UNIVERSITE DE YAOUNDE I
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SAFE DRINKING WATER OPTIONS FOR THE URBAN POOR OF YAOUNDE: CASE OF OBILI AND ETOUG - EBE

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTERS DEGREE IN GEOGRAPHY

SPECIALTY
Rural and Urban Dynamics

OPTION
Urban Dynamics

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March 2023

DEDICATION

To my dear parents Mr. Nibalum Tantoh (Late) and Mrs. Nibalum Regina

&

To my lovely husband Pr. Mbinkar Edwin and Kids Nakimera and Emery

ACKNOWLEDGEMENTS

I am greatly thankful to several persons who aided in a way or another in the realization of this dissertation. My earnest appreciation is given to my supervisor, Prof. NGUENDO BLAISE YOUGSI. I remain incessantly grateful to him for carefully accepting, reading, correcting, criticizing and making valuable observations which directed me in the completion of this study.

I am again actually thankful for the educational and moral support embedded in me by lecturers of the Geography Department such as Prof. TCHAWA Paul, Prof. DONGMO JEAN-LOUIS, Prof. KENGNE FODOUOP, Prof. MOUPOU Moise, Prof. NGOUFO Roger, Prof. TCHINDGANG Mesmin, and Prof. ENCHAW Gabriel. I am very grateful to late Prof. NGWA Nebasina who coached me on concepts, models and theories that were actually suitable in this research.

I also wish to sincerely show appreciation to my family particularly to my parents Mr.NIBALUM TANTOH (late) and Mrs. NIBALUM TANTOH, the entire Regina family, who assisted me morally and financially in getting some pertinent facts necessary for the realization of this research work.

I am grateful to my school mates, coworkers and friends who encouraged me to realize this piece of work. My honest appreciation goes to Mr. Nnen Thomson Ako, Nicolas who assisted in pinpointing some stakeholders. This permitted me to administer questionnaires, conduct interviews and focused group discussion. They help out to organize respondents thus easing getting hold of data on the ground. I am as well grateful to Mr. Bongajum Simplice who proofread this work and made vital rectifications and proposals. I am equally grateful to Mr. Kenfack Salomon for backing me up with satellite images and guiding me in the realization of the maps.

ABSTRACT

Cameroon is blessed with abundant fresh water resources. Thus an adequate, reliable clean acceptable and safe drinking water supply is to be made available for all. Yet, it is difficult for urban dwellers to have access to safe drinking water in Obili and Etoug – Ebe in Yaounde. This has created a gap which this work seeks to bridge. This analysis was enabled by both quantitative and qualitative research method. Water samples were collected and tested in the laboratory for coliforms, physical and chemical substances which are indications of contamination. Local perceptions were also studied with open ended questionnaires and the collected data was analyzed. With this, some Objectives to guide this work were;

- To fine out the different sources of drinking water in Obili and Etoug–Ebe.

- Examine the problems encountered by the urban poor having access to drinking water.

- Investigate the affordable options for safe drinking water for the urban poor.

- To propose HWTS that can help mitigate the impacts of consuming unsafe drinking water.

With these objectives, results obtained indicate that most of the drinking-water sources considered to be safe in theory are highly contaminated. The poor bacteriological quality of drinking-water in this area has resulted to the occurrence of waterborne diseases table 2.6. The study also reveals that government proposed policies and approaches are not in line with the perceptions, expectations and demands of the population. An integrated approach for understanding the issues of water supply and sanitation have been proposed. This goes further to propose solutions such as household water treatment and safe storage (HWTS) to remedy the situation. The study also recommends the creation of a Water Sector Regulatory Agency in Cameroon. This agency will look in to the problems plaguing the drinking water sector in Cameroon while proposing some solution and using them to ameliorating the situation.

Keywords: Portable water, urban poor, HWTS, Waterborne diseases in Obili and Etoug - Ebe

RÉSUMÉ

Le Cameroun est doté d'abondantes ressources en eau douce. Ainsi, un approvisionnement en eau potable adéquat, fiable, propre, acceptable et sûr doit être mis à la disposition de tous. Pourtant, il est difficile pour les citadins d'avoir accès à l'eau potable à Obili et à Etoug – Ebe à Yaoundé. Cela a créé un fossé que ce travail cherche à combler. Cette analyse a été rendue possible par une méthode de recherche quantitative et qualitative. Des échantillons d'eau ont été prélevés et testés en laboratoire pour les coliformes, les substances physiques et chimiques qui sont des indications de contamination. Les perceptions locales ont également été étudiées avec des questionnaires ouverts et les données recueillies ont été analysées. Avec cela, certains objectifs pour guider ce travail étaient ;

- Affiner les différentes sources d'eau potable à Obili et Etoug–Ebe.
- Examiner les problèmes rencontrés par les pauvres urbains pour accéder à l'eau potable.
- Étudier les options abordables d'eau potable pour les pauvres des villes.
- Proposer des HWTS qui peut aider à atténuer les impacts de la consommation d'eau potable insalubre.

Avec ces objectifs, les résultats obtenus indiquent que la plupart des sources d'eau potable considérées comme sûres en théorie sont fortement contaminées. La mauvaise qualité bactériologique de l'eau potable dans cette zone a entraîné l'apparition de maladies d'origine hydrique tableaux 2.6. L'étude révèle également que les politiques et les approches proposées par le gouvernement ne sont pas conformes aux perceptions, aux attentes et aux demandes de la population. Une approche intégrée pour appréhender les enjeux de l'approvisionnement en eau et de l'assainissement a été proposée. Cela va plus loin pour proposer des solutions telles que le traitement et le stockage sécurisé de l'eau à domicile (HWTS) pour remédier à la situation. L'étude recommande également la création d'une Agence de Régulation du Secteur de l'Eau au Cameroun. Cette agence se penchera sur les problèmes qui affligent le secteur de l'eau potable au Cameroun tout en proposant des solutions et en les utilisant pour améliorer la situation.

Mots-clés : Eau potable, pauvres en milieu urbain, HWTS, maladies hydriques à Obili et Etoug - Ebe

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

LIST OF MAPS

LISTE OF PLATES

LIST OF ABBREVIATIONS AND ACRONYMS

BUCREP	Bureau Central des Recensement et des Etudes des populations
CAMWATER:	Cameroon Water
CCMD	Centre de santé Mains Douce
CDC	Center for Disease Control
CDE:	Camerounaise des Eaux
CSEV	Centre de santé Espoir et Vie
CSCU	Centre de santé Catholique universel
CSND	Centre de soins Nature et Dérivés
GIS	Geographic Information System
HHC	Humanity Health Center
HWTS	Household Water Treatment and Safe Storage
IMF	International Monitory Fund
INS	National Institute of Statistics
JMP	Joint Monitory Program
MDGs:	Millennium Development Goals
NGO	Non-Governmental Organization
NIC	National Institute of Cartography
PPP	Public Private Partnership
SDGs:	Sustainable Development Goals
SNEC	Société National des Eaux au Cameroun
UN	United Nation
UNCHS	United Nation Human Settlement Program
UNDP:	United Nation Development Program
UNEP	United Nation Environmental Program
UNESCO	United Nations Educational Scientific and Cultural Organization
UNICEF:	United Nation International Children and Educational Fund
WB	World Bank
WHO:	World Health Organization
WWW	World Wide Web

GENERAL INTRODUCTION

INTRODUCTION

In Cameroon, having access to safe drinking water remains a nightmare especially to the urban poor. Most Cameroonian towns like Yaounde are not only faced with water scarcity, but they are also faced with water quality problems. The provision of potable water supply in Cameroon has been assured by CAMWATER and CDE for the last decade. However, many cities especially the rapidly expanding urban peripheries are frequently facing acute water crisis. This water crisis has pushed the population to drink water from doubtful sources, at times contaminated with fecal matter, urine and garbage. Rationing has become the order of the day. This situation is fast becoming a crisis with women and children spotted here and there with buckets and containers hunting the precious liquid. In 2007 with the help of the World Bank (W.B), and other agencies, reforms on urban water were put in place by the Cameroon government through a Public – Private Partnership (P.P.P) in bit to ameliorate the situation. This was because this program had proven successful in Senegal and Nigeria in 2001. Despite this the situation has not changed much.

Given that, access to safe drinking water is essential to sustain life, a satisfactory quality and supply must be made available to consumers, which is not the case in Cameroon. Despite the fact that Cameroon is the second country in Africa (after the Democratic Republic of Congo) in terms of quantity of "available" water resources, estimated to be three times the world's average, access to drinking water still remains a problem because of inadequate management practices (MAFANY and FANTONG 2006). The importance of water has been reflected in international policy forums. These have included water oriented conferences such as the United Nation General Assembly which declared the period from 2005 to 2015 as the International Decade for Action, "Water for Life". Most recently, the UN General Assembly declared safe and clean drinking water and sanitation a human right essential to the full enjoyment of all.

According to P. H Gleick (1996), an average person needs at least 20 liters of safe water each day to meet their physiological, hygienic and domestic needs. This is not the case as human beings have also altered the availability and quality of water through their activities such as land use changes, poor exploitation of ground water, insufficient facilities to safely dispose of solid and liquid waste as well as climate change. Water supplies in such cases tend to become contaminated. Without the ability to treat water before it is consumed, disease is spread as people drink from the contaminated water sources. Water is responsible for approximately 80%

of all infectious diseases, UNICEF/WHO (2009). Waterborne diseases caused by unclean water and poor sanitation are now the biggest killer of children in Africa, UNICEF/WHO (2009). Even water from fresh water sources such as rivers, lakes, springs, must often be treated to ensure that it is safe for consumption. Safe drinking water includes treated fresh water, as well as uncontaminated water that do not require treatment. Safe drinking water is vital as a health and development issue at national, international and regional levels. In some regions, it has been revealed that investments in water supply and sanitation can yield a net economic benefit, as the reductions in adverse health effects and healthcare costs overshadow the costs of undertaking the interventions. This is true for investments ranging from major water supply infrastructure through to water treatment in homes. Experience has also shown that interventions in improving access to safe drinking water favour the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies.

