Available online at www.derpharmachemica.com

ISSN 0975-413X
CODEN (USA): PCHHAX

Der Pharma Chemica, 2017, 9(13):125-131
(http://www.derpharmachemica.com/archive.html)

A Study of Access to Safe Drinking Water in Rural Upland and Coastal Communities of Akwa Ibom State, Nigeria

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ABSTRACT

Reports are available that most rural communities in Akwa Ibom State have limited access to safe drinking water, and the few drinking water sources they have are usually heavily polluted. The aim of this study was to assess access to safe drinking water and the water quality of rural upland and coastal communities of Akwa Ibom State. With a cross-sectional design, 420 respondents were selected and administered questionnaires to obtain information on water sources and water supply facilities, followed by physico-chemical and bacteriological analyses of the surface water of the communities using standard procedures. Result shows that respondents in upland (83.33%) and coastal (58.10%) communities obtained water from improved water sources, 16.67% and 41.90% respectively obtained from unimproved sources, while it takes respondents in upland (30.48%) and coastal (51.43%) 15-30 min to and from their water sources. The physical parameters were either below or within the accepted standards in both dry and rainy seasons in the communities. There was no significant difference ($P>0.05$) between upland and coastal water samples. The general pattern of metal concentration in dry season followed the sequence: Hg<Pb<Cd<As<Mn<Fe<Cr, while in the rainy season, it was Hg<Cd<Pb<As<Mn<Fe<Cr. This indicates that in both dry and rainy seasons the concentration of Hg is the least, and chromium is the highest. In the dry and rainy seasons, viable bacterial count, and total coliform were too high. In particular, faecal coliform count ranged from $1.02 \pm 0.14 \times 10^2$ cfu/100 ml in the dry season to $0.41 \pm 0.10 \times 10^2$ cfu/100 ml in the rainy season, all above the recommended standards. It is concluded that access to water sources and the quality of the water are not adequate.

Keywords: Drinking water, Akwa Ibom State, Coastal communities, WHO/UNICEF

INTRODUCTION

According to Mrs. Indira Gandhi, water is essential to life, and civilization is something of a dialogue between man and water [1]. Yet, even in the 21st century, about 1.1 billion people globally do not have access to improved water supply source [2]. About 2 million people die every year due to diarrhoeal diseases, most of them being children less than 5 years of age [2]. The most affected are the populations in developing countries and sub-Saharan Africa who live in extreme conditions of poverty [2].

WHO/UNICEF [3] reports that 37% of 884 million people that still use unimproved sources live in Sub-Saharan Africa. In Nigeria, for example, only about half (58%) of its 178.5 million population have access to improved drinking water sources. The challenges are further complicated by disparity in provision of water supply and sanitation facilities, which may be geographical (between urban and rural), socioeconomic (between the poor and the rich), or related to greater focus on water than sanitation. For example, 72% of Nigerians in the urban areas, compared to 47% of the rural population have access to improved water sources, while the ratio of water access to sanitation is 2:1 (i.e., 58% water access to 26% adequate sanitation) [3].

In Akwa Ibom State, over 90% of the population 0.05^2 n has no access to public water services. Current water supply efforts of government are concentrated in the urban areas. It is reported that the highest urban population that has access to public water services is 3.8% for Uyo, while 90% of the state rural water projects are either neglected, abandoned, non-functional or uncompleted [4,5]. In the rural areas, however, there is a high dependence on all forms of natural sources of water for domestic use (e.g., streams, river, rain, wells). These sources of water may be affected by natural and human-induced sources of pollution [2].

Major problems facing the Nigerian coastal environment, for instance, are linked to public health, such as contamination of drinking water. Waste is directly dumped into coastal water, thus posing a health risk to users of the water. The disposal of untreated human wastes into water or tidal mudflats in the waterfront communities is viewed from the public health aspect as hazardous [6]. This condition exposes coastal communities to faeco-oral infections transmitted through the consumption of contaminated food and water [7]. Sometimes direct defecation into the water bodies which is the practice of coastal dwellers can result in epidemics of cholera, typhoid, dysentery, malaria, among others in the communities.

