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Effectiveness of Indigenous Household Water Treatment on the Bacteriological Quality of Drinking Water in Illah Community, Oshimili North LGA, Delta State, Nigeria

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Abstract
A combination of dried fruits of *Xylopia aethiopica* and *Tetrapleura tetraptera* are used for indigenous household water treatment in Illah Community without information on its effectiveness in water purification. This study therefore, assessed the effectiveness of treatment method on the bacteriological quality of drinking water in Illah community. Raw water samples were collected from commonly used borehole and stream sources in the community using separate sterile containers. Total Coliform (TC) and *E. coli* Counts (EC) were determined using standard methods by American Public Health Association (APHA) (1998). Treated samples were also collected using sterile containers for analyses. Results obtained for TC and EC were compared with the WHO guideline limits of 10.0 and 0 Most Probable Number (MPN)/100mL. The WHO performance target of ≥4 (highly protective) and ≥2 (protective) bacteria log removal was used to assess potential effectiveness of the treatment. Data were analysed using descriptive statistics and t-test at $p \geq 0.05$. The TC and EC of water from borehole (129.4±7.8; 23.8±5.2 MPN/100mL) and stream (280.0±95.3; 133.3±37.5 MPN/100mL) sources exceeded the guideline limits. After treatment, TC and EC counts from borehole sources were 67.0±11.0 and 11.3±9.9 MPN/100mL showing a significant difference when compared with baseline. The TC and EC from treated stream were 203.0±54.9 and 83.3±24.7 MPN/100mL respectively. The log removal of TC and EC were 0.3 and 0.2 for borehole and stream sources respectively. The indigenous household water treatment method was non-protective. There is a need to upgrade the indigenous method through inclusion of simple and affordable methods.

Efficacité du traitement indigène de l'eau domestique sur le qualité bactériologique de l'eau potable dans la communauté d'Illah, d'Oshimili North, Etat du Delta, Nigeria

Résumé
Une combinaison de fruits séchés de Xylopia aethiopica et de Tetrapleura tetraptera est utilisée pour le traitement de l'eau domestique indigène dans la communauté Illah sans information sur

leur efficacité par rapport à la purification de l'eau. Cette étude a donc évalué l'efficacité du traitement sur la qualité bactériologique de l'eau potable dans la communauté d'Illah. Des échantillons d'eau brute ont été recueillis à partir de sources de forage et de cours d'eau communément utilisées dans la communauté en utilisant des conteneurs stériles séparés. Les comptes de coliformes totaux (TC) et d'E. Coli (EC) ont été déterminés en utilisant des méthodes standard par l'American Public Health Association (APHA) (1998). Des échantillons traités ont également été collectés en utilisant des récipients stériles pour les analyses. Les résultats obtenus pour TC et EC ont été comparés aux limites indicatives de l'OMS de 10,0 et 0 Most Probable Number (NPP) / 100 ml. L'objectif de performance de l'OMS de ≥ 4 (hautement protecteur) et ≥ 2 (protecteur) enlèvement de la bactérie a été utilisé pour évaluer l'efficacité du traitement. Les données ont été analysées en utilisant des statistiques descriptives et un test t à $p \geq 0.05$. Les TC et EC de sources de forage (129.4 ± 7.8; 23.8 ± 5.2 MPN / 100 mL) et de sources (280.0 ± 95.3; 133.3 ± 37.5 MPN / 100 mL) ont dépassé les limites recommandées. Après le traitement, les comptages de TC et de CE provenant des puits de forage étaient de 67.0 ± 11.0 et de 11.3 ± 9.9 MPN / 100 mL montrant une différence significative par rapport à la ligne de base. Les TC et EC provenant du flux traité étaient respectivement de 203.0 ± 54.9 et de 83.3 ± 24.7 MPN / 100 mL. L'enlèvement des billes de TC et d'EC était respectivement de 0.3 et de 0.2 pour les sources de forage et de ruisseau. La méthode de traitement de l'eau domestique indigène n'était pas protectrice.
Il est nécessaire d'améliorer la méthode indigène en ajoutant des méthodes simples et abordables.