Within the Millennium Development Goals (MDGs) now Sustainable Development Goals (SDGs), goal 7 centers on environmental sustainability, and the target is to reduce by half, by 2015 the proportion of the population without sustainable access to safe drinking water and basic sanitation. At current rates of progress, it will be over two centuries before the SDGs target is reached in Sub – Saharan Africa with Cameroon included. The growth and Employment Strategy Paper of Cameroon projected that by 2020, access to water should be increased to 75%. In the water code, law No: 98 – 005/ 1998, article 2 states that "water is part of the common heritage of the nation; the state provides its protection and management and must facilitate access to water for everyone". Unfortunately, implementing this law between the different actors and agencies has not always been easy. This is as a result of conflicting interest of different stakeholders. Those who suffer most from such conflicts are the youth, women and the poor. While the youth, poor and women are very often neglected, they are very resourceful in the functioning chain of safe drinking water as this work seeks to explain at some point.

This research topic has four chapters justified by the need for the researcher to focus on Obili and Etoug – Ebe in order to find out the existing water sources, bring out options for safe drinking water, the problems encountered by the urban poor in having access to safe drinking water, its effects on the population. Then to propose strategic solutions to these problems. It is also a component of effective policy for health protection. Water scarcity could have a major impact on the world's health and ability to feed its growing population.

0.1 STUDY BACKGROUND

0.2 DELIMITATION OF THE STUDY AREA

0.2.1 Thematic Delimitation

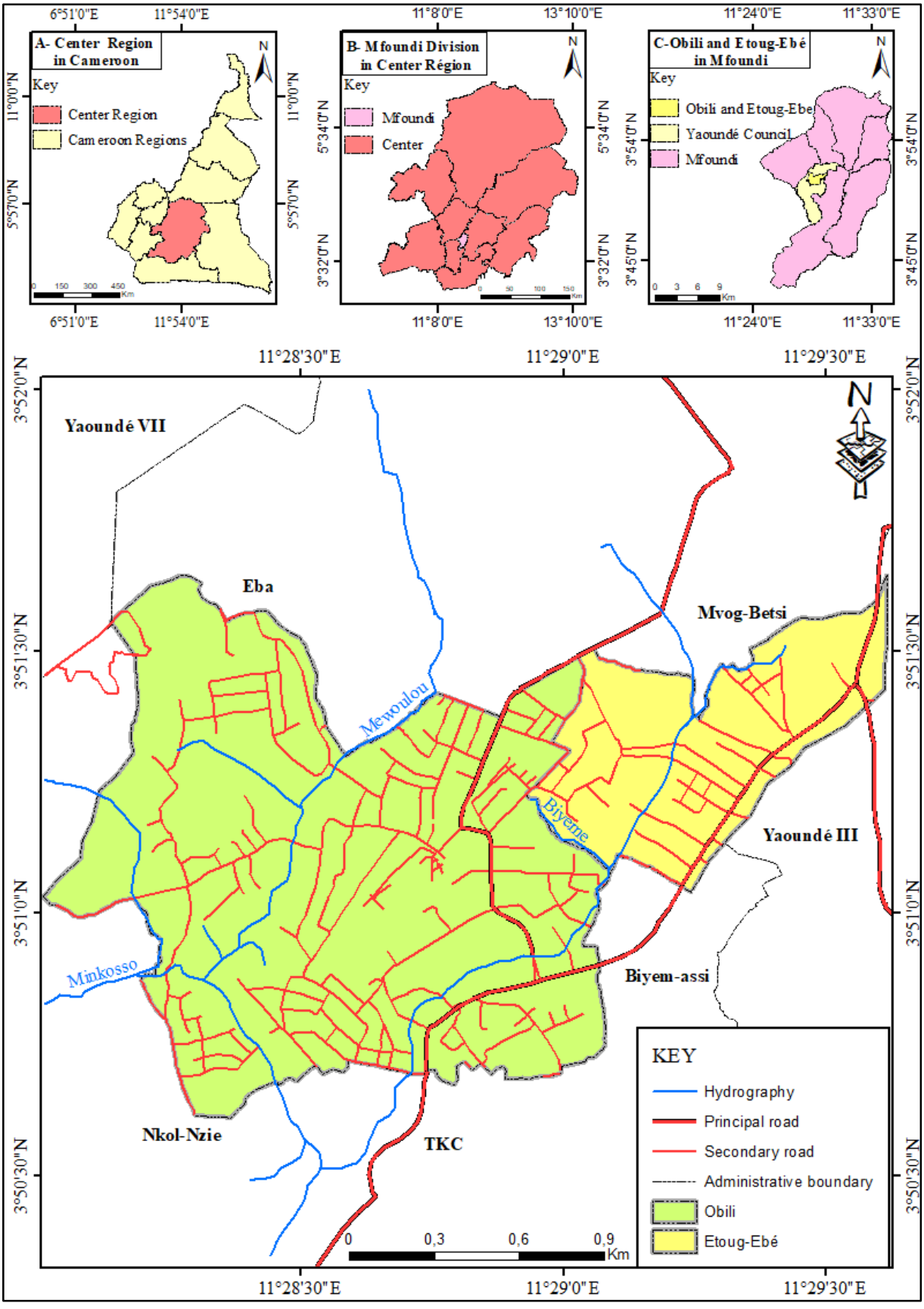
In order to get suitable information for this work, emphasis is laid on Safe Drinking Water Options for the urban poor of Yaounde: Case of Obili and Etoug - Ebe. This is characterized by water sources in the study zone, problems encountered by the urban poor in having access to safe drinking water, water treatment standards and how household water treatment methods and safe storage can remedy the situation. The urban poor are disproportionately affected by water rationing in a water crisis. This could be expanded to include access (financial, social, and legal) capacity to use water in addition to availability. Addressing urban water challenges will significantly improve the ability of cities to maximize their economic growth and alleviate the rise of urban slums in Cameroon.

0.2.2 Spatial Delimitation

This study is carried out in Obili and Etoug – Ebe in Yaounde. Yaounde is the political capital of Cameroon. It is delimited in the North West by Lekié Division, North –East and South –East by Mefou and Afamba, South – West by Mefou and Akono with a surface area of 180 km². The town has an estimated population of 2.8 million inhabitants in with an annual growth rate of 6.8%

Yaounde VI Sub Division with headquarters Biyem–Assi was created by Decree N°93/312 of 25 November 1993. The Sub - Divisional Council is located some few meters from the Government Bilingual High School Etoug – Ebe. There are several chiefdoms in the council area under the supervision of the Ministry of Territorial Administration (MINAT). It is bounded by the following Sub Divisions: to the North by Yaounde II, South by Mefou and Akono Division, East by Yaounde III and Mbankomo to the West; as on Map 1.

