondly, there is possibility of contamination which canbe introduced into the ground from anthropogenic activities in areas of high risk of faecal contamination.

The high number of *Escherichia coli* detected in the water samples which are above WHO standard in more than 85% of groundwater assessed, indicated a high risk of pathogen presence which may lead to water borne infections. Recommendations arising from concerns of the high risk contamination lay emphasis on the issue of the standards for routine monitoring and increased sampling frequency for water sources with high risk of faecal or chemical contamination, depending on the population as proposed in the Nigeria Standards for drinking water quality for human consumption.

Other recommendations include proper construction and supervision to protect groundwater sources from possible surface contamination; protection of wells from all sources of possible surface contamination; awareness rising amongst the public leading to collective responsibility for quality benchmarking; and adherence to regular checks for qualitative mitigation in observed cases and decommissioning of point of supply for serious offenders.

The above recommendations are on the short term basis for safe water consumption to the public based on the available sources, long term means of addressing this situation is for the State government to have a conscious plan to provide potable pipe borne water supply through micro, mini or major water treatment plant stations in the peri-urban areas.

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