Introduction

Water is a fundamental human need for the maintenance of health. Its importance is not only related to the quantity, but also the quality. Access to water in required quantity is needed to achieve good personal and domestic hygiene practices(Huttly*et al*., 1997); while potable water ensures that ingested water does not constitute a health hazard, even in a life time of consumption (Ezzati *et al*., 2003). Lack of access to safe drinking water is a major health problem worldwide, especially in developing countries. This problem is due to the rapid population growth and migration from rural to urban areas that have placed a lot of stress on the existing water resources (Macy and Quick, 2002). As a result of this, many countries have exceeded the capacity to keep up with demand for services. Also dispersed populations and poor transportation infrastructure in many rural areas could lead to lack of access to safe drinking water(Macy and Quick, 2002). This has led households in the developing world to rely on drinking water from unsafe surface sources and then held in household storage vessels(Mintz*et al.,* 1995).

According to the NDHS (2013) report, access to safe drinking water is still low in the rural communities of Nigeria. The situation is worse in the rural riverine communities of the Niger delta because of the widespread use of overhung toilets. Quality of drinking water is of highest importance and this depends on the source and level of contamination or pollution. About 80% diseases in the tropics for example, cholera, typhoid, diarrhoea, and dysentery are as a result of water source contamination. The level or extent of pollution and contamination is influenced by the human population being covered by the water source (Ojo *et al*., 2011). Treatment of water at the minimal level before drinking should therefore be encouraged to curb the spread of these diseases.

Several indigenous water treatment methods have been developed to enhance the quality of drinking water in some Nigerian communities. In Illah community, a combination of *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits are used for the household treatment of water without information on its effectiveness in water purification. *These dried fruits which* are of great repute in West Africa, have pleasant aroma and are used as a popular seasoning spice in Southern and Eastern Nigeria (Odesanmi *et al*., 2009). Some researchers have reported its use for managing various ailments including skin infections, candidiasis, dyspepsia, cough, fever, convulsions, leprosy, inflammation, rheumatism, diabetesmellitus, asthma, flatulence and jaundice (Odesanmi *et al*., 2009). Also, several studies have shown the presence antimicrobial activities in the crude extracts (both alcoholic and aqueous) of *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits (Tatsadjieu *et al.*, 2003; Asekun and Adeniyi, 2004; Okigbo *et al.,* 2005; Uchechi andChigozie, 2010). This study therefore, was carried out to determine the effectiveness of indigenous household water treatment on the bacteriological quality of drinking water in Illah community, Delta State, Nigeria.

Materials and Methods

Study area

The study area was Oshimili North Local Government Area (LGA), which is one of the 25 local government areas in Delta State, Nigeria. The State covers an area of 17,698 km^2. The state is located within coordinates of 5°30' N 6°00' E. The ethnic groups in the state are Igbo, Urhobo, Ijaw, Isoko and Itsekiri. The occupations of the people are farming, fishing and trading. Oshimili North Local Government Area has eight wards namely: Ward 1: Akwukwu-Igbo; Ward 2: Ebu; Ward 3: Illah; Ward 4:Ibusa; Ward 5: Okpanam; Ward 6:Atuma; Ward 7:Ukala; Ward 8: Ugbolu. Ward 3 was selected due to the large area it occupies as shown in Figure 1.

Study Design

A community-based descriptive cross-sectional study design which involved field sampling, survey and laboratory analysis was adopted.

Study Population

Women residents in Illah constituted the study because their specific household tasks make them more in touch with nature to make use of natural resources such as potable water.

Sample size determination

The determination of the study sample size for this research was calculated based on the sample size formula by Kish Leslie 1965 in equation (I):

$$n = \frac{Z_{\alpha}^2 pq}{d^2} \quad \text{.......................................} \quad (i)$$

Where;

$n \geq$ sample size; Z_{α} = 95% confidence level (1.96); p = 20% the estimated proportion of women in Illah community who use dried fruits of *Xylopia aethiopica* and *Tetrapleura tetraptera* to treat their drinking water (pilot study); $p + q \geq 1$ thus $q \geq 1 - p$; $p \geq 0.2$ therefore $q \geq 0.8$; $d \geq$ precision limit (limit of standard error) ≥ 0.04;

$$n \geq \frac{1.96^2 \times 0.2 \times 0.8}{0.04^2}$$

$n \geq 384$

10% of 384 were added to control for non-response to give approximately 400 research participants.