Map 1: Location of Yaounde the capital city of Cameroon

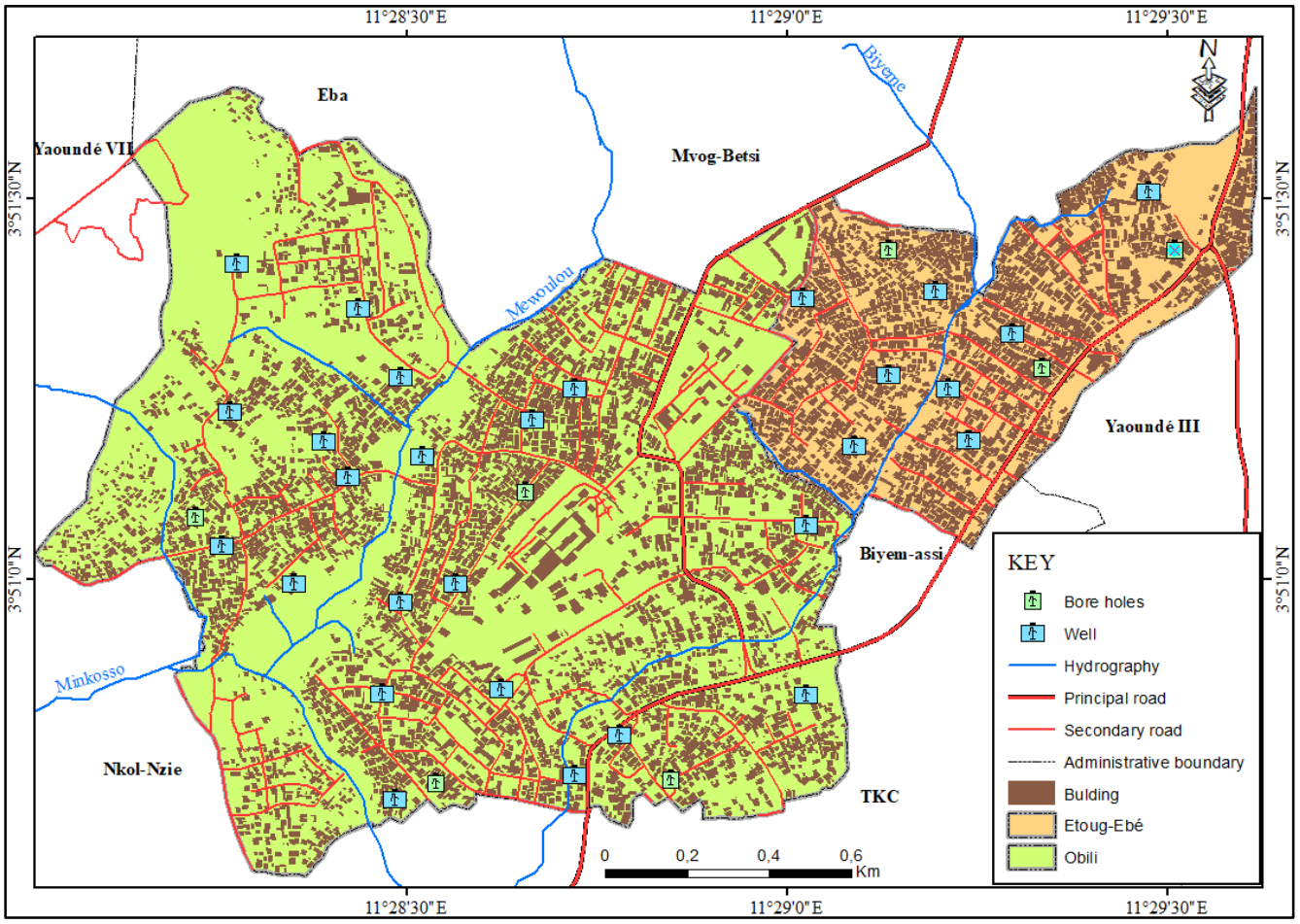


Source: Yaounde VI Council Archives

The precise study area of this work is Obili and Etoug-Ebe. Etoug-Ebe is a sub - quarter of Yaounde VI. It is delimited in the north by Mvog-Betsi quarter, in the south by Mendong, east by Obili, and west by Nkolbisson. Obili on the other hand is a quarter in the east of Yaounde VI situated beside the Ngoa-Ekelle quarter of Yaounde III municipality.

Map 1, gotten from Google Earth Software Program provides a base map and its interpretations. Map 2, presents the present state of Obili and Etoug–Ebe in the Yaounde VI municipality.

Map 2: Location and present state of Obili and Etoug - Ebe



Source: Google earth and fieldwork

0.2.3 TEMPORAL DELIMITATION

This work spans from the period 2000 to present. This time frame is chosen because it is within this period that the inhabitants of Yaounde experienced a lot of dynamics in population growth and the water sector following the Yaounde 2020 development plan (PDU - Yaoundé 2020) of 2008. The government through the Cameroon Water Utilities Corporation (CAMWATER) is putting more effort in ameliorating the quality and quantity of water in Yaounde though demand still exceeds supply.

0.3 STATEMENT OF THE PROBLEM

INTRODUCTION

Lack of accessibility to safe drinking water is a leading risk factors for infectious diseases including cholera, diarrhea and typhoid. In effect, water crisis is health crisis with the demand for drinking water exceeding supply. Without access to clean water where the quality is dirty, proper sanitation and hygiene facilities are not evident thus, a problem that need urgent solutions.

Securing drinking water supply is one of the most significant challenges for the urban poor of the study area. There is therefore an urgent need to assure that growth is sustainably and equitably translated into poverty reduction. In Yaounde for example, only 20% of the population have access to drinking water provided by CAMWATER (WHO, 2012). Consequently, Yaounde residents suffer from a growing drinking water shortage, especially during the dry seasons when the network is intermittent. The growing disparity amid supply and demand has led to long lasting shortages and the use of water from alternative sources like, springs, wells, rain and even rivers and ponds as observed on the field.

On the other hand, the quality of drinking water is becoming a serious public health concern. The quality of drinking water has depreciated in recent years due to inefficient management of pipe borne water, distribution systems and direct discharge of untreated sewage into streams, and infiltration into wells where raw water is collected. The contamination of water sources with fecal material, domestic and industrial waste leads to an increased risk of disease transmission among the urban dwellers especially the urban poor.

According to the World Bank, more than one fifth of the population of the developing world lives in extreme poverty, that is, with incomes below the threshold of $1.9 a day to acquire basic needs like drinking water. Over the next 20 years, the growth of African Urban

population would propel new demand for infrastructure. This rapid growth comes with numerous challenges with most city dwellers living in poverty. Figures from the UN Refugee Agency (HCR) show that the poverty reduction rate is lagging behind its population growth rate. Cameroon suffers from weak governance hindering its development and ability to attract investment. It is ranked 152th out of 180 countries in the 2018 Transparency International Corruption Perception Index. All these handicap the provision of basic needs with water being the essential.

In the Yaounde VI municipality, it is common to see waste water from overflowing toilets flowing along the streets. The situation has become so serious that some streets and junctions have been named after this phenomenon; such as the famous "*carrefour kaka*". Many households that cannot afford connection to pipe borne water use water from wells that are dug near toilets and streams into which others discharge their toilets. These wells are usually contaminated especially during the rainy season when the water table rises. Some households with pipe borne water still resort to these wells when there is no water supply by the utility company.

Having access to safe drinking water in Obili and Etoug–Ebe is not quite certain. Observation from field studies reveals that about 75% of the population consumes water from springs. These springs are not well protected and are polluted with waste either from households or animals, containers used to collect water, fecal matter, run-off or waste water. All of these pose as serious threat to the health of the population. Even when portable water is sometimes available, the storage containers too can be a problem, as some breed microorganisms. Safe drinking water is therefore a huge challenge for the urban poor of the Yaounde VI municipality especially with the aging of the city water infrastructure.

0.4 INTEREST OF STUDY

0.4.1 Scientific Interest

This research seeks to address some of the problems plaguing the drinking water sector so as to ensure its sustainability. Having access to drinking water is plagued by a number of problems that this research is out to address. These problems include population behavioral cause, intermittent water supply, limited water infrastructural means, overcrowded water points, urban poverty and poor adaptation measures. The problems are caused by several factors such as, climate variability or natural environment, negligence on the part of water users, poor

water engineering, and accessibility. These problems constitute a hindrance to having access to safe drinking water.

This study thus intends to investigate the nature of these problems and seek informed solutions to them. However, research has provided solutions in different localities but Obili and Etoug–Ebe still stand out as an area with little or no research in this field. Time generally goes with improvement in techniques of handling problems and it is expected that problems of this nature should be on the decline. Rather problems of having access to safe drinking water are on a rise. This portrays a gap which this study is out to bridge.

This choice of topic and study area are also driven by the researcher's curiosity to get an in depth knowledge about safe drinking water options for the urban poor through household water treatment and safe storage (HWTS). In addition to this, water is found everywhere but it not suitable for drinking. When the water is treated, it becomes expensive. This research will aid to identify future research opportunities and will also aid policy makers to take favorable decisions that should ameliorate the quality and quantity of water in the future.

Most scientists and scholars the world over have made it clear that "Water is life". This therefore implies that safe drinking water is very vital for livelihood. Much talk on international conferences has been ongoing in recent years as concerns water, its quality and its availability to the population (Rio 1992, Dublin 1992, Paris 1998 etc.). Law No 98/005 of April 1998 was named "organization of the water sector in Cameroon" with the liberalization of the sector. This law authorizes the usage of different water sources. This was due to the fact that the water utility corporation (SNEC) at the time could not satisfy the water demand of the population. This was as a result of the increase in population and poor planning strategies. This to an extent confirms Malthusian theory on population growth which stipulates that population increases at a geometric rate while resources increase arithmetically.

The persistent problem of water and its effects on the population provoked this study on "Sustainable Safe Drinking Water Options for the Urban Poor of Yaounde VI Municipality: Case of Obili and Etoug–Ebe". This work will serve as a reference for stakeholders in the Ministry of Water and Energy as well as other stakeholders in the water sector.

The outcome of this work will help the Ministry of Water and Energy on the ways to assist the urban poor treat their own water and make it safe for drinking at household levels. This work will also serve as a working document or instrument in the Ministry of Public Health,

Ministry of Decentralization and in the Department of Civil Protection, on how to ameliorate and formulate policies especially on safe drinking water in Cameroon.

This work will provide a starting point for individuals, stakeholders, as well international organizations to implement modern methods to help households improve the quality of their water. It will serve as a source of information to future researchers on related fields.

0.5 RESEARCH QUESTTIONS

0.5.1 Main Research Question

What are the affordable safe drinking water options for the urban poor of Obili and Etoug–Ebe in the Yaounde VI Municipality?

0.5.2 Specific Research Questions

i. What are the different sources of drinking water in Obili and Etoug–Ebe?

ii. What are the problems encountered by the urban poor having access to safe drinking water?

iii. Which are the Safe drinking water options for the urban poor?

vi. What are some of the ways in ameliorating the quality of drinking water?

0.6 RESEARCH OBJECTIVES

0.6.1 Main Research Objective

The main objective of this work is to identify the different sources of potable water and how it can be treated and stored to ensure that it is safe and sustainable for drinking by the urban poor of Obili and Etoug–Ebe in Yaoundé VI municipality.

0.6.2 Specific Research Objectives

i. To fine out the different sources of drinking water and what makes them limited as in Obili and Etoug–Ebe.

ii. Examine the problems faced by the urban poor having access and drinking water from doubtful sources.

iii. Investigate the affordable options for safe drinking water for the urban poor.

iv. To propose HWTS that can help mitigate the effects of consuming unsafe drinking water.

0.7 RESEARCH HYPOTHESIS

0.7.1 Main Research Hypothesis

There are different options through which safe drinking water can be provided sustainably to the urban poor of Obili and Etoug–Ebe in the Yaounde VI Municipality.

0.7.2 Specific Research Hypothesis

i. Springs, wells, tap water, boreholes are the main sources of drinking water in Obili and Etoug-Ebe.

ii. Intermittent water supply, rationing and environmental pollution are some of the problems encountered by the urban poor having access to safe drinking water.

iii. Boiled water, SODIS, chemical disinfectant are options for safe drinking water.

iv. Enforcement of HWTS can be a solution to greatly ameliorate drinking water problems in the study area.

CHAPTER ONE

CONCEPTUAL AND METHODOLOGICAL FRAME WORK

A. CONCEPTUAL FRAMEWORK

1. LITERATURE REVIEW

This is the relationship between the variables or the characteristics and properties that will be examined.

