Physicochemical and microbiological quality of Rumpi community water sources in rural south western Cameroon (Central Africa)

***Dzekewong S Ndzeshala[1], Suh C E[2], Lifongo L L[3]**

[1]School of Agriculture and Natural Resources, Catholic University Institute of Buea P.O. Box 563 Buea, Cameroon.
[2]Department of Geology, Faculty of Science, University of Buea P.O. Box 63 Buea, Cameroon.
[3]Department of Chemistry, Faculty of Science, University of Buea P.O. Box 63 Buea, Cameroon.

*Corresponding author E-mail: solleydze@yahoo.com.

Accepted 14 February 2016

Sustainable provision of potable water is a major challenge faced by developing countries. In Cameroon, water resources are abundant, but demand for potable water supersedes supply in both urban and rural communities, resulting in a plethora of health risks. In this study, the physicochemical and microbiological quality of 11 community water supply schemes (9 springs, 1 stream and 1 rain water) operated within the Rumpi Project area in the South West Region of Cameroon have been assessed, using colorimetric/turbidimetric methods, atomic emission photometry, titration, and Multiple Tube dilution Technique, in order to establish the link between anthropogenic activities, water quality and possible health impacts. Results revealed that Ca^{2+},15.81mg/L, Mg^{2+},13.63mg/L Na^{+}, 16.85mg/L, and HCO_3^{-}, 175.78mg/L were the major constituents in the water samples. These concentrations are within the World Health Organization (WHO) guidelines for safe drinking water however, they are lower than the recommended minimum daily intake. The low mineral content of the sampled water sources accounts for the soft nature of most of the sampled water sources in the study area and could pose a potential health risk to people depending solely on these sources for their mineral supply. 82% of the analysed samples had coliform count which ranged from 4 to 4800MPN/100mL; this is above the WHO guideline of 0MPN/100mL, thus unacceptable for drinking. A variety of anthropogenic activities were observed around the water sources, affecting the source water quality negatively, thus requiring sufficient treatment prior to distribution in order to reduce water related diseases.

Key words: Water quality, Rumpi project, anthropogenic activities, human health, water sources, south west Cameroon.

INTRODUCTION

Cameroon is ranked 49^{th} out of 182 countries in the world in terms of abundant water supply. Despite its enormous potential for water resources, demand greatly supersedes supply as only 47% of the population in semi-urban and rural communities have access to improved drinking water, (WHO/UNICEF, 2012). As a consequence, water related diseases such as cholera are frequent especially among children (WHO, 2008; WHO, 2014). It is estimated that children mortality can be reduced and general health improved by ensuring access to safe drinking water and improving sanitation and hygiene, (WHO, 2008; UN, 2010). Soltau (2003) reported that only about 11 of the 118 villages in Mount Cameroon (MC) region have tap water supply.

Currently, the unanticipated rapid population increase has generated low pressure of water flow and inconsistency in supply by the Cameroon Water Utilities (CAMWATER), the national water supply company in this region. Considering the fact that water supply infrastructure has not been improved upon to meet the current population growth, only the principal urban centres are supplied with potable water, while the rural population is left to seek solutions in community water supplies. Hence the exploitation of the natural water sources in the MC region is a function of availability rather than quality (Lambi and Kometa 2009; Folifac et al., 2010). This has a direct implication on the health and wellbeing of the communities involved, (Talib, 2014)

The Rumpi project is a Participatory Area Development Project, funded by the African Development Bank (ADB). It operates under the South West Development Authority (SOWEDA) with principal objectives being poverty alleviation and the improvement of rural livelihoods. Amongst other strategies to achieve these objectives, water supply and management is a key area. Unfortunately, the quality of water supplied is doubtful and the management of water supplies is unsustainable.

This prompts action as previous studies (Ayonghe 2001, *Endeley* et al., 2001; Soltau 2003; Ako et al., 2009; Lambi and Kometa 2009, Folifac et al., 2010) suggest that the quality of water in this region is being threatened by a number of factors such as anthropogenic activities and increase in population which has led to encroachment into water catchments. This has resulted in new land uses (farming, housing, personal hygiene, dumping of waste, bush fires and deforestation), with negative effects on water quality. Unfortunately, quality control measures are not often performed on these water schemes, (Folifac, et al., 2009).