Sampling Procedure

The study area was purposively selected since it is a major area where some households still use the combination of *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits to treat their drinking water. Illah community which is in ward 3 was purposively selected due to the large area it covers (Figure 3). Illah community was divided into three major strata using the distinctive feature on the map (major roads to separate them). A 2-stage sampling technique was used to select respondents in the community. Simple balloting was used to select one of three neighborhoods from each stratum as a representative. Household numbering in each stratum was done to obtain the total number of households in the community. Proportional allocation of sample size was done by dividing the number of households in each stratum by the total number of households in the strata then multiplying by the calculated sample size (400). Simple balloting was used to pick selected number of households in each stratum. From each selected household, a respondent was selected for the study. From the 400 households, 56 households indicated they used the combination of *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits to treat their drinking water. Only 11 of 56 households consented for their household water to be subjected to laboratory analysis.

Data Collection Methods and Instrument Survey

A total of 400 semi-structured self-administered questionnaires were sent to elicit information on the socio-demographic characteristics, current household drinking water sources and water treatment methods. All the 400 questionnaires sent out were completed and returned back thus, making a response rate of 100%.

Sample Collection for Microbial analysis

The containers (sterile glass bottles) that were used for sample collection for microbial analysis were properly washed, rinsed with distilled water, dried and sterilized in an oven at temperature of 170^{0}C for 1 hour. All the containers were closed until the point of sample collection. Samples were collected under aseptic condition, labeled, stored in a cool box with ice packs during transportation to the laboratory and analysed within six to ten hours.

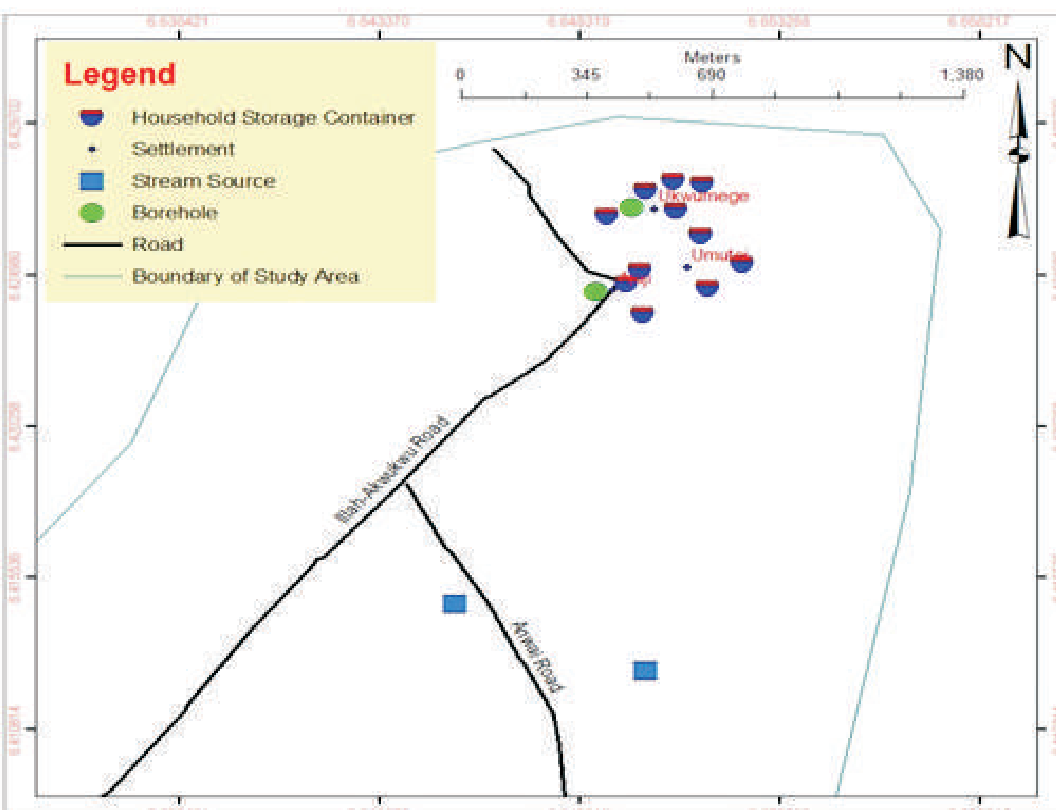

Figure 1: Map of Study area developed using the Garmin Global Positioning System (GPS) 60