The rural upland community dwellers also dump their wastes indiscriminately in nearby bushes resulting in environmental pollution. This practice has over time impinged on the quality of the drinking water sources in these areas with health consequences (Akwa Ibom State Hospitals' Management Board, 2009).

The aim of this research was to evaluate access to drinking water supplies of the upland and coastal areas of Akwa Ibom communities, besides analyzing the physicochemical and bacteriological properties of the sources of water of the communities, to obtain information on the level of pollution of the streams.

MATERIALS AND METHODS

Study location

The area of study is Akwa Ibom State located at the South-southern part of Nigeria. It lies between latitudes $4^{o}321$'' and $5^{o}331$'' North, and longitudes $7^{o}251$'' and $8^{o}251$'' East (Figure 1). The state is bounded on the East by Rivers State, the West by Cross River, the North by Abia State and the South by the Gulf of Guinea. The state has a population of 3,92,051, according to the 2006 Nigerian National Population Census. About 70% of the population lives in rural areas, vast areas of permanent swamps and coastal areas which are sparsely populated [8].

Specifically, the coastal areas under study were Oron, Mbo, Ibeno, Eket, Onna, Ikot Abasi, Eastern Obolo, Okobo, Esit Eket, Urue Offong Oruko and Udung Uko. The upland areas were Ini, Ikono, Uruan, Itu, Ibiono Ibom, Ikot Ekpene, Eastern Udim, Etim Ekpo, Obot Akara, Ika, Ukanafun, Oruk Anam, Abak, Etinan, Nsit Ibom, Mkpat Enin, Nsit Atai, Ibesikpo Asutan, Nsit Ubium and Uyo.