One of the United Nations MDGs was to reduce the amount of people living without safe drinking water by half before the end of the year 2015. Safe drinking water for human consumption should be free from pathogens such as bacteria, viruses and protozoan parasites, and meet the standard guidelines for taste, odor, color and chemical concentrations, and must be available in sufficient quantities, Kirkwood (1998). However, due to inappropriate sanitation, many people in developing countries do not have access to microbiologically safe drinking water and suffer from various diseases. Diarrheal related diseases are responsible for approximately 2.5 million deaths in developing countries annually, affecting mostly children and women especially in areas devoid of access to portable water and sanitation (Kosek *et al*. 2003).

Providing safe, reliable water to every household is an essential goal, which can yield optimal health gains while contributing to the targets for the United Nations MDGs now SDGs for poverty reduction, nutrition, childhood survival, school attendance, gender equity and environmental sustainability. Household water treatment (HWT) interventions may play an important role in protecting public health where existing water sources, including those delivered via a piped network or other improved sources, are untreated, are not treated properly or become contaminated during distribution or storage.

In urban areas in most developing countries, many people are living in slums and go fetching their drinking water some distances away from the household and transporting it back and storing in various containers. Microbiological contamination of the water may occur between the collection point and the point of use in the household due to inappropriate hygienic practices and storage conditions causing the water to become a health risk (Moyo *et al.* 2004). Esrey *et al*. (1991) and Fewtrell *et al*. (2005) suggested that safe drinking water supply curbs down the prevalence of diarrhea.

In order to improve and protect the microbiological quality and to minimize the potential health risks of water to the households, different techniques that are easy to use, effective, affordable and sustainable are necessary. Many water collection and storage systems have been developed and evaluated through laboratory testing of water samples Sobsey, 2002. Furthermore, a variety of physical and chemical treatment methods to improve on the quality of drinking water have been developed CDC, 2001. The purpose of this work is to improve the microbiological quality of water available to the urban poor of Yaounde VI municipality; through the implementation of strategies which include the traditional use of storage containers as well as the UNICEF approved standards MINSANTE, 2015, with or without the use of chemical additives such as sodium hypochlorite solution at the point of use.

Nguendo Yongsi 1, 2011, stated that contamination by human or animal faeces is the most regular and pervasive health risk associated with drinking water. His studies investigated water quality at sources and points of consumption of urban communities. Accordingly, most people living in slums use water directly from available sources, without any treatment and therefore are exposed to a variety of water related diseases as the drinking water is contaminated with pathogenic bacteria. Through his findings, it is logical to suggest that water regulations be revised to include water quality testing in all the neighbourhoods in which dwellers are served through ground water sources.

1.1.1 Contamination of Drinking Water

When considering safe, clean drinking water, the types of water contaminants of prime concern are of a biological nature, and include human fecal waste, Leclerc *et al.* (2002). From human waste comes disease causing bacteria like *Escherichia coli* and numerous other deadly pathogens that not only cause disease and death, but also impair social and economic development. In addition to the biological contamination of water through disease causing pathogens, it is important to consider the biological contamination of treated water by the transfer of pathogens through unprotected water sources, poor sanitation practices, contaminated storage containers, etc.

The survival of microorganisms such as bacteria in water depends upon the presence of nutrients and the water temperature, Edberg *et al.* (2000). The infectious dose of bacteria varies from organism to organism. Viruses cannot replicate outside living cells, but can survive extended periods in the water, Leclerc *et al.* (2002). Some enteric protozoa such as *Giardia* and *Cryptosporidium* cannot replicate in water but are highly resistant to most disinfectants and

antiseptics used for water treatment, Leclerc *et al.* (2002). The infectious dose for parasites depends on host susceptibility and strain virulence, Masago *et al.* (2002).

A piped supply as described by Cairncross and Valdmanis (2006) is the presumed ideal solution to our drinking water problems, since a tapped connection is able to eliminate contamination occurring from the 'public domain' (occurring due to the unsafe sources and due to improper filling and transportation of water) as well as from the 'domestic domain' (occurring within the household owing to issues of handling, storage and use). The developed world has been able to provide most of its inhabitants with a safe and secure piped source of water supply. Still, about 884 million people across the world lack access to improved water supplies while many more rely on other improved supplies such as boreholes improved dug wells, springs and harvested rainwater JMP (2008).

Briand and Laré (2013) clarify the choice of household connection to the water network of informal small scale operators in peripheries. They postulate that household accesses to different sources of drinking water are chosen when neighborhoods are neglected by the official operator. They further propose education of the household head will be very significant in household water choice.

1.1.2 The Microbiological Quality of Water

Coliform bacteria are a group of bacterial organisms used as indicators to help determine if treated water is of a microbial quality acceptable for human consumption. Since specific disease-causing organisms are difficult to detect, the microbial quality is determined indirectly through counts of these indicator organisms, Water Security Agency (2017). The presence of coliform bacteria suggests that disease-causing bacteria may also be present but these indicators cannot serve as a direct way of measuring the presence of pathogens. The presence of total coliforms in drinking water indicates treatment is inadequate or the distribution system may be experiencing regrowth or infiltration.

Indicators are easily detectable organisms whose presence correlates directly to one or more pathogens contaminating a water source. In order to be considered an appropriate indicator, an organism must meet the following five criteria, JoVE (2019):

- ✓ The indicator organism must be present when the pathogen is present, and the indicator organism must be absent when the pathogen is absent.

- ✓ The indicator organism's concentration must correlate with the pathogen's concentration. However, the indicator organism should always be found at higher numbers.
- ✓ The indicator organism should be able to survive easier and longer in the environment than the pathogen.
- ✓ Detection for the indicator organism should be easy, safe, and inexpensive.
- ✓ The indicator organism should be effective for all water types.

Most indicators are enteric (intestinal) organisms or viruses, which are commonly found in warm blooded mammalian and avian gastrointestinal systems, giving a direct connection to fecal contamination, WHO (2001). However, many indicators can lack effectiveness due to a poor correlation with certain pathogens. Two of the most widely accepted bacterial indicator organisms are *Escherichia coli* and coliforms due to their fecal linkages, and ease in laboratory analysis, JoVE (2019).

1.1.3 Water Quality Testing

The quality of freshwater supplies is under increased threat of contamination. While water contains natural contaminants, it is becoming more and more polluted by human activities, such as open defecation, inadequate wastewater management, dumping of garbage, poor agricultural practices, and chemical spills at industrial sites. Chemical contamination of drinking water is a very serious problem. Arsenic and fluoride alone threaten the health of hundreds of millions of people globally, CAWST (2013).

But even more serious is microbiological contamination, especially from human feces. Fecal contamination of drinking water is a major contributor to diarrheal disease. Globally, an estimated 2,000 children under the age of five die every day from diarrheal diseases. Almost 90% of child deaths from diarrheal diseases are directly linked to contaminated water, lack of sanitation, or inadequate hygiene UNICEF Canada, (2013). For every child that dies, countless others, including older children and adults, suffer from poor health and missed opportunities for work and education.

Water quality testing is a tool that can be used to help identify safe drinking water whether at the source, within a piped distribution system, or within the home. Water testing plays an important role in monitoring the correct operation of water supplies, verifying the

safety of drinking water, investigating disease outbreaks, and validating processes and preventative measures Bain *et al*. (2012).

Historically, conventional laboratories were mainly used to carry out water quality testing. Now there is a wide variety of good kits and products available in the commercial market that allows testing to be done at the home setting. There are five options for water quality testing: observation, testing using portable (field) kits, mobile laboratory testing, commercial laboratory testing, and setting up a project laboratory, CAWST (2013).

These tests are broadly classified into physical tests, chemical tests and bacteriological tests. Physical tests consist of Colour, turbidity, total solids, dissolved solids, suspended solids, odour and taste are recorded. The chemical tests consist of pH, hardness, presence of a selected group of chemical parameters, biocides, highly toxic chemicals, and Biochemical Oxygen Demand (BOD).

For bacteriological tests, analytical procedures for the detection of harmful organisms are impractical for routine water quality surveillance, CAWST (2013) & FAO (2013). It must be appreciated that all that bacteriological analysis can prove is that, at the time of examination, contamination or bacteria indicative of faecal pollution, could or could not be demonstrated in a given sample of water using specified culture methods. In addition, the results of routine bacteriological examination must always be interpreted in the light of a thorough knowledge of the water supplies, including their source, treatment, and distribution. Whenever changes in conditions lead to deterioration in the quality of the water supplied, or even if they should suggest an increased possibility of contamination, the frequency of bacteriological examination should be increased, so that a series of samples from well-chosen locations may identify the hazard and allow remedial action to be taken.

1.1.4 Storage of Drinking Water

Key factors in the provision of safe household water include the conditions and practices of water collection and storage and the choice of water collection and storage containers or vessels. Numerous studies have documented inadequate storage conditions and vulnerable water storage containers as factors contributing to increased microbial contamination and decreased microbial quality compared to either source waters or water stored in improved vessels. Some studies also have documented increased risks of waterborne infectious diseases from inadequately stored water compared to water stored in an improved vessel (safe storage),

treated in the home to improve microbial quality, or consumed from a quality source without storage.

Higher levels of microbial contamination and decreased microbial quality are associated with storage vessels having wide openings (e.g., buckets and pots), vulnerability to introduction of hands, cups and dippers that can carry fecal contamination, and lack of a narrow opening for dispensing water. Some studies have noted the vulnerability of storage vessels with these undesirable characteristics to fecal and other contamination without having reported microbiological data on water quality or increased levels of diarrheal disease Miller, (1984). Other factors contributing to greater risks of microbial contamination of stored water are higher temperatures, increased storage times, higher levels of airborne particulates (dust storms), inadequate hand washing and the use of stored water to prepare food that also becomes microbiologically contaminated and contributes to increased infectious disease risks Echeverria *et al*. (1987).