Hence, the monitoring of drinking water sources in the MC region has become very crucial. This study was aimed at assessing the physicochemical and microbial quality of some 11 community water supplies, which included 9 springs, 1 stream and 1 rainwater, identifying anthropogenic activities around the water sources and possible health impacts therefrom.

MATERIALS AND METHODS

Study area

The study area which extends from lat 9^0 0' E to long 4^0 0' is located in two divisions (Fako and Meme) of the South West Region (SWR) of Cameroon, within the watershed of MC. Fako Division covers an area of about 2093 km^2 and host 367,000 (31%) of the about 1.2 million inhabitants of this Region, (Lambi and Kometa, 2009). Meme Division on the other hand has an estimated population of 80,000 inhabitants (Kumba City Council, 2007). The communities involved in this study are within 250 to 1000 m above sea level, (Figure 1). The climate of the study area is humid tropical characterized by extreme rainfalls and temperatures of about 22^{o}C all year long (Bennedetti et al., 2003). The mountain moderates the diurnal temperatures and maintains atmospheric humidity levels at ca. 85% due to altitudinal gradient (Endeley et al., 2001; Deruelle et al., 2005; Lambi and Kometa, 2009).

These promote high rates of weathering accompanied by abundant and luxuriant vegetation growth. The combination of high relief (4,095 m) and proximity to the sea leads to strong local climatic contrasts. The main rain-bearing winds coming from the southwest are interrupted by MC, consequently, the highest rainfall is recorded on the southwest flank of the mountain. The eastern flank which is partially sheltered from the oceanic influence receives less rainfall. Vegetation cover and type influence stream water chemistry through diverse processes including direct chemical uptake and indirect influences such as supply of organic matter to soils and channels, modification of water movement, and stabilization of soil (Lucas, 2001; Dosskey et al., 2010).

The geology of this region is influenced by the presence of MC, an active volcano, and the Douala sedimentary basin. The MC region is characterized by volcanic materials such as pyroclastics, basalts, lahars and etindites, while the Douala basin is composed of Tertiary and Quaternary conglomerates, sandstones and shales. Majority of perched aquifers take their rise from lahars due to their high clay content, while others originate from terraced pyroclastic materials and basalts.

Springs generally arise where the lava-scoria interface intersects the slope. High permeability of scoria and the presence of numerous lava tubes within basaltic flows elucidate a tendency for streams to disappear underground at various points and reappear as springs on the lower slopes. Faults and fractures generated by tectonic activities particularly along the low lying piedmont regions can retain large volumes of running and infiltrating water which surge out down slope as springs **(**Akoachere et al., 2006; Endeley et al., 2001).

Water sampling and analytical methods

All eleven Rumpi community water sources in the study area were located and sampled, (Table 1). At Ekona Lelu where rain water is the principal source, samples were collected at three points; direct rainfall (dr) from the roof, before the treatment chamber (btc) and after the treatment chamber (atc). .Prior to sampling, sampling containers (1.5 litres polyethylene bottles) were thoroughly washed and rinsed with distilled water and at least three times with water from the source. Sterilized 500mL polyethylene bottles were used to collect samples for microbiological analysis. In order to ensure quality results, two samples were collected at each point and stored in an ice chest at 4^{o}C. Samples for microbial analysis were immediately transported to the Microbiology Laboratory at the University of Buea, where analysis was done within six hours of sample collection to avoid changes in microbiological characteristics

On-site observation

This involved the assessment of immediate surroundings of the water source and the identification of the level of protection or ease of contamination of the water source

