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Physico-Chemical and Bacteriological Quality of Water Sources in the Coast of Ndian, South West Region, Cameroon: Health Implications

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ABSTRACT

The study of water sources used by the population of Ndian for drinking with the exception of the Ekondo Titi beach was carried out by investigating 51 water sources. Due to the lack of pipe borne water in this area, the population is compelled to consume water from unprotected shallow aquifers and surface water sources, there by exposing the population to infections form of water borne diseases. In this perspective, the present study was aimed to check the suitability of these water sources for drinking. The bacteriological quality of the water sources was performed using the Most Probable Number (MPN) technique. Temperature, pH, electrical conductivity (EC) and total dissolved solids (TDS) were also determined. The pH values reflect slightly acidic, neutral and basic water sources. Sixty percent (60%) of the ground water samples where slightly acidic (5.5 – 6.4) and out of the WHO (2011) guideline limit (6.5-8.5) for drinking water. This situation puts the inhabitants at risk to stomach ulcer. The electrical conductivity values (3.00-274 us/cm) for groundwater sources represents water experiencing slight mineralization. Based on the total coliform bacteria, 96% of water sources were polluted to grossly polluted (75-2400 MPN/100 ml) and 4 % excellent following the acceptable maximum limits prescribed by the World Health Organization Standards which exposes the population to water-borne diseases such as typhoid, cholera and dysentery. The bacteria contamination of the water sources may result from the waste of pit toilets that intersect the water tables of shallow unconfined aquifers and also from poor sanitation practices carried out along stream channels and springs. Proper water treatment at household levels is highly recommended.

KEYWORDS: *Ndian- Cameroon, contamination, drinking water, total coliforms, unconfined aquifers*

INTRODUCTION

Water is necessary for life and must be of good quality before consumption. Due the presence of poor sanitation systems there is an increase of contamination of surface and groundwater resources (Coulibaly et al., 2004; Kuitcha et al., 2008; Ndjama et al., 2008) in most communities. For drinking purposes, the most important water quality parameter is total coliform (Younger, 1994). High coliform counts are attributed to poor sanitary handling and/or environmental conditions due to urbanization which now outpaced growth of public utilities and sewage disposal system (Ejechi et al., 2007). Health problems faced by African countries are water related: typhoid, diarrhoea, cholera, dysentery (Hamer et al., 1998; Kuitcha et al., 2008; WHO Regional Office for Africa, 2012). For example, diarrhoea disease remains a leading cause of mortality for children in Sub-Saharan Africa (Hamer et al., 1998) where more than one child dies every minute from diarrhea (WHO Regional Office for Africa, 2012). Consequently, potable water cannot be said to be safe if the quality of water is unknown (Nwankwoala and Udom, 2011; Wotany et al., 2014). In different parts of Cameroon, domestic water sources have an alarming level of microbiological pollution (Katte et al., 2003; Mpakam, 2008; Wirmvem et al., 2013). Cases of water-borne diseases are recurrent in most localities (Kuitcha et al., 2010) and these have been traced to the use of water from shallow, unprotected hand-dug wells (Nola, 1996; Wirmvem et al., 2013). Health problems related to groundwater intake have been associated to enriched coliform counts as a result of anthropogenic pollution along the Cameroon coast line (Wotany et al., 2006; Ako et al., 2009; Eneke et al., 2010). Related observations have been reported by Nola et al. (2002) in Yaounde; Mpakam (2008) in Bafoussam. The consumption of water from unprotected water sources as in the case of the Douala Basin (Ako et al., 2009; Eneke et al., 2011) and the Niger Delta to the west (Edet, 2008; 2009) is a call for concern. Eighty percent (80%) of the population depends on groundwater sources which are mainly springs and hand-dug wells due to the absence of pipe-borne water. Poor citing of wells has led to problems of shortages of potable water in some of the communities especially during the dry season. These communities therefore resort to doubtful water quality from streams, rivers and the creeks for household use during such periods. Therefore, understanding the quality of water in this area of study is an important step for the sustainable management and development of this resource. In this circumstance, the present study was aimed to check the suitability of the water sources for drinking purpose.