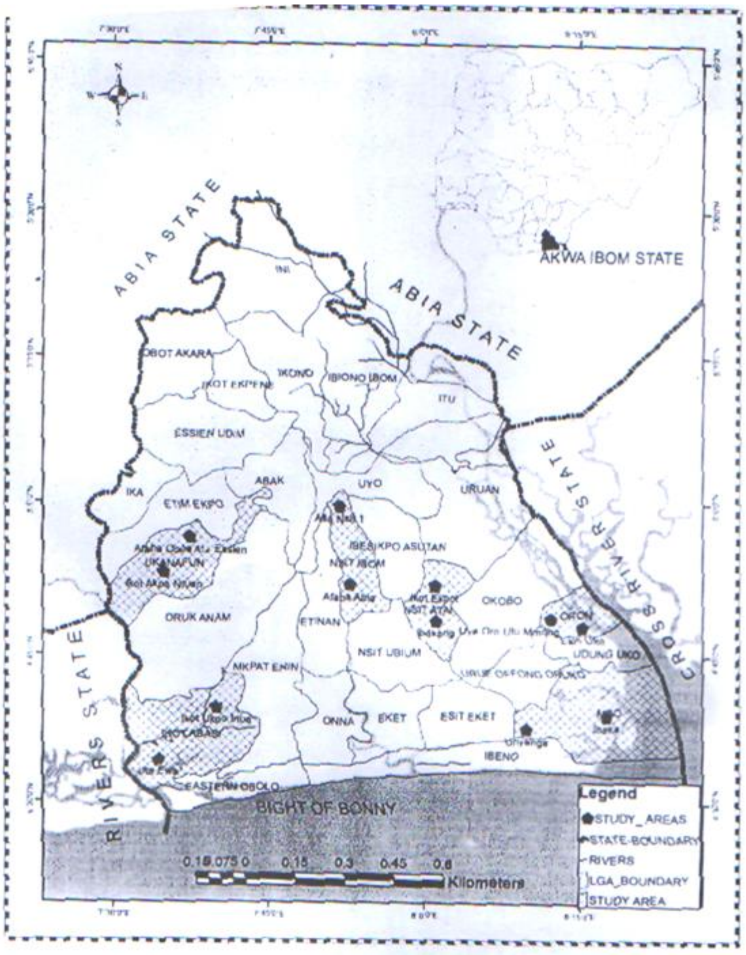

Figure 1: Map of Akwa Ibom state showing study areas

Study design

Both cross-sectional and analytical designs were employed for this study. To obtain information on water sources and water supply facilities of selected households, questionnaires were administered on household basis. Using a multi-stage sampling technique, sampling was carried out in three stages. In the first place, three Local Government Areas (LGAs) were randomly selected from each coastal and upland communities, making a total of 6 LGAs. Secondly, 2 villages were randomly selected from each of the LGAs, making a total of 12 villages. The last stage was a systemic selection of 35 households from each of the selected villages for questionnaire administration. The study population was made of household heads or adult members of each household. The study population was determined using the statistical formula of Lutz [9], in which $n=Z^2(Pq)/d^2$, where n is minimum sample size, Z is confidence limit (1.96), p is estimated rural population with access to improved water sources (0.47), q is 1-p (1-0.47) which is 0.53, d is the precision which is 0.05.

$$n = \frac{1.96^2 \times 0.47 \times 0.53}{0.5^2} = 382.8$$

Considering an attrition bias of 5%, i.e., 382.8/0.95, equivalent 402, to obtain the required sample size, 35 households were selected from each of the 12 villages drawn from 3 upland and 3 coastal LGAs respectively, giving a study population of 420 respondents.

Instrument for data collection

Two questionnaires, one for the researcher's observation and other for the respondents, were developed. The questionnaires for respondents consisted of two parts. Part A consisted of close-ended questions on personal data of respondents while section B consisted of questions on households' water supply facilities. As the questionnaires were administered to the respondents, the questions were read out to the respondents and their responses were ticked. All the questionnaires administered were retrieved.

Water sample collection

Water samples were collected from surface water (stream), the source of water supply common to all the communities in each sampling area, to get information on the level of pollution. Water samples (60 per season) were collected aseptically with sterilized polyethylene sample bottles from the various streams in accordance with standard procedures. The samples were stored in coolers with ice blocks at 4°C and transported to the laboratory within 6 h. Collection of samples was made twice during the rainy season (July-October) and dry season (November-January). The water sample was taken from the points at which the community members fetched their drinking water.

Determination of physico-chemical properties of water

The analyses of temperature, turbidity, Total Dissolved Solids (TDS), Electrical Conductivity (EC) and pH were carried out *in situ* [10]. The pH and temperature were measured using a pH meter JENWAY 3071, model HI 82 equipped with a temperature probe. The electrometric method using membrane electrode and dissolved oxygen meter was used for the measurement of dissolved oxygen. The conductivity meter JENWAY 40710 models HI 9032 was used to measure the electrical conductivity of the water sample *in situ*. Also, TDS was measured *in situ* using a JENWAY 40710 model HI 9032.

The metals (Hg, Cd, Pb, As, Cr, Zn and Fe) were determined using the standard procedures [11]. In this case, digestion was done for all the water samples meant for metal analyses before individual metals were then determined using Atomic Absorption Spectrophotometer (AAS) with varying frequencies.

Determination of the bacteriological quality of water samples

The bacteriological water quality involved the enumeration of viable, bacteria, measurement of total coliform and faecal coliform (*Escherichia coli*) using the method described by APHA [10].

Plate counts

Spread plate counts were made on tryptone glucose yeast agar as described in standard methods for the examination of water and waste water [10]. Incubation was done at 37°C for 48 h. The counts were expressed as Colony Forming Units per ml (cfu/ml). When colonies on duplicate plates were counted, and results averaged before being recorded, counts were rounded off to two significant figures to convert to colony-forming units [10].