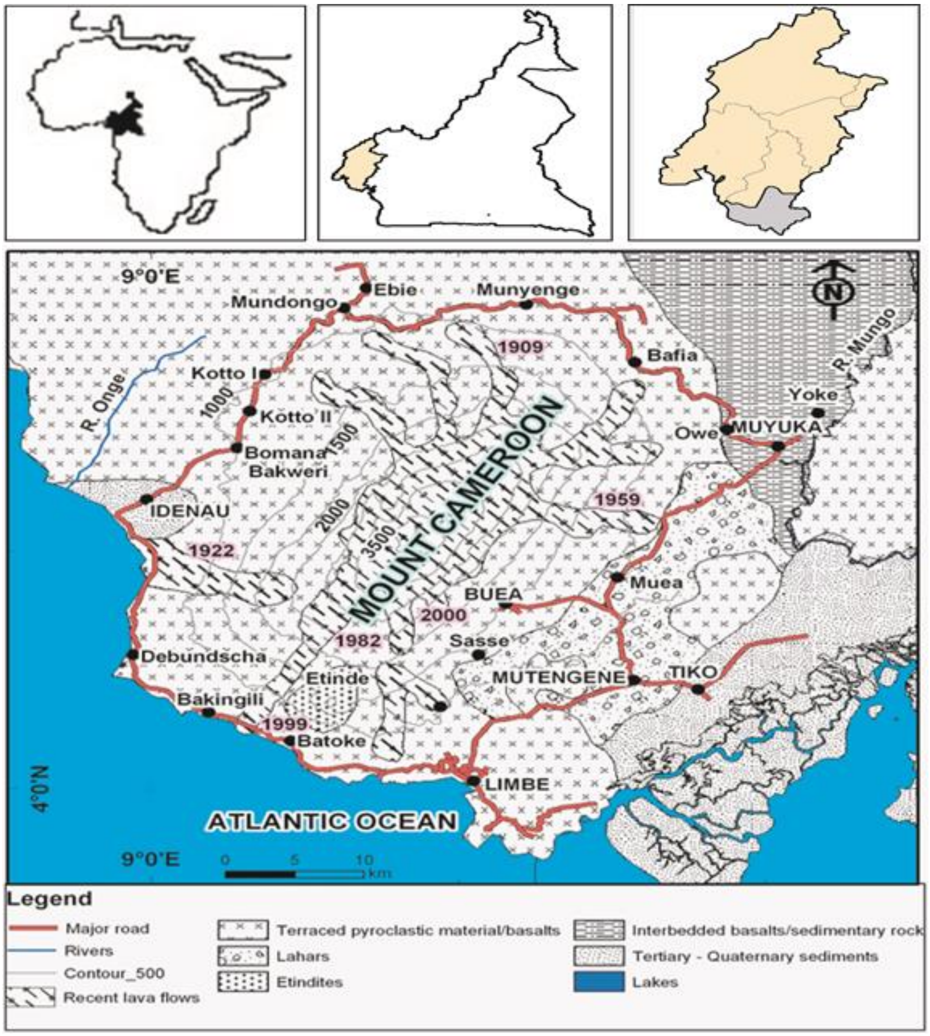

Figure 1. Geographical location of the study area in the South West Region of Cameroon.

Table 1. Sampled Community water Sources.

Name of Community	Code	Water source
Sasse	SE	Spring
Bwitingi I	BI	Spring
Bwitingi II	BII	Spring
EkonaLelu	EL	Rain water
Owe	OM	Spring
Kotto I	KI	Spring
Kotto II	KII	Spring
Ebie	EB	Spring
Mbalangie	BL	Stream
Kake	KK	Spring
Itoki Bakundu	IB	Spring

from human and animal activities within the vicinity. Observations included: examination for signs of water accumulation close to the source, identification of activities such as personal hygiene with potential to affect water quality, assessment of the closeness of the source to pit latrines or waste dumps.

Field analysis

Temperature of the water samples was measured *in situ* using the Casella London 28237c mercury thermometer while electrical conductivity (EC) was measured with a hand held Hanna Instruments H 19811 pH-EC-TDS meter and pH with a PL 150 Thermo Russel Model pH meter.

Laboratory analysis

HCO_3^- and Cl^- concentrations were determined by titration while SO_4^{2-}, NO_3^-, PO_4^{3-} and NH_4^+ were analysed by colorimetric/turbidimetric methods using a Perkin-Elmer Spectrophotometer 295E. The concentration of Ca^{2+}, Na^+ and K^+, were determined by atomic emission photometry using a Gallemkamp digital flame photometer and the Piper Trilinear diagram was used to display the relative concentrations of the major cations and anions in order to determine the dominant water classes in the study area. The Multiple Tube dilution Technique was used to determine total coliform load. The Most Probable Number (MPN) of coliform in each sampled was inferred as described by Rompre et al. (2002).