MATERIALS AND METHOD

LOCATION OF STUDY AREA

The study area is located in the South Western Coast of Cameroon at the western end of the Gulf of Guinea (Figure 1). The area is an extension of the western margin of the Niger Delta of Nigeria (Regnoult, 1986). Together with the Douala and Kribi-Campo Basins, it was formed during the Aptian-Albian times (Agyingi et al., 2006). It is bordered in the west and northwest by the Niger Delta Basin, in the south it is limited by the Gulf of Guinea (Atlantic Ocean), in the north by the Rumpi Hills and to the east by the Cameroon Volcanic Line which separates the basin from the Douala Basin.

HYDROGEOLOGY

Water sources in the study area developed from three geological ranges: superficial alluvial aquifers and weathered/fractured crystalline rocks. The springs ooze out from alluvium, jointed basalts to weathered and fractured gneisses. Wells in the study area are characterized with depths of ≥ 7 m made up of sand, gravel and clayey sand (Wotany et al., 2014). Aquifers of the study area are similar in geology to those of the Niger Delta (Okereke et al., 1998; Edet, 2009). They are characterized by alternating layers of gravels, sands, silts and clays thus giving rise to a multi-aquifer system as in the Douala Basin in Cameroon (Regnoult, 1986; Mafany et al., 2006). Borehole depths are generally less than 100m (UNESCO-ISARM, 2011). Volcanic aquifers in the study area are same as those in the Buem formation in Ghana (Yidana, 2010). Gneisses constitute the major rock types in the north and northeast of the area. The fractured gneisses are of immense importance with regards to water delivery in Mundemba town and environs.

In-situ physico-chemical measurements (pH, EC, TDS) and water sampling

Water sampling involved the collection of 51 water samples and the measurement of physical parameters (pH, temperature, EC TDS) in situ. The physical parameters were measured on-site due to their unstable nature to avoid unpredictable changes in characteristics as per the standard procedures (APHA/AWWA, 1998). The pH, temperature and total dissolved solids (TDS) were measured using the Hanna 98128 multi parameter type. Electrical conductivity (EC) values were measured using the Model 3301 conductivity meter. These meters were calibrated before and during fieldwork using buffer solutions as prescribed by the manufacturers. The method prescribed by APHA (1992), was used for collection of water samples for microbial analysis. Fifty one different localities of Ndian (Fig.1) were selected for collection of water samples. Samples were collected from the areas where people are using ground and surface water for drinking. At each sampling site, water from springs, streams, beaches and rivers was collected into a plastic bottle after thorough rinsing with distilled water to clean the bottles and the water to be sampled in order to prevent contamination. Water from open wells was drawn using buckets tied with ropes. Water from pump well was pumped for 5 to 10 minutes in order to purge any aquifer stagnant water to acquire fresh aquifer samples.

Microbial analysis

The analysis of samples (51) was carried out at the Microbiological Laboratory of the University of Buea, Cameroon, within 24 hours of sampling to ensure proper results. The samples were assessed for total coliforms (TC) using the multiple fermentation tube method (APHA, 1992). This method is used to determine if gas- producing lactose fermenting- bacteria are present in a water sample and to determine the most probable number (MPN) of coliform count present per 100 ml of water (APHA, 1992; Benson, 2002). The set up test was made based on the fact that the water samples were relatively clear and not turbid. The culture media used was lactose broth, prepared in accordance with the manufacturer instructions (Benson, 2002). Results are expressed in most probable number (MPN) per100 ml of water sample. The materials used were three tubes of Double Strength Lactose Broth (DSLB), six tubes of Single Strength Lactose Broth (SSLB) (total of 9 tubes), 10 ml pipette and 1ml pipette. All glass ware used for the study were thoroughly washed and rinsed with distilled water. This was followed by sterilization in a hot oven at 160^{o}C.Three tubes containing 10ml double strength lactose broth (DSLB), 3 tubes containing 5ml of single strength lactose broth (SSLB) and another set of 3 tubes of 5 ml SSLB were prepared for each sample. An inverted Durham tube was inserted into each tube to collect the gas produced. The tubes were autoclaved at 121^{o}C for 15 minutes and then allowed to cool down. The sample to be tested was vigorously shaken. To the tubes with DSLB was added 10ml each of sample, 1.0ml to each of sample to the three tubes containing 5ml of SSLB and 0.1ml to another set of three tubes containing 5ml SSLB. The tubes were incubated at 37^{o}C for 48 hours. All tubes showing acid production (change in colour of medium from yellow to purple) and gas production in the Durham tubes were recorded as positive. The presence of 10% or more gas and acid in one or more of the tubes in 24 hours, indicated water is polluted. The most probable number (MPN) of coliform was determined as described in Benson (2002).The presence of gas and acid, for example, in the first and second sets of 3 tubes, but none in the last three tubes was read as 3-3-0. From the most probable number (MPN) index (APHA, 1992; Benson, 2002), the most probable number (MPN) for this particular sample of water would have approximately 240 organisms per 100 ml of water with 95% probability of it being between 36 and 1300 organisms (APHA, 1992; Benson, 2002).