Coliform and *Escherichia coli* counts on membrane filter

Water sample (100 ml) was filtered with the help of a vacuum pump. After filtration, the membrane was placed face upwards on an absorbent pad previously saturated with about 2 ml Endo medium which contains 0.5% meat extract, 1% peptone, 1% lactose, 0.03% basic fuchsin, 0.12% Na_2SO_4, after placing the pad in a petridish. This was incubated for 4 h at 30°C for attenuated organisms to recover from stress, followed by incubation for 14-18 or 34 h at 37°C [10]. Dark purple-green colonies observed are considered to be coliform bacteria. There was further incubation of 44°C for coliform and *E. coli* counts respectively [10].

Before confirming the faecal coliform, the coliform must be enriched in lactose broth. A lapfulz was thereafter transferred from the positive tubes to the confirmatory broth (Brilliant Green Lactose Bile Broth) and incubated at 44 ± 0.5°C for 24 h.

Statistical analysis

A two-way Analysis of Variance (ANOVA) was used to determine differences in means of bacterial counts of the water sources between coastal and upland water sources, and between rainy and dry season's water samples. The statistical analysis was done using the Statistical Package for Social Sciences (SPSS), version 20.

Ethical consideration

Before the commencement of this study, ethical clearance was sought and obtained from the Planning, Research and Statistics Department of the Akwa Ibom Ministry of Health-Informed consent was also sought from the respective village heads and household respondents.

RESULTS AND DISCUSSION

Demographic data of respondents

The demographic data of the household respondents are presented in Table 1. The table shows that 39.05% and 43.33% of the household respondents in the rural upland and coastal communities respectively were males while 60.95% and 56.67% in upland and coastal communities respectively, were females. A majority of the respondents were married both in the upland and coastal communities (79.52% and 77.62% respectively). 20% and 20.48% of the respondents from the households in the rural upland and coastal communities respectively, had no form of formal education while the remaining 80% and 79.52% respectively, had either primary, secondary or higher education. The major occupations of the respondents in the upland communities were trading (33.33%) and farming (40.48%), while those of the coastal areas were trading (40%), farming (14%) and fishing (19.52%).

Table 1: Distribution of household survey respondents by gender, marital status, educational status and occupation (N=210 per area)

S. No.	Demographics	Communities/Responses frequency			
		Upland areas		Coastal areas	
	Gender	**No. of respondents**	**%**	**No. of respondents**	**%**
1	Male	82	39.05	91	43.33
	Female	128	60.95	119	56.67
	Total	210	100	210	100
2	**Marital status**				
	Single	22	10.48	38	18.10
	Married	167	78.52	163	77.62
	Divorced/Widowed	21	10.00	9	4.29
	Total	210	100	210	100
3	**Educational status**				
	Never Attended School	42	20	43	20.48
	Primary Education	89	42.38	74	35.24
	Secondary Education	58	27.62	74	35.24
	Higher Education	21	10	19	9.04
	Total	210	100	210	100
4	**Occupation**				
	Civil Servant	24	11.43	12	5.71
	Trading	70	33.33	84	40
	Farming	85	40.48	30	14.29
	Fishing	0	0	41	19.52
	Others/not Specific	31	14.76	43	20.48
	Total	210	100	210	100

Water supply and access in rural upland and coastal communities of Akwa Ibom State

Table 2 shows the responses of the household heads on main water supply sources and proximity. There was no pipe-borne water supply in both upland and coastal communities. The table shows that 155 (73.8%) and 117 (55.71%) households in the upland and coastal communities respectively, obtained their drinking water from boreholes, while 35 (16.67%) and 88 (41.90%) in the upland and coastal communities respectively, obtained their drinking water from surface sources (streams, river or wells). A few households, 13 (6.19%) and 5 (2.38%) households in the upland and coastal communities respectively, harvested rain water as their drinking water (Table 3). The table shows that 10.48% and 8.57% households in the upland and coastal communities respectively had a borehole in each of their premises. Also 49.52% and 30% of respondents in upland and coastal communities respectively use the least time (5-10 min) to and from their main sources. It takes about 15-30 min for 30.48% and 51.43% of households in the upland and coastal communities respectively, to go, get water and return from their respective water sources.