Water Sample collection and Treatment method

Raw water samples were collected from commonly used borehole and stream sources in the community using separate sterile containers for laboratory analyses. *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits (Figures 2a and 2b) were used to treat the raw water samples in the selected households. In this indigenous water treatment method, a hot charcoal was kept on a flat tray. Quantities of oil palm mesocarp fibre (Figure 2c) was added on top of the hot charcoal, after which 50g dried fruits each of *Xylopia aethiopica* and *Tetrapleura tetraptera* were ground together using clean mortar and pestle and added on top of the hot charcoal with oil palm mesocarp fibre, thus, producing a smoke (Figure 3a). The washed and dried storage container (clay pot) was faced upside down on the flat tray, which contains hot charcoal with oil palm mesocarp fibre burning dried fruits to produce smoke, for 10 minutes after which 10 litres of water from the selected source was immediately poured into the container (Figure 3b, 3c and 3d). Treated water samples were collected for analyses using sterile containers.

Determination of bacteriological quality

Samples were appropriately diluted with sterile diluent up to 1:1000 and analysed for total coliforms (TC) and *Escherichia coli* (EC) using standard method by APHA (1998). The presumptive coliform count was determined by measuring volumes of samples and the dilutions thereof; and inoculated into sets of MacConkey Broth which were incubated at 37°C for 18-24hours. Thereafter, positive bottles showing gas formation (in small 30mm inverted Durham tubes) and colour change (from purple to yellow) were sub-cultured into sterile Brilliant Green Bile Broth and incubated at 44°C for 18-24hrs. Gas formation showed presence of *Escherichia coli*. An estimate of the most probable number (MPN) of total coliform and *E.coli* present in the samples was obtained from MacGrandy's statistical table.

Data Management and Statistical analysis

Data was entered and analysed using statistical package forthe social sciences (SPSS) version 20. Descriptive andinferential statistics were used in this study. Data from the survey were analysed using descriptive statistics. Descriptive statistics (mean, standard deviation, maximum and minimum values) was used to summarise total coliform and *E. coli* counts for raw and treated water. T- test was used to determine the statistical difference in the mean levels of bacteriological parameters in raw and treated water. All analysis was carried out at 5% level of significance. The percentage reduction in bacterial count was calculated using the formula in equation (ii).

$$\text{Percentage Reduction} = \frac{\text{Initial bacterial count} - \text{Final bacterial count}}{\text{Initial bacterial count}} \times 100 \ldots \text{(ii)}$$

The WHO (2004) performance target of ≥ 4 (highly protective) and ≥2 (protective) bacteria log reduction was used to assess potential effectiveness of the treatment. The bacteria log reduction can be calculated using a formula in equation (iii) [15].

$$\text{Bacteria log Reduction} = \frac{\log_{10} \text{Mean bacterial count of raw water}}{\log_{10} \text{Mean bacterial count of treated water}} \ldots\ldots \text{(iii)}$$