Statistical Methods

Univariate and multivariate statistical methods in Statistical Package for Social Science (SPSS) were used to summarize and interpret the data set. Pearson's correlation coefficient was employed to identify the strength of linear relationships between variables. It is worth noting that the data set was log transformed (base 10) because all parameter were not normally distributed.

RESULTS AND DISCUSSION

Physicochemical characteristics of water samples

The physicochemical characteristics of sampled water sources were generally within WHO guideline (Table 2). Water samples from nearly all sources were generally clear owing to natural filtration provided by the fine soil particles and sorption by rock layers in the region of study. However, water sampled from Mbalangi and Ekona Lelu was turbid and corresponded respectively to a running stream across a forest/settlements and rainwater harvested from dirty roofs surrounded by tall trees.

The mean alkalinity values of 2325.75 and 1616.17 signify the ability of the water bodies to resist changes in pH. These high values could be as a result of the extraction of calcium from ferromagnesian minerals (pyroxene, amphibole and calcic plagioclase), in the volcanic region and from the dissolution of limestone bedrock within the sedimentary basin.

It is important to note here that most of the sources fall within the same geological setting, (volcanic), apart from Mbalangi, Kake and Itoki Bakundu (Figure 1) which are located within the Douala sedimentary basin. Owe and Kotto II are suspected to be at the junction between the volcanic and the sedimentary basin as they exhibit mixed characteristics of both the volcanic and sedimentary setting. From field observation it is apparently obvious that the presence of nitrate, phosphates and sulphates in the water could be as a result of agricultural activities through runoff of inorganic fertilizer, waste dumps, human or animal wastes. In addition sulphate residuals could have resulted from the use of insecticides, fungicides and detergents.These are below the threshold value of WHO but their accumulation in water bodies may pose a great danger to human health in the near future.

A plot of chemical data on the Piper Trilinear diagram (Figure 2) revealed that Ca - Mg– Na- HCO_3 was the dominant water type in the study area and was found in Kotto I, Kake, Ebie, Bwitingi I, Bwitingi II and Sasse. The second water type was Ca - Na - HCO_3, which was found only at Itoki Bakundu. While the last water type Na - Mg- HCO_3 was identified in Mbalangi and Kotto II.Owe water source exhibited special characteristics, with a mixture of two water types; Ca- Mg – HCO_3 and Ca - Mg – Na- HCO_3 suggesting a freshwater aquifer system. Similar observations were reported by Endeley et al. (2001).

Based on the US quality association standards for water hardness, samples were further placed into three groups. Samples designated: KI, KII, EB, ML, KK and IB had a $CaCO_3$ concentration within the range: 43.0 to 82.91mg/L and were classified as moderately soft water. SE and BI sources had $CaCO_3$ concentration in the range 83 to 116.84mg/L and were classified as moderately hard water. Sample OM had a $CaCO_3$ concentration of 124.34 mg/L and was classified as hard water. Previous studies by Ako et al. (2010) has supported these findings by reporting the soft nature of drinking water sources in this region. The low levels of Ca^{2+} and Mg^{2+} associated with softness of these waters could present a potential risk of morbidity and mortality from cardiovascular diseases (Rylander et al., 1991; Sauvant and Pepin, 2002). Recent studies also suggest that the intake of soft water may be associated with higher risk of fracture in children, certain neuro-degenerative diseases (Jacqmin et al., 1994), pre-term birth and low weight at birth (Yang et al., 2000). In addition to an increased risk of sudden death, the intake of water low in magnesium seems to be

Table 2. Physicochemical characteristics of water samples from Fako and Meme compared to WHO guidelines.