However, the proportions of utilization of improved and unimproved water sources in both upland and coastal communities are represented in Table 3. Upland and coastal communities respectively had 83.33% and 58.10% households utilizing improved water sources, while 16.67% and 41.90% respectively utilized unimproved sources.

Table 2: Household's water supply in study area (N=210 per area)

S. No.	Water supply	Communities/Responses frequency			
		Upland areas		Coastal areas	
	Water supply type	**No. of respondents**	**%**	**No. of respondents**	**%**
1	Pipe-borne water	0	0	0	0
	Borehole	155	73.8	117	55.71
	Stream	35	16.67	75	35.71
	River	0	0	3	1.43
	Well with cement	0	0	10	4.76
	Wall and lid	-	-	-	-
	Rain water	20	9.52	5	2.38
	Other	0	0	0	0
	Total	210	100	210	100
2	**Time to and from water source**				
	Within premises	22	10.48	18	8.57
	5-10 min	104	49.52	63	30
	15-39 min	64	30.48	101	48.1
	Above 30 min	20	9.52	28	13.33
	Total	210	100	210	100

Table 3: Proportion of utilization of improved and unimproved water sources

Improved water sources utilization			Unimproved water source utilization		
Facility type	**Upland**	**Coastal**	**Facility type**	**Upland**	**Coastal**
Borehole	155	117	Stream	35	75
Rain Water	20	5	River	-	3
			Well with cement Wall and lid	-	10
Total	175	122	Total	35	88
Percentage (%)	83.33	58.10	Percentage (%)	16.67	41.90

Results of physico-chemical analysis of water samples

The mean concentration of physico-chemical properties of surface water in the study communities are represented in Table 4. In the dry season, the concentrations of the physical parameters of upland communities were 5.710 ± 0.092 for pH, 28.620 ± 0.115°C for temperature, 1.185-0.256 mg/l for total dissolved solids, 23.448 ± 3.916 µs/cm for electrical conductivity, 0.118+0.039 NTU for turbidity and 14.137 ± 2.741 mg/l for total dissolved solids, the rainy season levels in the upland areas were respectively 6.281 ± 0.129, 26.981 ± 0.094°C, 1.608 ± 0.283 mg/l, 25.019 ± 3.294 µs/cm, 0.704 ± 0.071 NTU, and 10.3 ± 1.808 mg/l for pH, temperature, dissolved solids.

For coastal areas (Table 5), the dry season recorded 6.021 ± 0.089, 28.281 ± 0.182°C, 1.040 ± 1.185 mg/l, 32700 ± 5.452 µs/cm, 3.119 ± 0.856 NTU and 21.818 ± 3.854 mg/l for pH, temperature, dissolved solids, electrical conductivity, turbidity and total dissolved solids respectively. There was no significant difference (P>0.05) between upland and coastal water samples with respect to physical parameters.

During the dry and rainy seasons, the mean metal levels were generally low in water. The general distribution pattern in water in the dry season followed the sequence; Hg<Pb<Cd<As<Mn<Fe<Cr. This indicates that during the dry season, the concentration of Mercury (Hg) was the lowest and below detectable limit, while that of Chromium (Cr) was the highest. On the other hand, the general distribution pattern in water during the rainy season followed the sequence: Hg<Cd<Pb<As<Mn<Fe<Cr. This indicates that during the rainy season, the concentration Mercury was also the lowest and still below detectable limit, while that of Cr was the highest.

Table 4: Mean of physico-chemical parameters of water samples in upland and coastal communities during dry and rainy seasons