RESULTS AND DISCUSSION

Results of the bacteriological quality of the analyzed water samples and physical parameters are presented in Table 1. Total coliform counts were recorded in 96% of the water sources (Table1; Fig.1) with the exception of the reservoir in Mundemba and a spring in Ekombe Liongo with zero coliform count per mil (0cfu/100ml). The high total coliform counts did not show any visible relationship with TDS, Water temperature and pH (Fig.2abc).

Table 1: Physico-chemical parameters and total coliform counts of water sources in the coast of Ndian

Locality	Water Source	Water T°C	pH	EC	TDS	av. TC	Class	Quality type
Bulu Camp, Mundemba	Spring	28.5	7.4	9	5.85	2400	D	Grossly polluted
Mission Camp, Mundemba	Spring	26.6	6.1	24	15.6	7	B	Polluted
Ikassa Camp, Mundemba	Spring	29.3	7.1	17	11.05	2400	D	Grossly polluted
Last Camp, Mundemba	Spring	27	6.8	9	5.85	2400	D	Grossly polluted
Ekondokondo I	Spring	24.6	6.9	8	5.2	2400	D	Grossly polluted
Ekondokondo I	Spring	21.3	7.1	11	7.15	240	D	Grossly polluted
Ekondokondo I	Spring	24.8	7	7	4.55	1100	D	Grossly polluted
Mekagolo	Spring	25.5	6.7	20	13	2400	D	Grossly polluted
Ekumbako	Spring	27.5	6	7	4.55	21	C	Unacceptable
Dibonda	Spring	26.5	5.8	3	1.95	2400	D	Grossly polluted
Funge	Spring	28.2	7	13	8.45	210	D	Grossly polluted
EkombeLiongo	Spring	27.4	6.4	14	9.1	2400	D	Grossly polluted
EkombeLiongo	Spring	27	7.6	122	79.3	2400	D	Grossly polluted
EkombeLiongo	Spring	27.1	6.4	5	3.25	0	A	Excellent
IdibaNyanga	Spring	25.4	7	38	24.77	2400	D	Grossly polluted
Njima	Spring	26	7.6	74	48.23	2400	D	Grossly polluted
Oron, Isangele	Spring	25.1	6.2	11	7.35	2400	D	Grossly polluted
Pamol Camp, Mundemba	Spring	26.1	6.8	26	16.71	460	D	Grossly polluted
Ilor	Spring	25.5	7.1	14	8.97	240	D	Grossly polluted
Loe	Spring	25.9	6.2	16	10.34	93	D	Grossly polluted
Mbengmong, Akwa II	Spring	26.8	6.3	15	9.75	2400	D	Grossly polluted
Gov't quarter, Isangele	Spring	25.7	5.6	11	7.28	1100	D	Grossly polluted
Ekwe	Spring	24.4	7.6	50	32.5	1100	D	Grossly polluted
Idibawase	Spring	26.5	7	14	8.97	2400	D	Grossly polluted
Besingi	Spring	25.6	6.5	15	9.43	1100	D	Grossly polluted
Ghana Quarter, Mundemba	Spring	26.6	6.5	11	6.83	75	D	Grossly polluted
Massore	Open well	28	5.8	16	10.4	2400	D	Grossly polluted
EkondoTiti	Open well	27.7	6.4	27	17.55	2400	D	Grossly polluted
EkondoTiti	Open well	27.8	6.4	12	7.8	2400	D	Grossly polluted
Bongongo I	Open well	27.9	5.5	65	42.25	2400	D	Grossly polluted
EkombeLiongo	Open well	28	7.2	142	92.3	28	D	Grossly polluted
Mbonge	Open well	27.8	6.1	78	50.83	93	D	Grossly polluted
Iloani	Open well	26.3	5.9	19	12.16	150	D	Grossly polluted
Bekora	Open well	27.9	5.7	274	178.1	460	D	Grossly polluted
Mbonge	Pumpwell	28.8	6.1	7	4.55	2400	D	Grossly polluted
Akwa, KomboAbedimo	Pumpwell	26.9	5.9	45	29.25	4	B	Polluted
Mosongesele	Pumpwell	29	8	159	103.35	240	D	Grossly polluted
EkombeMofako	Pumpwell	26.6	7.2	172	111.48	93	D	Grossly polluted
Mosongesele	Beach	28.5	6.4	27	17.55	2400	D	Grossly polluted
Beach, EkondoTiti	Beach	30.6	7.3	2000	1300	2400	D	Grossly polluted
Moko, Dibonda	River	32.3	6.8	19	12.35	210	D	Grossly polluted
Mbonge	River	28.6	7.5	132	85.8	210	D	Grossly polluted
EkombeLiongo	River	28.7	7.4	155	100.75	2400	D	Grossly polluted
Catchment, Mundemba	Stream	25.1	6.5	3	1.95	1100	D	Grossly polluted
Berenge	Stream	28.8	8	67	43.29	2400	D	Grossly polluted