The collection, storage and use of contaminated water containing excessive levels of fecal bacteria poses health risks to consumers, regardless of where or how the water has become contaminated. In some cases, water is collected from a contaminated source to begin with. In other cases, water is obtained from a source of high microbiological quality, including treated supplies containing residual chlorine, but it becomes contaminated in the home due to inadequate and unsanitary storage conditions that allow for the introduction and/or proliferation of disease-causing microbes.

In developing countries, many of the traditional types of water collection and storage methods employing vessels of various compositions and sizes are widely used CDC, (2001). These include traditional pots or urns fashioned from natural materials such as clay, copper, brass and other impervious materials. Other metals, including aluminum, steel and iron, as well as plastics, are also widely used for water collection and storage in the form of buckets, jerry cans, picnic coolers and other vessel types and shapes.

An important consideration of household water storage vessels is their compatibility with household water treatment methods. In some cases, water treatment takes place in the collection and storage vessel or the treated water is delivered to the storage vessel. In any case the properties of household water collection, treatment and storage vessels must be compatible with the intended uses (collection, treatment and storage), meet the daily water volume needs

of the household, be practical and manageable for the users (women, men or children) and be socio-culturally acceptable.

1.1.5 Water Treatment for Household Consumption

The purpose of water treatment is to reduce or remove all contaminants that are present in the water and to improve water quality so that it is completely safe to drink. Water is unlikely to be completely free of contaminants at the original source. The types of water treatment processes depend on the characteristics of the raw water (untreated water direct from its source) and required water quality standards. Suspended solids, bacteria, algae, viruses, fungi, minerals such as iron and manganese, and fertilisers are among the substances that are removed during water treatment. Suspended solids are tiny particles of solid material that are carried along or suspended in the water. Effective treatment should ensure the removal of all disease-causing agents and so reduce the possibility of the outbreak of waterborne disease.

Household drinking water treatment and safe storage provides a means to improve the quality of water by treating it in the home. Popular treatment technologies include chemical disinfectants, coagulants, ceramic filters, biological sand filters, solar disinfection (SODIS) or ultraviolet disinfection processes, and combined products with both coagulant and disinfectant. These technologies have been shown to improve the microbiological and, in some cases, the chemical quality of drinking water and to reduce diarrheal disease Sobsey *et al*. (2008) and Clasen T. (2009).

1.1.6 Institutional Management of Drinking Water

The main justification for government involvement in the provision of an improved domestic water supply is the health benefit. However, consumers normally demand improved water supply primarily for convenience, for which they are often willing to pay. Because convenience influences the amount of water used which affects health benefits, these two factors, health and convenience, have to be kept in balance.

Wibke Ott (2014) in his M.Sc. thesis in the Freie Universität Berlin, Department for Geographical Development Studies, worked on Access to Drinking Water and Stakeholder Action - Drinking Water Governance in Cameroon from a Political-Ecological Perspective. The objective was a holistic presentation of the strengths (S), weaknesses (W), opportunities (O) and threats (T) - SWOT in the Drinking Water Governance in Cameroon.

Mehul Jain (2010) evaluated the status of household water treatment and safe storage in 45 countries and a case study in Northern India. He examined the status of household drinking water treatment and safe storage technologies across the world and also analyzed the user's perception and behavior relative to Household Water Treatment and Safe Storage strategies. This literature, if well exploited can be of great use to achieving safe drinking water.

According to the UN, WHO/UNICEF (2004), one of the goals in their millennium declaration is to reduce the amount of people without safe drinking water by half in the year 2015. According to a civil society review of progress towards the Millennium Development Goals in Commonwealth countries in 2015, the proportion of people with access to clean drinking water rose from 50% in 1990 to 74% in 2008, meaning that 8 million people obtained access to an improved water source over this period. However, the report notes that progress in and funding for the water supply and sanitation sector in Cameroon is still sporadic. During a National Committee of Water Supply Leasing Contracts meeting in May 2012, the Minister of Water and Energy described the situation of water supply in Cameroon as 'difficult and financially unbalanced'. New initiatives to increase water supply will still fall short of current demand when they come on line and will not reach rural areas.

1.2. DEFINITION OF TERMS.

1.2.1 URBAN

Urban in Human Geography means belonging to or relating to a town or city (Collins English Dictionary 12th Edition 2014). The mutation in Yaounde has been a process that has experienced tremendous evolution from the colonial period till date. But as a result of the problems associated with the economic crisis, the government is still making some efforts, but has not been able to sufficiently provide basic services such as safe drinking water to all parts of the city. This has left the urban poor in some parts of the city like Obili and Etoug - ebe with no choice but to use their own initiatives to mobilize and coordinate members of their quarter to contribute financially, materially and even human resources so as to ameliorate their livelihoods and make it sustainable.

1.2.2 POVERTY

It is a multifaceted concept, which includes social, economic, and political elements. According to the United Nations, poverty is the inability of having choices and opportunities, and is a violation of human dignity. It is the lack of the capacity to participate effectively in society, not having enough to feed or cloth a family, not having a school or clinic to go to, not having the land on which to grow one's food, not having a job to earn one's living from, or not having access to credit facilities. It means insecurity, powerlessness and exclusion of individuals, households and communities. It is susceptibility to violence, and often implies living in marginal or fragile environments, without access to clean water or sanitation. The World Bank defines Poverty as pronounced deprivation in well-being, and comprises many dimensions. It includes low incomes and the inability to acquire the basic goods and services necessary for survival with dignity. International attention is increasingly focused on issues of poverty. Some 30 million urban dwellers do not have access to safe drinking water (UN-Habitat, 2001). Writers such as Chambers (1995) and Satterthwaite (1995) have criticized conventional approaches to measuring poverty as reductionist, not only for measuring only what is measurable, thereby establishing the measurable as being what is important, but also for ignoring the perceptions of the poor themselves about what constitutes poverty. Poverty is general scarcity or the state of one who lacks a certain amount of material possessions or money.

Absolute poverty or destitution refers to the lack of means necessary to meet basic needs such as food, clothing and shelter. Absolute poverty is meant to be about the same independent of location.

Relative poverty occurs when people in a country do not enjoy a certain minimum level of living standards as compared to the rest of the population and so would vary from country to country, sometimes within the same country (Sabastes, Ricardo 2008).

Extreme poverty is a global challenge; it is observed in all parts of the world, including developed economies. UNICEF estimates that half of the world's children (or 1.1 billion) live in poverty. It has been argued by some academics that the neoliberal policies promoted by global financial institutions such as the IMF and the World Bank are actually worsening both in equality and poverty.

1.2.3 MUNICIPALITY OR COUNCIL

A council or a municipality is a locality in which a group of people are elected to manage affairs for the well-being of the inhabitants. Councils are the oldest administrative institutions in Cameroon. A municipality or a council is a sub administrative division of a territory which is being administered by a mayor. In Cameroon, it corresponds to the territorial division placed under the authority of a Divisional Officer. Some roles and responsibilities of the council are: to ensure the provision of services to communities in a sustainable manner; to promote social and economic development; to promote a safe and healthy environment; and to encourage the involvement of communities and community organisations in the matters of local government. All these are more often than not neglected by the authorities making life very difficult for the population and urban poor in particular.

Councils during the colonial era in Cameroon moved from the appellation native court to native authority through local councils. All these appellations followed the different approaches applied by the different colonial masters who administered Cameroon (Germans, English and the French). The French colonial authority gave birth to urban councils in the year 1914, Kenfack Salomon (2014).

1.3. THEORITICAL FRAMEWORK

New Dictionary of Cultural Literacy 3rd edition defines a theory as a coherent group of tested general propositions, commonly regarded as correct, that can be used as principles of explanation and prediction for a class of phenomena. Theories as defined by Ngwa Nebasina Emmanuel (2010 Updated Edition) are principles that underline a fact or are supposition to explain a fact. In effect, some theories from social and behavioral sciences are brought forward to support this work.

1.3.1 THEORY OF RISK PERCEPTION

Theories of Risk Perception: Who Fears What and Why? By Aaron Wildavsky, Karl Dake . It is a social conduct as explained by Chanuncey (1967). He said, people ignore risk at a hundred percent if they want to meet their needs. This is applicable in the area of study as, the inhabitants are aware the quality of water is not good but they still go ahead drinking without any treatment. The risk involves in drinking unsafe water is ignored despite its effects on health. This idea differs from that of Slovic (1987)

Slovic 1987 stated that, people in general; perceive risk in the society as being unacceptably high. The more people receive benefits in a given activity, the greater they tolerate the range of risk. For instance, if is more beneficial for the inhabitants to drink water from doubtful sources, they will do it to avoid staying without drinking water. Knowhow, experience, importance and value all play in the way society judge and accept risk.

Chanuncey argument and Slovic provides the degree of risk inhabitants are willing to take in drinking water from doubtful sources. These theories help in understanding the population perceptions and how they minimize the risk of drinking water from sources that expose them to infections and diseases.

1.3.2 THE THEORY OF COLLECTIVE ACTION

This theory was first published by Mancur Olson in 1965. He argues that any group of individuals attempting to provide a public good has troubles to do so efficiently. On the one hand individuals have incentives to "free-ride" on the efforts of others in certain groups. On the other hand, the size of a group is of high importance and difficult to optimally determine. Collective action refers to action taken together by a group of people whose goals are to enhance their status and achieve a common objective (Encyclopedia Britannica). It is enacted by a representative of the group. *(*Stephen C. Wright; Donald M. Taylor; Fathali M. Moghaddam (June 1990). It is a term that has formulations and theories in many areas of the social sciences. This theory is applicable to this work as it presents how groups of people can collectively part take in developmental projects to improve on their living conditions (drinking water) in Obili and Etoug-ebe. For instance, behind the petrol station TKC, the chief together with the population dug a well where they improved upon and are using for drinking. Also, above the Handicap Center in Etoug – ebe, the inhabitants contributed and built a spring where they get water for drinking. They also work together to keep the surroundings clean and make sure maintenance is regular.