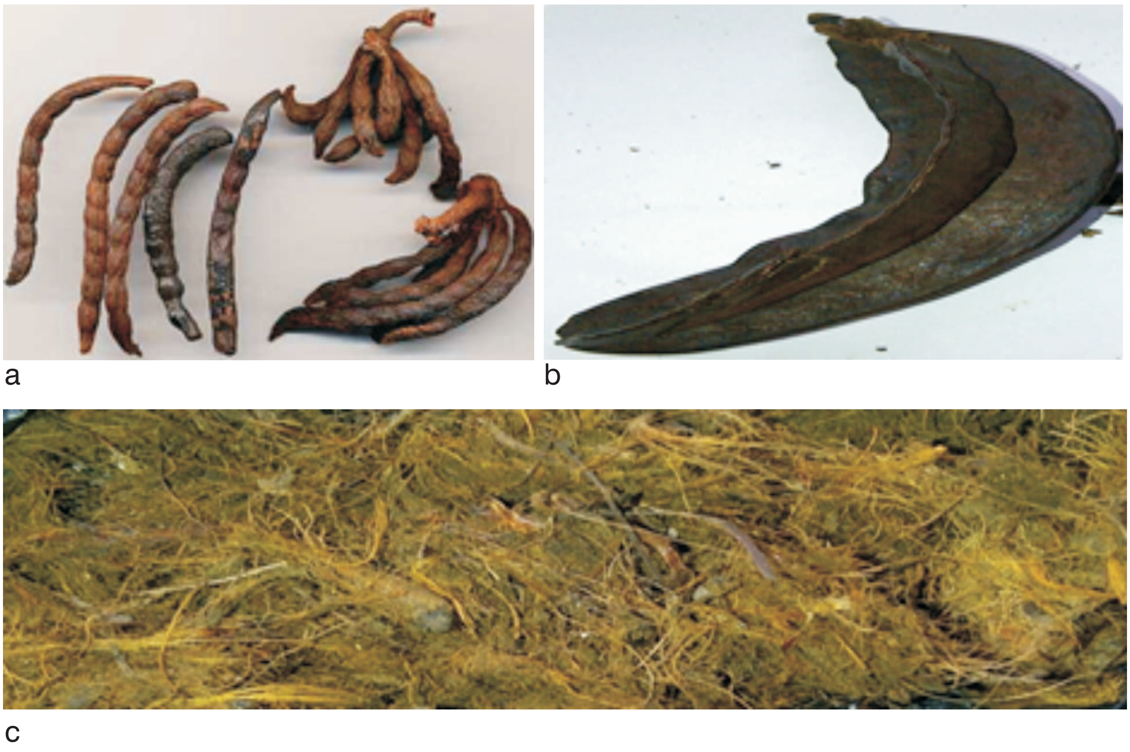

Figure 2: Materials for indigenous treatment method

(a) Dried fruit of *Xylopia aethiopica* (Dunal) A. Rich
(b) Dried fruit of *Tetrapleura tetraptera* (Schum. α Thonn.) Tant
(c) Oil palm mesocarp fibre

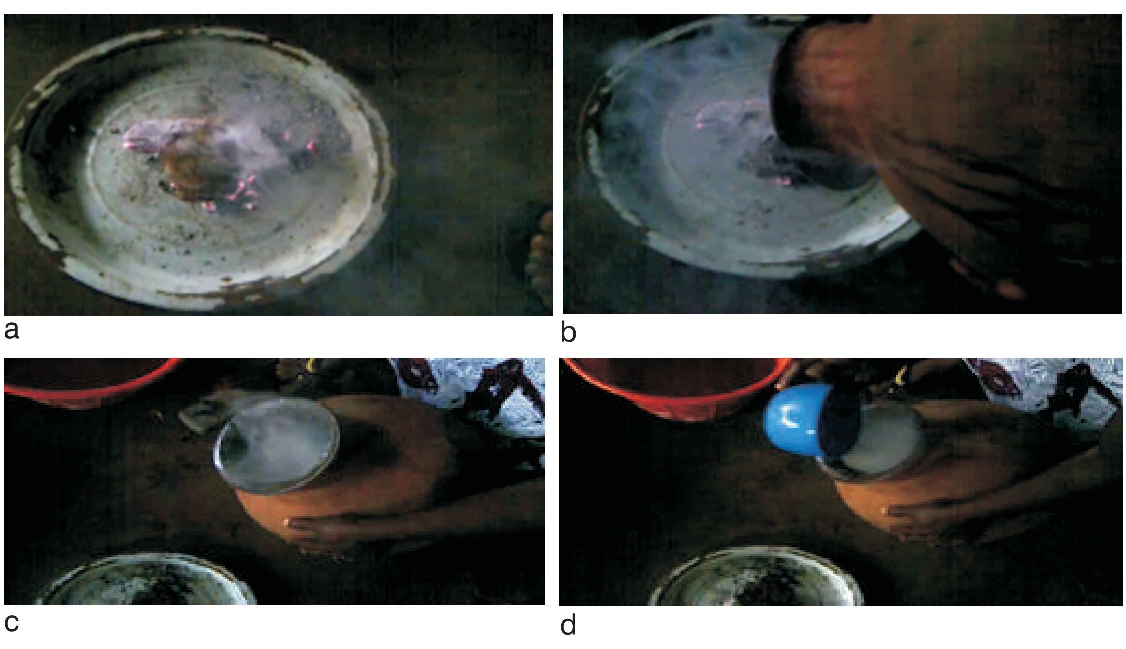

Figure 3: Indigenous water treatment method.