Parameter	FAKO	MEME	WHO, (2008) Mg/L
T°C	26.36 ± 0.85	27.08 ± 0.38	15-35
pH	7.77 ± 0.21	7.68 ± 0.18	6.5-8.5
EC(µS/cm)	264.25± 60.31	199.67± 15.54	1000
Alk	2325.75± 615.40	1616.17± 258.03	-
Na^+	16.85±2.90	14.37± 0.50	200
NH_4^+	0.00 ±0.00	0.00 ± 0.00	0.50
Ca^{2+}	15.81 ±6.02	7.95 ± 0.84	700
K^+	4.41 ±0.73	7.74 ± 1.65	<10
Mg^{2+}	13.63 ±4.46	6.29 ± 1.78	250
F^-	0.05 ± 0.02	0.05 ± 0.02	-
Cl^-	2.36 ± 0.61	2.38 ± 1.02	250
NO_3^-	0.42 ± 0.80	1.07 ± 0.81	50
SO_4^{2-}	2.22 ± 3.48	4.89 ± 2.33	250
PO_4^-	0.04 ± 0.04	0.16 ± 0.19	-
HCO_3^-	141.87 ± 37.54	175.78 ± 5.30	250

Values are expressed as mean ± standard deviation

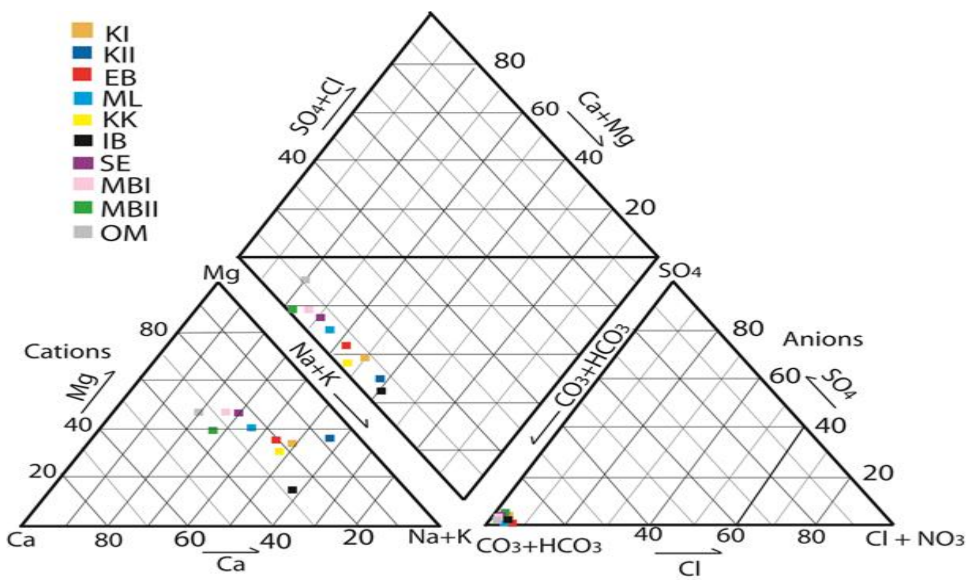

Figure 2. Piper plot for water samples from Fako and Meme division showing major water types.

associated with a higher risk of pregnancy disorders (preeclampsia) and some types of cancer (Yang et al., 1999a; Yang et al., 1999b; Yang et al., 2000). The low concentration of essential ions in the water sources studied are likely to predispose the inhabitants of this region to the enumerated problems especially in cases where these ions are not complemented from other sources such as food.

Microbiological quality of sampled water sources

The presence of *coliforms* in a drinking water sample almost always indicates recent faecal contamination, Thus *E. coli* or thermo tolerant coliform bacteria must not be detectable in any 100mL sample of all water directly intended for drinking, (Rompre et al., 2002 and WHO 2008).

Water samples from Kake and Itoki Bakunduall in Meme division, were of excellent quality (no coliform was detected) owing to the fact that they are far from human habitation, void of any anthropogenic activity and the presence of a good vegetation cover. Though some anthropogenic activities such as personal hygiene, laundry, and farming were observed around the catchment of Sasse, the total coliform count was low.

Table 3. Bacteriological Classification of Water Samples from Fako and Meme Based on Cheesbrough's (1991), Criteria.