Some Schools of Thought are also very enhancing in this research. These Schools of Thought are possibilism (the French) and determinism (the Germans) school of thoughts.

1.4. CONCEPTUAL FRAMEWORK

Introduction

A concept is an idea, notion, abstraction, theory, hypothesis, belief, conviction, opinion, image, impression, picture conceived in the mind and which is capable of generating some usable results, Ngwa Nebasina Emmanuel (2010), and inspiration from class work. Several concepts and theories are being retained from related literature revealed and brought forward in this research work.

A conceptual framework includes one or more formal theories (in part or whole) as well as other concepts and empirical findings from the literature. It is used to show relationships among ideas and how they relate to the research study. This include relationship between the variables or the characteristics and the properties that will be brought forward in this chapter.

1.4.1 WATER CONCEPT

Water is defined as a colorless, transparent, odorless liquid that forms, the seas, lakes, rivers, and rain and is the basis of the fluid of living organisms. A water molecule contains one oxygen and two hydrogen atoms that are connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but it often co-exists on earth in three states, which are liquid, solid (ice), and gaseous state (steam or water vapor). (Source: Wikipedia, the free encyclopedia). Water as a concept could be looked upon as most important in shaping the land and regulating the climate. It is one of the most important wealth that greatly influences life. Water quality is the most fundamental controlling factor when it comes to health and the state of diseases in both humans and animals. According to WHO report about 80% of all the human diseases in human beings are caused by water.

Depending on the purpose of water quality analysis, water quality can be defined based on a set of biological, physical and chemical variable, which are closely linked to the water's intended use. As a principle, drinking water is supposed to be free from harmful pathogens and toxic chemicals. Contamination of freshwater (especially groundwater) sources is one of the main challenges currently faced by Yaounde, more especially in communities who depend almost exclusively on groundwater like in Obili and Etoug-Ebe. Groundwater is used for domestic, industrial and agricultural globally. Therefore, the presence of contaminants in natural freshwater continues to be one of the most important issues in many areas of the world, more especially in developing countries like Cameroon. Once the groundwater is contaminated, its quality cannot be restored back easily, the best way is to protect it.

The concept and theory of water quality is very broad since it is influenced by many factors. Water quality is based on the intended uses of water for different purposes, that is, different water uses require different criteria to be satisfied. In water quality analysis, all of the accepted and unaccepted values must be clearly defined for each quality variable. If the quality variables meet the pre-established standards for a given use is considered safe for that use. When water fails to meet these standards, it must be treated if possible before use.

1.4.2 SAFE DRINKING WATER

Safe Drinking Water is water that will not have any negative effect on human health when consumed. Drinking water, also known as potable water or improved drinking water is water that is safe to drink or to use for food preparation, without risk of health problems. The amount of drinking water required is variable and depends on: physical activities, age, health issues and environmental condition.

1.5. IMPORTANCE AND JUSTIFICATION OF THE STUDY

Most Scientists and scholars the world over have made it clear that "Water is life". This therefore implies that safe drinking water is very vital for livelihood. Much talk on international conferences has been ongoing in recent years as concerns water, its quality and its availability to the population (Rio 1992, Dublin 1992, Paris 1998), Law No 98/005 of April 1998 was name a "regime of water in Cameroon" with the liberalization of the water sector. This law authorizes the usage of different water sources. This was due to the fact that the water utility corporation (SNEC) at the time could not satisfy the water demand of the population. This was as a result of increase population and poor planning strategies. This to an extent confirms Malthus theory on population growth where he said population was growing at a geometric progression.

The persistent problem of getting safe drinking water and its effects on the population provoked this study on "Sustainable Safe Drinking Water Options for the Urban Poor of Yaounde VI Municipality: Case of Obili and Etoug – Ebe". This work will serve as a reference to stakeholders in the Ministry of Water and Energy as well as related works in Cameroon.

Apart from the insufficient supply of drinking water, the population has been frustrated by frequent intermittent water supply. Most of the families that do not have formal jobs are able to construct their houses and manage their families mainly with income generated from selling well or spring water. This research thus seeks to address some of the problems plaguing the sector so as to ensure its sustainability.

Getting access to safe drinking water is plagued by a number of problems that this research is out to address. Having safe drinking water is plagued by severe conflicts at water points, climate variability, water rationing, rising water insecurity and intermittent supply, poor water engineering, poor adaptation measures, long queue at water points and urban poverty. These problems have several causes. These problems have been projecting access to safe drinking water as a serious problem that needs urgent solutions. This study thus intends to investigate the nature of these problems and seek informed solutions to them. From the literature review, these problems are deeply rooted in the societies. However, research works has provided solutions in different localities and aspects but Obili and Etoug – Ebe still stand out as an area with little or no research in this field. Time in general goes with improvement in techniques of managing problems and it is likely that problems of this nature should be on a decline. This is rather the contrary in Obili and Etoug – Ebe where problems linked to getting safe drinking water are on a rise. This exposes a gap which this study is out to bridge.

In addition to these, this work will shade more light on options for safe drinking water to the urban poor. Through this the authorities and decision makers concern can integrate them, thus reducing the burden of water borne diseases and its spread on the population and urban poor most especially.

The choice of this topic and study area is also driven by the author's curiosity to get an in depth knowledge about safe drinking water options and consequences on the population. To add, little or no research on this topic in Obili and Etoug – Ebe has greatly attracted the attention of the author.

This work will provide a starting point for individuals, stakeholders, as well international organizations to implement modern methods to help households improve on the quality of water in Obili and Etoug - Ebe. Finally, it will serve as a source of information to future researchers on related fields of study. Research gotten from this study would aid to identify future research opportunities and will also aid policy makers to take sound decisions that will ameliorate the quality of life in Obili and Etoug- Ebe.

B. RESEARCH METHODOLOGY

1. STUDY DESIGN

An all-inclusive qualitative and quantitative descriptive cross-sectional design was used to collect data from inhabitants of Obili and Etoug - Ebe. Administration of questionnaires was

from July 2016 to September 2017. This data was on drinking water sources, the challenges faced, and possible solutions. Both primary (Questionnaires, interviews, observation, and snap shots) and secondary data (snap shots and compilation of statistics from relevant offices over the years) were used to accomplish this task as indicated in the temporal delimitation of the study. As summarized on the chart of research methodology on figure 5.

1.1 PRIMARY DATA COLLECTION

- **Questionnaires:**

Questionnaires were administered based on systematic random sampling approach with interest being on experience gain on the theme of this research. Out of the small quarters, in Obili and Etoug - Ebe, 162 questionnaires were administered. These questionnaires were structured into sub themes. Given the variation in the sizes of the Quarters in terms of the population, this data was on the motives of sources of drinking water, the challenges faced, and possible solutions. The fieldwork and research topic was carried out with the available means and literature. The summary of administered questionnaire is shown on table 1.1 bellow

Table 1.1: Questionnaire administered per Quarter

S/n	Name of village	questionnaire administered	Returned	% Percentage
1	Obili	72	60	83.33
2	Etoug - Ebe	90	72	80
3	TOTAL	162	132	81.48

Source: Ngebung 2016

The fieldwork and research topic was carried out with the available means and literature. Nonetheless, a comprehensive analytical deductive qualitative and quantitative survey process which depended on the local and environmental context was used. Based on that, and the fact that the problem of safe drinking water access is more influenced by CAMWATER and CDE than natural circumstances, the research objectives and hypothesis were tested and verified during the field work. Sample size for this work was 162 but 135 questionnaires were retrieved. Questionnaires were designed and administered using random sampling technique. This is because, this technique gives every individual from the sample an equal opportunity or chance

of being interviewed at a given point or place like; houses, designated areas (quarters). Information in this case is obtained at random. The sample size of the targeted population is seen on the table below.

The population was divided in to two. Obili and Etoug - Ebe. The random sampling method was applied in order to carry out investigation in households of the study area.