Ekondo Nene	Stream	27.9	6.6	18	11.7	150	D	Grossly polluted
Manja, Mundemba	Stream	26	7.4	12	7.8	2400	D	Grossly polluted
Lobe Estate	Tap water	28.9	7.3	61	39.65	23	C	Unacceptable
Mundemba Town	Reservoir	26.8	6.8	7	4.55	0	A	Excellent
Last Camp, Mundemba	Rain	25.9	5.8	7	4.55	2400	D	Grossly polluted
Mundemba Town	Rain	22.8	6.7	19	12.03	2400	D	Grossly polluted

T⁰C, temperature, EC, electrical conductivity (µS/cm), TDS, total dissolved solids (mg/l), av. TC, mean total coliform counts (MPN/100 ml); bacteriological classification is based on WHO (2011)

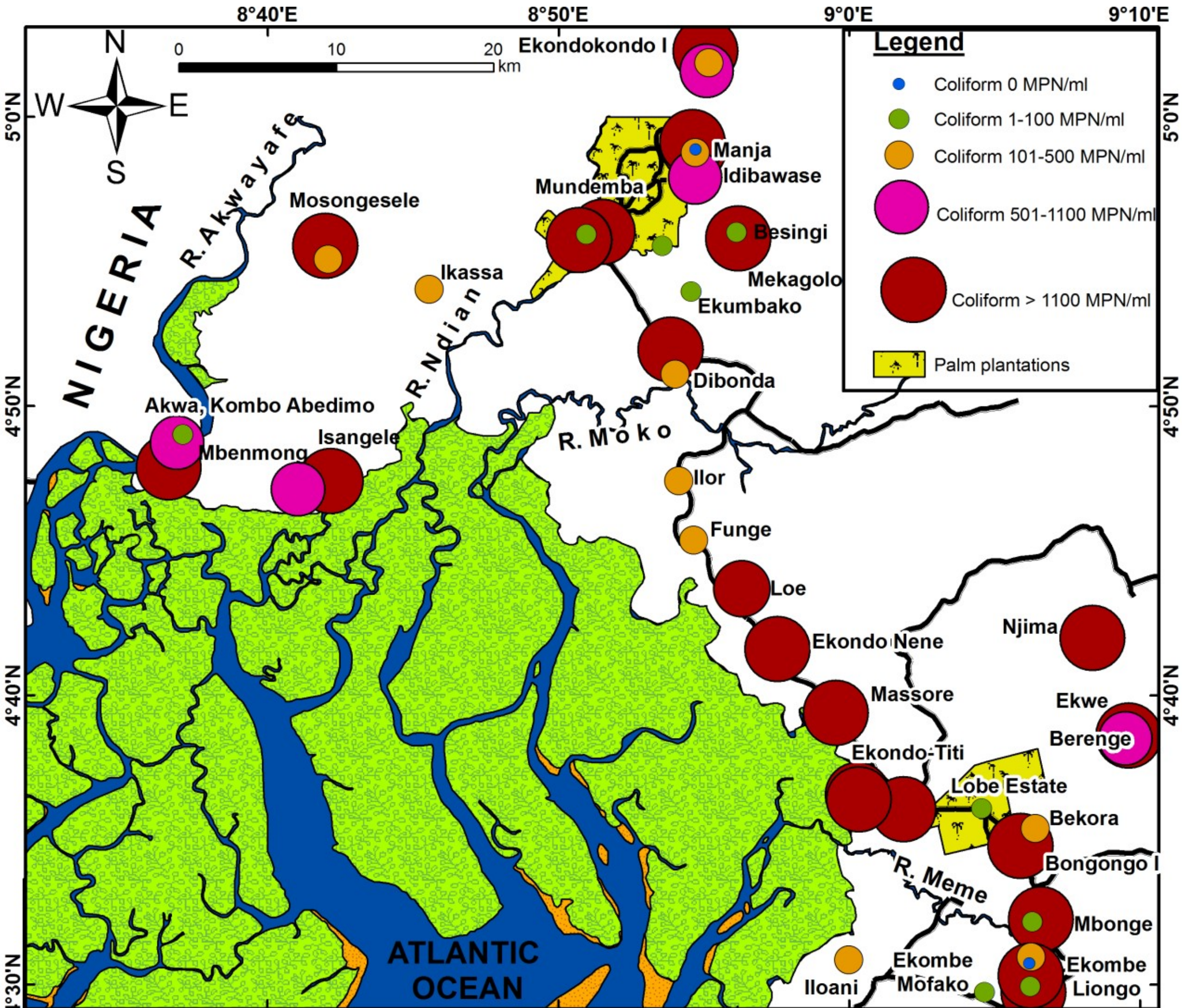

Fig.1: Sample location and spatial variation of total coliform counts in groundwater and surface waters sources

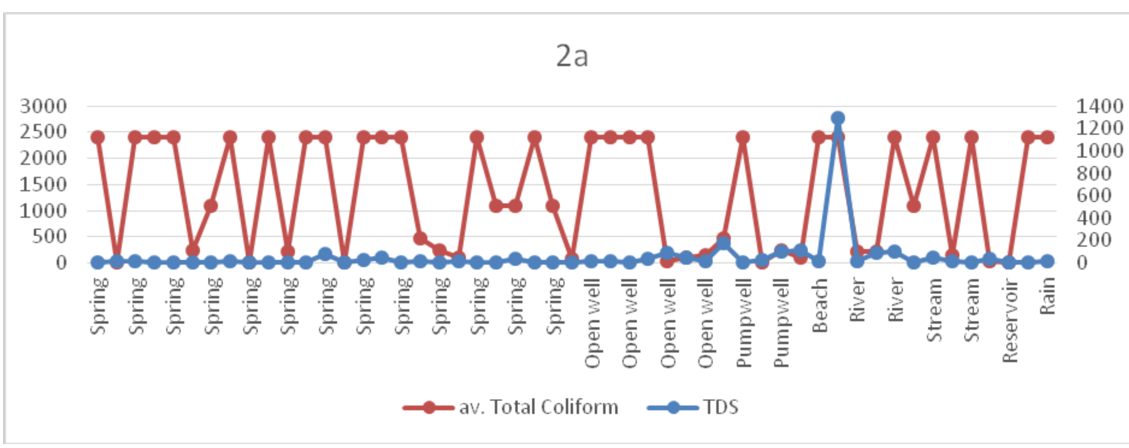

Fig.2: Relationship of total coliform counts with TDS (a), Water temperature (b) and pH(c) of studied water sources