(a) Burning of the dried fruits on a flat tray
(b) Washed clay pot placed on the tray
(c) Clay pot removed from the tray
(d) Raw water treatment

Results

Socio-demographic Information

The mean age of respondents which were all females was 38.9±12.8 and ranged from 20 – 74 years. Majority of the respondents were Christians and Igbo (Table 1). A large proportion of the respondents 194 (48.5%) had secondary education, 90 (22.8%) had up to primary school education; 73 (18.2%) had up to tertiary education and 42 (10.5%) had no formal education (Figure 4). From the socio-economic status of respondents, majority 150 (37.5%) engaged in trading while 10 (2.5%) females engaged in nothing other than being full time housewives (Figure 5).

Water Supply and Water Treatment Methods

Majority 250 (62.5%) of the respondents in Illah community depend on borehole as their main source of drinking water while 98 (24.5%), 31 (7.8%) and 21 (5.2%) respondents indicated they depend on stream, well, and on packaged water respectively as their sources of drinking water (Table 2). Majority 216 (65.2%) reported treating their drinking water before storing. The preferred methods of treatment by the respondents in the study include sedimentation (32.6%), boiling (21.5%), use of chemicals like alum and chlorine (6.1%), filtration (3.8%), solar disinfection (0.4%) while 21.5% indicated the use of *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits for water treatment (Table 2).

Bacteriological quality of drinking water from sources and households

The mean values for total coliform and *E. coli* counts of raw and treated drinking water were presented in Table 3. The result showed that the mean total coliform and *E. coli of raw borehole water* were 129.4±7.8and 23.8±5.2 MPN/100mL while the total coliform and *E. coli counts of raw stream water* were280.0±95.3and 133.0±37.5 MPN /100mL. The values are far above WHO guideline value of 10 MPN/100mL and zero MPN/ 100mL for drinking water.
The total coliform counts in borehole and stream water reduced by 48% and 28% respectively. Also *E.coli* counts in borehole and stream water reduced by 52% and 38% respectively. Table 4 showed that between the sources there was a significant difference in Total Coliform and *E. coli*counts. Also after treatment there was a significant difference in Total Coliform and *E. coli* counts (Table 5).

The removal efficiency of the household treatment was 0.3 and 0.2 log removal of TCC for borehole and stream water respectively. The log removal efficiency of treatment for EC was also 0.3 and 0.2 for borehole and stream water respectively. When these values obtained were compared with WHO (2004) guidelines on default performance targets of≥ 4 (highly protective), ≥ 2 (protective) and < 2 (non-protective) bacteria log reduction for household water treatment and safe storage, the treatment was non-protective (Table 4).

Table 1: Socio-demographic Characteristics of Respondents

Socio-demographic Characteristics	Number	%
Sex		
All females	400	100
Age		
< 30	94	23.5
30 – 50	252	63.0
> 50	54	13.5
Ethnicity		
Ibo	378	94.5
Non – Ibo	22	5.5
Religion		
Christian	365	91.2
Islam	11	2.8
Traditional	24	6