Sample Location		Mean Coliform Counts in 100ml	Category	Comment
FAKO	EkonaLelu, (atc)	4	B	Acceptable
	Sasse	9	B	Acceptable
	Bwitingi I	21	C	Unacceptable
	Owe	23	C	Unacceptable
	Ekona Lelu, (dr)	43	C	Unacceptable
	Bwitingi II	93	D	Grossly Polluted
	Ekona Lelu, (btc)	>4800	D	Grossly Polluted
	Sample Location	**Mean Coliform Counts in 100ml**	**Category**	**Comment**
MEME	Kake	0	A	Excellent
	Itoki Bakundu	0	A	Excellent
	Ebie	15	C	Unacceptable
	Kotto I	>4800	D	Grossly Polluted
	Kotto II	>4800	D	Grossly Polluted
	Mbalangi	>4800	D	Grossly Polluted

dr= direct rain, btc=before treatment chamber, atc=after treatment chamber

The low coliform counts in Sasse could be attributed to its distance from human settlement coupled with the fact that observed anthropogenic activities were downstream to the spring source which is equally protected, (Table 3). The source of bacteria in the rainwater sample from Ekona Lelu which was direct rain (dr) resulted either from the dirty roofs, animal faeces and or atmospheric deposition on the roofs.

The sample from Mbalangi, was grossly polluted, contained particulate matter and was equally turbid, owing to the fact that it is a stream (surface water source) that runs through settlements and serves many purposes such as irrigation, personal hygiene, livestock activities etc. The rate of deforestation was equally high as well as inputs from runoff. These are likely to have a negative effect on both the quantity and quality of water in the long run through their influence on water chemistry as suggested by Moulton and Berner (1998), Bennedetti et al. (2009) and soil stabilization as observed by Doskey et al. (2010).

Conclusion

The mineral content of water operated within the Rumpi project in the MC region was low compared to the WHO, guidelines. As a result people consuming water from these sources have an elevated risk of contracting cardiovascular diseases. In addition, the total coliform load in most water sources was far above the stipulated standard of 0 MPN/100ml with the exception of only 2 sources (Itoki Bakundu and Kake) being of excellent quality. Hence, the risk from water borne diseases like cholera, typhoid, dysentery and diarrhoea is obvious. Most of the polluted water sources were characterized by poor vegetation cover, where anthropogenic activities such as logging, grazing, personal hygiene, and farming were identified.

This implies that anthropogenic activities are exerting a negative influence on water quality.Considering the poor quality of most community water sources in terms of coliform content, it is highly recommended that the sources be treated prior to distribution using conventional treatment methods like chlorination, sand filtration and boiling. Periodic monitoring of quality should therefore be set up to ensure that water supplied to the communities does not become a public danger with time.

Acknowledgements

The authors are grateful to Dr. Che Vivian Bih, of the University of Buea, Dr. Hako Touko, Dr. Laetitia Ako Kima, Mr. Egbe Daniel, Mr. Othniel Mobit, Mr. Nyidem Asongwe Benard and Mr. Ojong Briand, all of the Catholic University Institute of Buea for their useful criticism and contribution to this work. We also wish to thank the inhabitants of study area for welcoming us, assisting and providing relevant information on the field.

REFERENCES

Ako AA, Shimada J, Eyong GE, Fantong WY (2010). Access to potable water and sanitation in Cameroon within the context of Millennium Development Goals (MDGS). Water Sci. Technol., 61(5): 1317-1339.

Ako AA, Eyong GE, Nkeng GE (2009). Water resource management and integrated water resource management (IWRM) in Cameroon. Water Resource Manage., 24: 871-888.

Akoachere R, Itie M, Yaya O, Oteze G (2006).

Morphometric analysis of the Piedmont Regions of Mount Cameroon, West Africa. Conference paper in J. Nig. Ass. Hydrology American Water Works Association (2001). Water resource planning: Manual of Water Supply Practices. 1st edition. Quincy Avenue, Denver.

Ayonghe S (2001). A Qualitative Evaluation of Global Warming and Precipitation in Cameroon from 1930 to 1995 and Projections to 2060: Effects on the Environment and Water Resources In: Readings in Geography. Unique Printers Bamenda- Cameroon, pp 142-155.

Benedetti MF, Dia A, RiotteJ, Chabaux F, Gerard M, Boulegue J, Fritz B, Bulourde M, Deruelle B and Ildefonse P (2003). Chemical weathering of basaltic lava flows undergoing extreme climatic conditions: The Water Geochemistry Record. Chem. Geol., 201:1-17.

Cheesbrough M (1991). Water and Sanitation Decade: Bacteriological testing of water supplies in Medical laboratory manual for tropical countries. Microbiolol., 2: 206-224.