Sources of microbial contamination in groundwater

Total coliforms comprise bacterial species of fecal origin as fecal pollution. They are found in water that is contaminated with fecal wastes of human and animal origin as well as other bacterial groups commonly occurring in soil (Djuikom et al, 2009; Kuitcha et al., 2010; Eneke et al, 2010). The coliforms are indicative of general hygienic quality of the water and potential risk of infectious diseases from water (Ako et al., 2009; Djuikom et al., 2009; Kuitcha et al., 2010; Eneke et al., 2010). The non visible relationship with TDS, Water temperature and pH (Fig.2abc) is an indicative of anthropogenic influence of point and nonpoint sources of pollution within the environment .The bacteria contamination of the water sources may result from the waste of pit toilets that intersect the water tables of shallow unconfined aquifers and also from poor sanitation practices carried out along stream channels and springs. Similar bacterial contamination in unprotected drinking water sources have been reported in Douala (Ndjama et al, 2008; Ako et al, 2010), Yaounde (Kuitcha et al, 2010) and Dschang (Katte et al., 2003; Temgoua, 2011) due to defecation in and close to water sources, and run offs from urban and municipal sewage systems.

Suitability of groundwater for human consumption and health effects

The pH values reflect slightly acidic, neutral and basic water sources. This indicates that the dissolved carbonates are predominantly in the form of HCO3 (Adams et al., 2001). Slightly acidic nature of water sources are linked to the formation and dissolution of minerals and are also influenced by biochemical processes in solution (Freeze and Cherry, 1979; Williams and Benson, 2010; Nduka and Orisakwe, 2011; Wotany et al., 2013). Sixty percent (60%) of the ground water samples where slightly acidic (5.5 – 6.4) and out of the WHO (2011) guideline limit (6.5-8.5) for drinking water (Table 1). This situation puts the inhabitants at risk to stomach ulcer. The electrical conductivity values (3.00-274 us/cm) (Table 1) represents water experiencing slight mineralization (Gnazou et al., 2011). According to Freeze and Cherry (1979), TDS values <1000 mg/l represent fresh water. From Table 1, TDS values for groundwater sources were below 248 mg/l, thus considered as fresh water. Such low values have also been observed in Ndop plain by Wirmvem et al. (2013). Colifom counts are used to evaluate the hygienic status of water and the presence of coliform in water suggests contact with sewage (Markosova and Jezek, 1994). Based on WHO (2011) classification, 86, 6, 4, and 4%, (Table 2) provided grossly polluted, unacceptable, acceptable and excellent water quality respectively for drinking purposes. The contamination of these water sources by the high total coliform bacteria, exposes the population to water-borne diseases such as diarrhoea, dysentery and typhoid as observed in most urban and rural communities in Cameroon (Kuitcha et al., 2008; Ndjama et al., 2008; Eneke et al., 2010; Wirmvem et al., 2013).

Table 2: Summary classification of water quality in the coast of Ndian after WHO (2011)

Total coli form counts (MPN/ 100ml) ranges	No. of sam ples	Total coli form counts	Percent age of water sample (%)	Class	Type of water
0	2	0	4	A	Excellent
1-10	2	4-7	4	B	Polluted
10-50	3	21-28	6	C	Unaccept able
Above 50	44	75-2400	86	D	Grossly polluted
Total	51		100		

Conclusion

The pH values reflect slightly acidic and basic water sources. Sixty percent (60%) of the ground water samples where slightly acidic (5.5 – 6.4) and out of the WHO (2011) guideline limit (6.5-8.5) for drinking water. This situation puts the inhabitants at risk to stomach ulcer. The electrical conductivity values (3.00-274 us/cm) for groundwater sources represents water experiencing slight mineralization. Based on the total coliform counts as per the WHO (2011) standard of 0MPN/100ml, 96% of the water sources are polluted to grossly polluted and exposes the population to water-borne diseases such as typhoid, cholera and dysentery. This study suggests that: deep boreholes be drilled to meet confined aquifers to avoid water shortages and to provide good quality drinking water free from anthropogenic influences: the connection of water supply networks: improvement of garbage collection: construction of pit latrines about 20m away from the shallow hand dug wells in order to reduce the bacterial contamination of water sources and proper treatment of water before consumption.

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