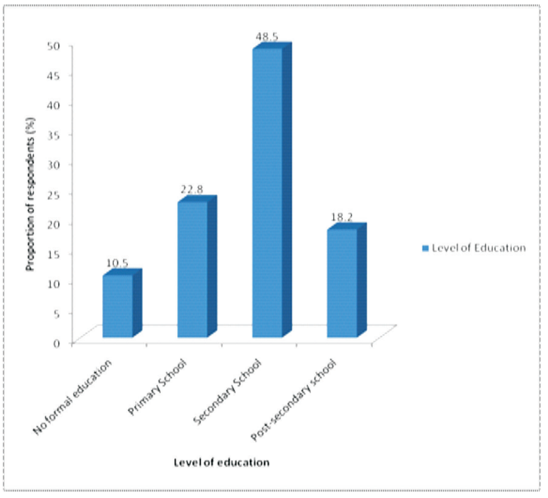

Figure 4: Respondents' Level of Education in Illah Community

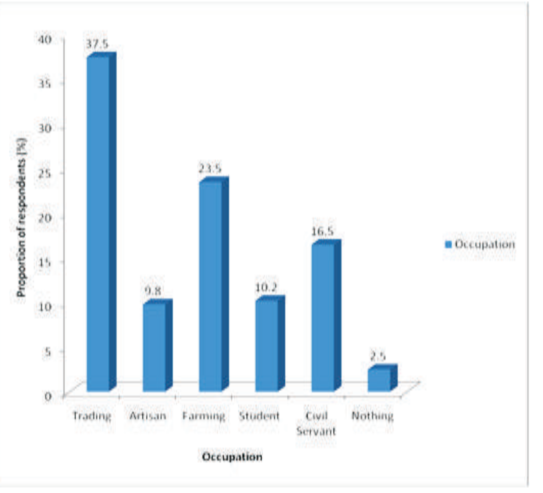

Figure 5: Respondents' occupation in Illah community

Table 2: Water Supply and Treatment Methods

Variables	Number	%
Main source of drinking water in the household		
Borehole	250	62.5
Well	31	7.8
Stream	98	24.5
Bottled Water	5	1.2
Sachet Water	16	4
Drinking water treatment in the household		
Yes	261	65.2
No	139	34.8
Preferred method of treatment (n= 261)		
Boil	85	32.6
Add bleach/chlorine/Alum	16	6.1
Use water filter	10	3.8
Sedimentation	93	35.6
Use of *Xylopia aethiopica* and *Tetrapleura tetraptera*	56	21.5
Solar disinfection	1	0.4

Table 3:Mean coliform counts of raw and treated drinking water

Parameter	Borehole (n=8)		Stream (n=3)		WHO
	Raw	Treated	Raw	Treated	STD
TCC (MPN/100mL)					
Mean	129.4	66.9	280.0	203.3	10
SD	±7.8	±11.0	± 95.3	± 54.8	
Minimum	120	50	170	140	
Maximum	135	80	335	235	
***E.coli* (MPN/100mL)**					
Mean	23.8	11.3	133.3	83.3	0
SD	± 5.2	±9.9	± 37.5	± 24.7	
Minimum	20	0	90	55	
Maximum	30	20	155	100	

Table 4: Removal efficiency of household treatment for TCC and EC

Log reduction of TCC		**Log reduction of EC**		**WHO Performance targets**
Borehole	**Stream**	**Borehole**	**Stream**	
0.3	0.2	0.3	0.2	≥ 4 (Highly Protective)≥2 (Protective)

Table 5: Variations in mean coliform counts for raw and treated water

Parameter	**F**	**Sig.**	**Sig. (2-tailed)**	**Decision**
Total Coliform (Source)	42.25	0.00	0.00	**
Total Coliform (Treatment)	26.08	0.00	0.00	**
E.coli (Source)	35.42	0.00	0.00	**
E.coli (Treatment)	9.12	0.01	0.00	**

**$p<0.05$ level (2 tailed)

Discussion

The majority of respondents in the study depended on borehole water due to the closeness of the sources to the households. The study revealed that majority of the respondents treated their drinking water in the households. Some respondents indicated that they still use specific combination of *Xylopia aethiopica* and *Tetrapleura tetraptera* dried fruits as preferred method of water treatment in the households. This may be due to its low cost, availability in the market and also the belief that these dried fruits have medicinal properties that can protect them from sickness and death when used.

This study showed that the household water supplies in the rural community were of poor bacteriological quality which makes it unsafe for drinking. This is in agreement with the report by NDHS (2013) which revealed that access to safe drinking water was still low in the rural communities of Nigeria. The stream water had the highest faecal coliform count which was in support with the study by Albert *et al* (2010) which revealed that surface water had significantly higher faecal coliform count when compared to other water sources.

Treatment with the dried fruits of *Xylopia aethiopica* and *Tetrapleura tetraptera* in selected households reduced total coliform and *E.coli* counts in the borehole and stream water. The reduction in bacterial counts may be as a result of the antimicrobial activity reported by some researchers in the volatile oils and phytochemical compounds released from the dried fruits during heating into the storage container (Tatsadjieu *et al.,* 2003; Asekun and Adeniyi, 2004; Okigbo *et al.,* 2005; Uchechi and Chigozie, 2010).

Conclusion

This study revealed that the total coliform and *E.coli* counts in the treated borehole and stream water were higher than the WHO guideline limit. The household water treatment was observed to be non-protective with reference to WHO performance targets for bacteria. This study therefore emphasizes the need to upgrade the indigenous method through inclusion of simple and affordable methods like boiling and other forms of effective water treatment.

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