Deruelle B, Chauvel C, Dia AN, Bulourde M, Chabaux T, Durand S, Ildefonse P, Gerard M, NgounounoI (2005). Do decades of tropical rainfall affect the chemical composition of basaltic lava flows in Mount Cameroon. J. Volcanol. and Geothermal Res., 141(3-4): 195-223

Dosskey MG, Vidon P, Noel P, Gurwick C. J, Allan T, Duval T and Richard L (2010). The role of riparian vegetation in protecting and improving chemical water quality in streams. J. American Water Resourc. Assoc., 46(2): 261-277.

Endeley RN, Ayonghe SN, Tchuenteu F (2001). A Preliminary hydrogeochemical and baseline study of water sources around Mount Cameroon. J. Cameroon Academy of Sci., 1(3):127-185.

Folifac F, Lifongo l, Nkeng G, Gaskin S (2009). Municipal drinking water source protection in low income countries: Case of Buea Municipality-Cameroon. J. Ecol. and Environ., 1(4): 073-084.

Jacqmin H, Commenges D, Letenneur L, Barberger-Gateau P, Dartigues JF (1994). Components of drinking water and risk of cognitive impairment in the elderly. American J. Epidemiol., 139: 48-57.

Lambi CM, Kometa SS (2009). An evaluation of water resources on the eastern slopes of mount Cameroon. J. Human Ecol., 28(1): 47-55.

Lucas Y (2001). The role of plants in controlling rates and products of weathering: Importance of biological Pumping. Annual Review on Earth Planet Sci., 29: 135-165.

Moulton KL, Berner RA (1998). Quantification of the effects of plants on weathering in iceland. Geol., 26: 895-898.

Rompre A, Servais P, Baudart J, Roubin M, Laurent P (2002). Detection and enumeration of coliforms in drinking water: Current methods and emerging approaches. J. Microbiological Methods, 49: 31-54.

Rylander R, Håkan B, Rubenowitz E (1991). Magnesium and calcium in drinking water and cardiovascular mortality. Department of Environmental Hygiene, University of Göteborg, Sweden. Environ Health,17:91.

Sauvant MP, Pepin D (2002). Drinking water and cardiovascular disease. Food and Chemical Toxicol., 40: 1311-1325.

Soltau KS (2003). Rural livelihood and social infrastructure around Mount Cameroon. background information for the Mount Cameroon Socio-Economic Geographical Information System, (MC-SE GIS). Final Report. Mount Cameroon Project, Cameroon, Pp23, 30-35.

Talib Najjar (2014). Role of Community development schemes on the health and wellbeing of households.

UN (2010) Global annual assessment of sanitation and drinking water. Targeting resources for better results.

WHO (2014). Drastic consequences of diarrheal diseases

WHO (2008). Guidelines for drinking-water quality, Second Addendum to the 3rd Edition, Recommendations Geneva, 1: X-Y

WHO/UNICEF (2012). Joint Monotoring Programme for Water supply and Sanitaion, Cameroon. www.wssinfo.org (Accessed on November 2012).

Yang CY, Chiu HF, Cheng MF, Tsai SS, Hung CF and Tseng YT (1999b). Pancreatic cancer mortality and total hardness levels in Taiwan's drinking water. J. Toxicol. and Environ., 56: 361-369.

Yang CY, Chiu HF, Cheng MF, Tsai SS, Hung CF, Lin MC (1999a). Oesophageal cancer mortality and total hardness levels in Taiwan's drinking water. *Environ. Res.*, Section A, 81: 302-308.

Yang CY, Chiu HF, Cheng MF, Hsu TY, Cheng MF, Wu TN (2000). Calcium and magnesium in drinking water and the risk of death from breast Cancer. *J. Toxicol. and Environ. Health*, Part A, 60: 231-241

LIST OF ABBREVIATIONS

MC: Mount Cameroon
ADB: African Development Bank
SOWEDA: South West Development Authority
CAMWATER: Cameroon Water Utilities
SWR: South West Region
EC: Electrical conductivity
MPN: Most Probable Number
SPSS: Statistical Package for Social Science
USWQA: United States Water Quality Association
WHO: World Health Organization