Quality parameter	Water sources			
	Upland Communities		**Coastal Communities**	
	Dry Season	**Rainy Season**	**Dry Season**	**Rainy Season**
pH	5.710 ± 0.092	6.281 ± 0.129	6.021 ± 0.089	6.394 ± 0.143
Temperature (°C)	28.620 ± 0.115	26.918 ± 0.094	28.271 ± 0.182	26.961 ± 0.091
Dissolved oxygen (mg/l)	1.185 ± 0.256	1.608 ± 0.283	1.040 ± 0.185	1.490 ± 0.218
Electrical conductivity (µs/cm)	23.448 ± 3.916	25.019 ± 3.294	32.700 ± 5.452	26.616 ± 2.031
Turbidity (NTU)	0.117 ± 0.039	0.704 ± 0.071	3.119 ± 0.856	2.978 ± 0.756
Total dissolved solids (mg/l)	14.137 ± 2.741	10.370 ± 1.808	21.818 ± 3.854	16.764 ± 3.235
Mercury (mg/l)	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
Cadmium (mg/l)	0.000 ± 0.0004	0.001 ± 0004	0.000 ± 0.000	0.000 ± 0.000
Lead (mg/l)	0.001 ± 0003	0.002 ± 0.001	0.001 ± 0.0003	0.0003 ± 0.0002
Arsenic (mg/l)	0.003 ± 0.003	0.004 ± 0.004	0.000 ± 0.000	0.000 ± 0.000
Chromium (mg/l)	0.129 ± 0.065	0.264 ± 0.075	0.021 ± 0.005	0.130 ± 0.058
Manganese (mg/l)	0.002 ± 0.001	0.035 ± 0.012	0.045 ± 0.014	0.127 ± 0.056
Iron (mg/l)	0.058 ± 0.039	0.009 ± 0.065	0.295 ± 0.107	0.512 ± 0.161

Values represent mean of results ± S.E

Results of bacteriological analysis of water samples

The bacteriological parameters of surface water in both upland and coastal communities are shown in Table 5. The table shows that total viable count in the upland communities ranged from 48.31 ± 14.02 × 10^2 cfu/ml in the dry season to 92.67 ± 2.91 × 10^2 cfu/ml in the rainy season. On the other hand, the counts for the coastal communities ranged from 24.63 ± 2.87 × 10^2 cfu/ml in the dry season to 53.03 ± 18.01 × 10^2 cfu/ml in the rainy season. The total coliform counts for the upland communities ranged from 2.40 ± 0.33 × 10^2 cfu/100 ml in the dry season to 0.63 ± 0.33 × 10^2 cfu/100 ml in the rainy season. However, counts in the coastal communities ranged from 1.61 ± 0.39 × 10^2 cfu/100 ml in the dry season to 0.48 ± 0.06 × 10^2 cfu/100 ml in the rainy season. The faecal coliform (*E. coli*) counts in the upland communities ranged from 1.02 ± 0.14 × 10^2 cfu/100 ml in the dry season to 0.41 ± 0.10 × 10^2 cfu/100 ml in the rainy season, while the counts in the coastal communities ranged from 0.82 ± 0.12 × 10^2 cfu/100 ml in the dry season to 0.49 ± 0.10 × 10^2 cfu/100 ml in the rainy season.

Table 5: Mean bacterial and coliform counts of water samples in upland and coastal communities during dry and rainy seasons

Quality Parameter	Water Sources			
	Upland Communities		**Coastal Communities**	
	Dry Season	**Rainy Season**	**Dry Season**	**Rainy Season**
Total viable plate count (cfu/ml)	48.31 ± 14.02 × 10	92.67 ± 29.0 × 10^2	24.63 ± 2.87 × 10^2	53.03 ± 18.01 × 10^2
Total coliforms (cfu/100 l)	2.40 ± 0.33 × 10^2	0.62 ± 0.09× 10^2	1.61 ± 0.29 × 10^2	0.48 ± 0.06 × 10^2
Faecal coliforms (cfu/100 ml)	1.02 ± 0.14 × 10^2	0.41 ± 0.10 × 10^2	0.82 ± 0.12 × 10^2	0.49 ± 0.10 × 10^2

Values represent mean of results ± S.E

Demographics survey of households

The result of the demographic survey of household's shows that a greater percentage of the respondents in both upland and coastal communities were females. This is probably due to the fact that women and children bear the primary responsibility of water collection [3]. They are the group mostly involved in providing water for household drinking and domestic use in Africa and Asia (UNESCO, 2015).