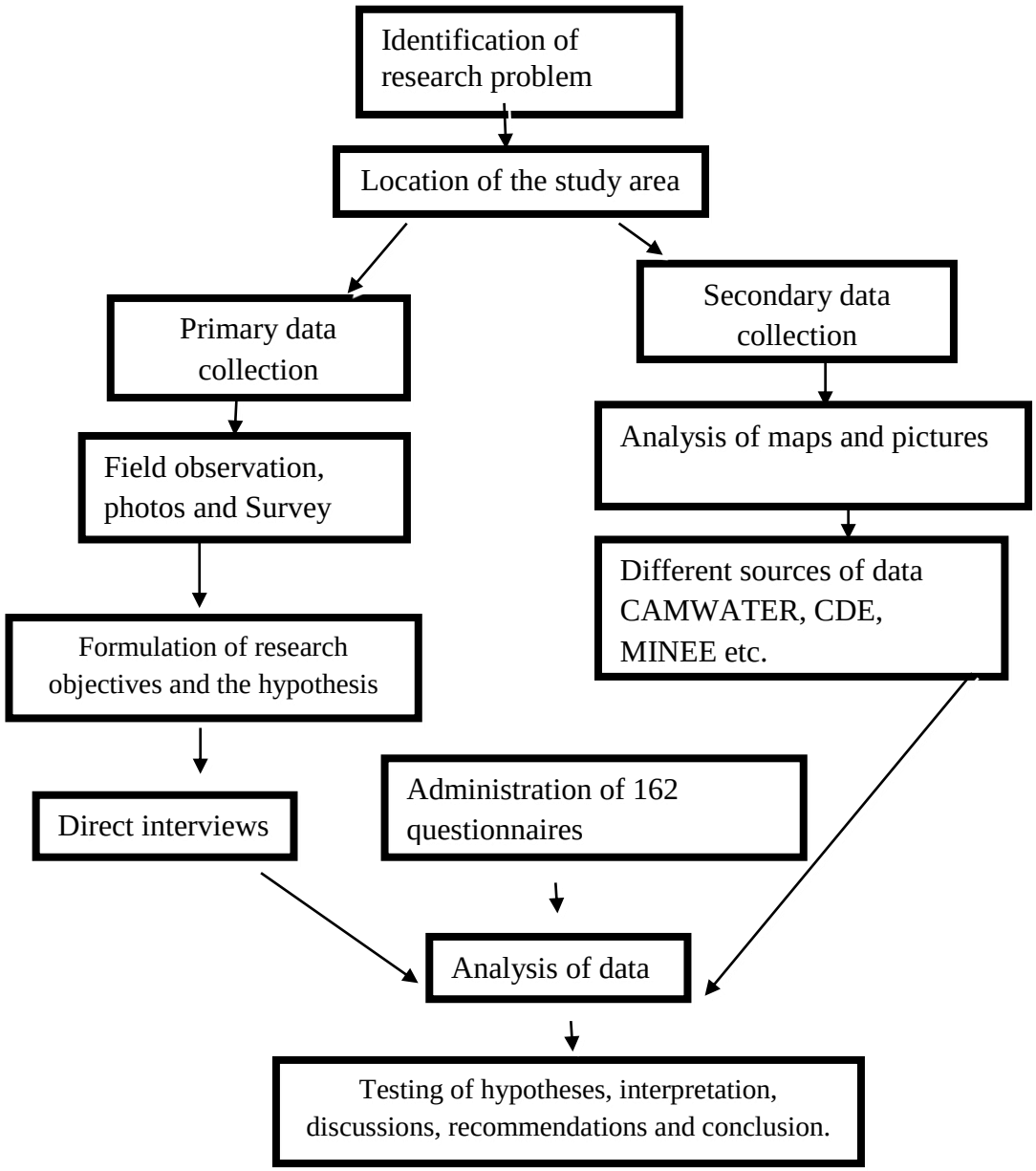
This Work made use of tools, methods and techniques in geography.

- Tools included: questionnaires, interview guide, observation, snap shots
- Methods included analytical deductive process, surveys, observations, field trips and compilation of statistics from relevant offices over the years indicated in the temporal delimitation of the study. See summary of research methodology on figure 5.
- Collection of vital materials was enhanced by the methods and tools put in place.

FLOW CHART ON RESEARCH METHODOLOGY

This flow chart breaks down the methodology used in accomplishing this research work.

Figure 1.1: A flow chart of research methodology



Source: Ngebung Field work, and deduction from class work.

Primary and secondary data collected were also put to use in this piece of work.

Questionnaire pre-testing was carried out with the goal to improve on the structure of questions. Precautions were taken to ensure the language is properly understood and to verify the average duration of time needed to answer each questionnaire. This was done in July 2019.

Adjustments were carried out that made the tools more reliable. Questionnaires were then administered with the help of senior experienced research students who already defended their work. However, due to the vast nature of Etoug – Ebe and Obili, other people were integrated during the administration of questionnaires. The people that helped to administer the questionnaires were mainly those having Bachelor's degrees and this was after a brief explanation of their roles. The point of view of individuals and the population was gotten through questionnaires. The questionnaires of this work were shared in four different sections.

- The first section was based on the identification of respondent regarding sex, age, marital status educational level and the list continuous.
- All the other sections brought forward questions aim to verify the research hypothesis as outline in the work. Open and close- ended questions were used. These questions were very important to understand the problems of having access to safe drinking water in Obili and Etoug-Ebe.

- **Direct observation on the field**

Direct observations in the field enable us to better understand and get acquitted with the research environment. Direct observation gives the researcher a valued option and tools to relate information obtained from questionnaires, to cross check information gathered from interviews and relevant institutions as noted by Burgess 1984, and Denzin 1989 and Patton 1990.

This field study enabled us to meet and discuss with quarter heads, inhabitants of the study area, and the proprietors of some of the water sources. This field work also enabled us to observe, explore and better understand the physical, economic and social aspects or characteristics of the study area. The field trips and visits could be expressed as gaining insight into insiders' point of view to get a broader knowledge. It is simply used to understand how things happen. It however enables us to establish our questionnaires.

1.1.2 INTERVIEWS

- **Interview with experts**

Expert interviews are a section of qualitative research and serve the understanding of complex coherences, World Bank (2003). The focus is on a certain topic and target group but not on specific methods. Practically, expert interviews were conducted as semi-structured

interviews. The bases for these semi-structured interviews were central questions. The chief of technical service as well as hygiene and sanitation were interviewed concerning drinking water and the council contribution towards drinking water. Personnel of CAMWATER and CDE were also interviewed. Some chiefs were as well interviewed for same purpose. The advantage was to focus on several questions and react to certain responses; thereby common questions and specific questions were adapted to the expert knowledge.

- **Household Interviews**

The household interviews were accomplished in the study area. A one-month participant observation period was used to get an insight into the living environment of the city dwellers, and to get in touch with the municipal authorities to develop confidence to get the permission for household interviews. The approached methodology for the fieldwork on local level is the application of semi-standardized questionnaires. This approach of consultation is used to gather empirical facts, knowledge, estimations and needs of the households.

1.2 SECONDARY DATA COLLECTION

Secondary source of data was collected from internet, hospitals, National Institute of Statistics (INS), National Institute of Cartography (NIC), Ministry of Public Health, Ministry of Water and Energy, BUCREP, NGOS, Yaounde VI Council, Reports articles, Newspapers and libraries.

Internet was a very fundamental source of information for this work. Wikipedia, Google scholar, Yahoo, ASK. COM and Acta Vista were put to use

Libraries were also explored. Libraries visited were University of Yaounde 1, Higher Teacher Training College (ENS) Yaounde library. In the libraries, published and unpublished scientific works furnished us with materials which spans from specific to general knowledge (that is deduction or deductive). Related literature from Textbooks, dissertations, articles, journals were made use of. The exploration of all these provided us with bibliography for further research and web sites were being consulted. All of these orientated and ease the research work.

The audiovisual sources were not left out. Radio, Television both national and international programs were closely listened to. This was to get information concerning safe drinking water and the recent developments. Some of the data of this work was gotten from these sources that other sources could not furnish.

Newspapers were also exploited (Cameroon Tribune, the Post, le messenger, the Herald). These multimedia sources also enhance the work as they reveal data that could not be brought forward using other means.

1.2.1 Quantitative and Qualitative analysis of data

The analytical framework was done with the aid of some concepts and theories. H.B. Nguendo Yongsi (2010) which says that access to drinking water depends on the political, socio-cultural, economic and ecological that determines the scope of action of the various stakeholders). Technical and man-made inducted problem of access to drinking water are a serious problem which needs to be handled at all levels. The data gotten from the field provided us with quantitative and qualitative data. Questionnaires, interview guide, observation, snap shots were used as tools to analyze the data. Software such as Microsoft Excel, words, MapInfo Professional 7.5 and Arc GIS for drawing maps were also used for the treatment and analysis of data. Digital cameras and telephones were used to collect photos which enhance the work. Sorting of data of this work was done manually.

1.3 PROBLEMS AND LIMITATIONS OF WORK

The collection of information and various data needed for this work was not without setbacks. These problems and setbacks varied in their numbers and nature.

In the Ministry of Water and Energy Resources, they were not willing to furnish us with information needed to accomplish this work. This was due to protocol, bureaucracy and poor ways and means of preserving data and information in Cameroon. These challenges hampered and delayed the study. However, other alternatives were put in place (interviews, newspapers were read, television and radio news follow up).

A request for an internship in CDE to enhance study was rejected and thus frustrating but other alternatives relief the situation.

Some of the inhabitants of the study area were very hostile during the administration of questionnaires. Others were unwelcoming and even refuse to answer the questionnaires or any other question posed.

Some of the homes had very big and wild dogs posing as a risk zone. Others had sticks or zinc fences; others had dilapidating bridges to cross over thus rendering access quiet difficult

and even impossible elsewhere. The roads in the area are very dusty in the dry season and very muddy in the rainy season hindering access.

Some households did not answer all of our questions due to the absence of family heads. This made the work very cumbersome and challenging.

Some of the inhabitants wanted us to pay them before they could answer our questions. Others said we were being paid to spy on them. This rendered our work very hectic as vital information necessary to accomplish the work was quite difficult to come by.

Tears were shaded just to obtaining an authorization of research from the council to carry out this research on the study area. (Over two month two weeks) was wasted waiting almost every day for this to be done). This made the work tedious and very challenging.

Some inhabitants asked us to leave our questionnaires for them to answer when chance but failed to do so. Others were never present to return questionnaires.

Some of the inhabitants went a long way insulting us as thieves who came to monitor their homes.

Our samples for analysis in the laboratory also took quite some time to accomplish with certitude.

Most of the health units visited feared giving us information on diseases caused by drinking water from doubtful sources and others refused. This is a big challenge for the study.

All these problems and challenges undoubtedly retarded the time frame for this work. However, these obstacles were combated by looking for alternative sources of information and creating contacts with people working in related fields around.