Majority of the respondents in this study were married and also had some form of formal education. At least they could know that they lacked some basic infrastructure for their livelihood. The majority of the respondents who were farmers, traders and fishermen, were equally not happy with their state of basic infrastructure.

Water supply and access in rural upland and coastal communities of Akwa Ibom State

This study revealed that majority of households in upland and coastal communities obtained their drinking water from boreholes and surface waters. No pipe borne water from government. Access to drinking water sources is generally limited, and does not meet the standards of WHO/UNICEF [12]. WHO/UNICEF defines access to drinking water as the source being less than 1 km (30 min round trip) away from its place of use with the possibility of obtaining at least 20 L per member of a household per day. Also, access to safe drinking water is the proportion of people using improved drinking water sources [12]. Statistics, however, show that the highest percentage of urban population that has access to public water services is 3.8% for [13] the state capital [4], while some upland and coastal communities resort to rain harvesting during the rainy season. Thus, Udom [4] reports that in Akwa Ibom State, over 90% of the population lives without access to public water services.

In this study, however, 83.33% of upland communities as opposed to 58.10% of coastal communities utilize improved water sources (borehole and rain water). Also, upland (16.67%) and coastal communities (41.90%) utilize unimproved water sources (stream, river and well with cement wall and lid). Okon [2], reports that these unimproved sources are prone to contamination by wastes and faecal wastes in particular. This situation is global, but developing countries have been reported to suffer more from lack of access to safe drinking water and sanitation [14]. WHO/UNICEF [15] also report that Africa has the lowest total water supply coverage than any region in the world. This situation is the principal cause of death in Africa.

Bacteriological quality of drinking water sources in study area

In this study, the total viable counts in upland water sources recorded $48.31 \pm 14.02 \times 10^2$ cfu/ml and $92.67 \pm 29.08 \pm 10^2$ cfu/ml during the dry and rainy seasons respectively. The count was equally high in the coastal areas, recording $24.63 \pm 2.87 \times 10^2$ cfu/ml and $53.03 \pm 18.01 \times 10^2$ cfu/ml during the dry and rainy seasons respectively. These counts exceeded 1.0×10^2 cfu/ml which is the standard for drinking water [16]. The high total viable count is indicative of organic pollution of the surface water sources. There was no significant difference (P>0.05) in mean count between upland and coastal water sources.

The total coliforms in all the water sources were generally high (ranging from $0.48 \pm 0.06 \times 10^2$ cfu/100 ml to $2.40 \pm 0.33 \times 10^2$ cfu/100 ml, thus exceeding international standards [14,17]. However, the presence of coliform indicates possible faecal contamination, but their origin must always be sought to determine whether they are of any sanitary significance [16,18].

The normal intestinal bacteria, e.g., *E. coli*, are used as indicators or tracer bacteria of faecal pollution of water, their presence indicating only that pathogens might also be present [19]. In this study, faecal coliform levels were more than $0.41 \pm 0.10 \times 10^2$ cfu/100 ml during the dry and rainy season in both upland and coastal communities. The faecal coliform was significantly higher (P<0.05) during the dry season than during the rainy season. This result gives credence to the finding of Jeyaraj et al. [20] in which faecal coliform was observed to be higher during the summer than during the rainy season in River Noyyal. This was probably due to direct discharge of human and animal waste into the water. Similarly, as a result of the long standing practice of direct and indiscriminate defecation into open water bodies, swamps and bushes, the surface water of the communities had a poor bacterial quality. However, there was no significant difference (P>0.05) between the faecal coliform levels of the upland and coastal water sources.

CONCLUSION

Access to safe drinking water in the study communities is low. This is responsible for drinking from unimproved water sources most often by the community members, resulting in water-related diseases. The low bacteriological quality of drinking water sources presented in this study shows that the drinking water in the respective communities is not safe. This calls for more aggressive awareness by researchers and public health experts on the need for treatment of drinking water before use. Also, intervention by government and private agencies is needed.

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