Conclusion: This chapter brought to light the concepts characteristics and theories that aided in the accomplishment of this work. This therefore paves the way for chapter two which will throw more light on water sources in the study area and the affordable options

CHAPTER TWO
PROBLEMS ENCOUNTERED BY THE URBAN POOR ACCESSING DRINKING WATER AND THEIR EFFECTS ON HEALTH

2. Introduction

In this chapter, problems encountered by the urban poor having access to safe drinking water and its effects on the inhabitants are examined. These problems as well as the effects are varied and numerous. Coupled with piping engineering which requires huge capital investment has handicapped the supply of sufficient portable water to meet the demand. The structures charged with the provision of funds are reluctant to disburse the required capital to handle the problems faced by the water supply companies. There are also problems of operating costs. The cost of replacing the deteriorating water infrastructure is very high. Leakage of untreated as well as treated water from pipes reduces access to water.

Due to these investment problems, CAMWATER and CDE could not afford to sustain appropriate water quality to meet demand. With all these difficulties; Law No 98/005 of April 1998 referred to as "The regime of water" in Cameroon came to remedy the situation. This law simply liberalized the water sector. It authorized the use of diverse water sources due to the fact that SNEC by then was not able to supply sufficient water to the population. All these created problems and untold consequences on the population and most especially the "bidonvilles" as they turn to doubtful water sources for their daily needs without minding the effects on health.

2.1 The Problems Encountered with drinking water from doubtful sources

The problems are many and varied. Some of these problems are enunciated below. These problems range from human behavioral problems, management structures to environmental concerns.

2.1.2 Population behavioral problems

It has been observed in the study zone, that water resources themselves are contaminated if they come in contact with human or animal feces. This is as a result of lack of adequate knowledge to handle water for drinking. For example, Surface water often contains fecal bacterial due to human activities at the surroundings of water points. Even if water is purified in the treatment plant, it can become contaminated during delivery to the consumers. For instance, if there is no continuous pressure in the distribution system, contaminated water may

still enter pipes through cracks and joints, points of collection, or during transportation and storage.

- **Point of collection:**

The point of collection itself can be contaminated as dirt is littered around the water points as observed on the field. A communal tap, a well, a borehole spot, which is handled and contacted by, children, and even animals as seen on the field facilitates contamination. These collection points are located outside of the homes where containers are used to fetch water. The containers themselves are often dirty enhancing contamination even if the water was initially of good quality for drinking.

- **Fetching process:**

This comprises of placing containers on the ground or on a stone and toping it with the use of a plastic pipe at the mouth of the source of water with the aid of the hand of the one fetching the water. The plastic pipe is made use of by everyone and is never replaced except when destroyed or broken. This is an enabling environment which leads to the introduction of germs and bacterial in the water, especially as the water fetching is done by children who have very little or no knowledge on how to handle water. As observed, those who fetch water, hurry to do so while forgetting to rinse containers, others rinse it at water sources. While trying to make sure the containers for fetching water is clean, the water is ignorantly contaminated by unwashed hands. Splashes of dirty water sometimes enter the container when fetching as the children are often distracted (by their playmates around the water source) making the water unfit for consumption. Photo 2.1 shows how children fetching water contaminate it in the process. These children are usually so distracted that even if their friends introduce dirt into the water, they might not notice. This clearly explains why it is not advisable for very young children to go fetching drinking water for the household. If young children must go fetching drinking water, they need to be educated or even accompanied by their elders. Therefore, households that send very young children to fetch drinking water are exposed to water related diseases like typhoid, gastrointestinal infections and many others. Therefore when fetching drinking water, some basic hygienic procedures must be taken into consideration to maintain the quality of the water and prevent contamination.

Photo 2.1: Children playing while fetching water

Source: Ngebung 2016

- **Transportation:**

After fetching is done, the water is then transported back to homes. This process of transportation gives an opportunity for further contamination. Open containers are especially vulnerable because it is easy for hands to get in contact with the water during lifting to put on the head or on the ground. Dust, insects or even microorganisms can enter uncovered containers in the course of transporting the water. Most often, water transported to the house is transferred to other containers using cups or by pouring. This creates room for further contamination. The mode of transportation here is by foot and those who use their hands to transport the water easily introduce debris in the water through their slippers or shoes unknowingly. Children, who fetch water, use this opportunity to play with their friends on their way back home. In the course of this, they put the water at road sides where some of their playmates even use their mouths or hands to drink from the containers. When water is directly in contact with the air it is easily contaminated with particles, bacteria and germs that are present in dust particles raised by wind or passing vehicles. All of these render the water unsafe for drinking. Consuming such water leaves the consumer susceptible to water borne diseases.

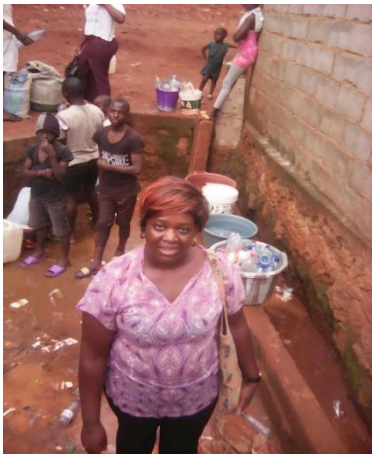
- **Storage conditions:**

At home, the manner in which the water is stored can pose a problem. Many households in the study area have the habit of storing drinking water in uncovered containers such as buckets, clay pots and gallons. This is a rough practice that is conducive to the propagation of bacteria such as E. *coli*, *Pseudomonas aeruginosa*, Salmonella *sp*. That is associated with

diarrheal diseases (Nguendo Yongsi, 2010). Drinking water containers are very often left open with no lid and at times the containers are even dirty. Plates 2.19
(a) shows water fetched in open container before being transferred into mineral water bottles using a cup or a pan. Plate 2.1 (b) indicates water fetch in bottles directly.

Plate 2.1: Indicates water fetch in bottles directly

(a) Fetched water in buckets being poured in plastic bottles



(b) Fetching water in plastic bottles.

Source: Ngebung 2016

These storage processes act as fertile ground for contaminates. The drinking vessel itself, a cup or a glass can be contaminated if not washed with clean water and soap. Again as noted on the field, some individuals ignorantly wipe their drinking vessels with dirty cloth or napkins before using them. This act can actually introduce new contaminants in the water. Drinking such water enhances diseases like typhoid, gastrointestinal diseases as well as liver problems. Having access to drinking water in this study zone is not always an easy task with inhabitants mostly children and women spotted here and there hunting the precious good.

- **Water treatment procedures:**

Water treatment at household level and safe storage is supposed to offer possibilities to remove any contamination introduced at collection point or during transportation. Unfortunately, of the household visited, most had little or no knowledge on household water treatment methods. The few who knew did not routinely apply their knowhow. It is important to minimize the possibilities of clean water being re-contaminated through improper storage or by using cups and glasses that are contaminated. Treating water at household level is without doubt a means to minimize the risk of drinking water from doubtful sources.

2.1.3 Environmental problems

Human interaction with the natural environment constantly affects the quality of life and water. The World Health Organization (WHO) defines environment, as it relates to health, as “all the physical, chemical, and biological factors external to a person, and all the related behaviors.” Environmental health consists of preventing or controlling disease, injury, and disability related to the interactions between people and their environment. Water contamination by infectious agents or chemicals can cause mild to severe illness. This is due to the consumption of water from doubtful sources.

In the area of study, there is very limited access to safe drinking water and sanitation facilities. This is as a result of rapid emergence of spontaneous, unplanned settlements accommodating a huge proportion of the population. There is considerable urban degeneration due to poor housing and the disorderly nature of construction and planning. Water pollution (particularly drinking water) is a serious problem. Protecting water sources and minimizing exposure to contaminated water sources are important parts of environmental health which are visibly neglected by urban actors on the one hand and population on the other hand. Changes in temperature and rainfall conditions also influence transmission patterns for various diseases, including water-related diseases such as diarrhea and vector-borne infections such as malaria. This is quiet glaring as waste water is disposed of in streams and toilets are also drained in these streams and rivers. Water sources are in close proximity to garbage disposal points and toilets. This area of study is poorly saved by roads rendering accessibility very difficult.

The UN recognizes the importance of taking care of the people without sustainable access to clean water and sanitation. Much water has become polluted and unsuitable or otherwise unavailable for drinking. Water needs to be managed and used more efficiently to avoid a global water crisis. Based on the foregoing, it can be said that in Cameroon following the government’s plans towards the year 2025 (Horizon 2025), there will be adequate water resources throughout the country. Therefore a lot of work is still to be done in the water sector to meet the demand of the population, as 2025 is just 5 years from today.

2.1.4 Poor integrated management policies

Efforts directed towards improving the management of water resources in the world and extending access to safe drinking water and adequate sanitation do not take in to consideration the role of women in water management. In Cameroon and many countries the world over, women are less represented in integrated water management policies. In spite of the fact that their main duty is running of the household hygiene and well-being of the family, women

depend mostly on water resources. Some of them have acquired substantial knowledge - the site, quantity and quality as well as storage methods. The main aim of UNICEF in the water and sanitation sector is to promote the survival, protection and growth of children, and to promote behavioral changes essential to realizing the full benefits of water and sanitation services. These and other goals cannot be realized without the full involvement of women.

Women and girls are traditionally responsible for domestic water supply and sanitation, in the homes and the environment. They are gifted with management skills at household levels. Women also have an advanced role in the improvement of water and sanitation services and in sustaining them. UNICEF and the UNDP are working to make sure that women are directly engaged in the planning and management of water supply and sanitation programs. Promoting culturally appropriate means to involve women in water management, rather than merely increasing the percentage of women on water committee as is the case of Cameroon will significantly be a blessing than a curse in the area of study.

2.1.5 Malpractices at water points

Public nuisance is not taken serious in Cameroon as in other countries of the world where public nuisance is a crime. It was observed that malpractices at water fetching points were just normal practices. Many forms of pollution were noticed - animal wastes, heavy fertilizer application around water sources, household waste, waste water, open defecation around water sources and urinating were common. All these contaminate shallow water sources and render them unsafe for consumption though the inhabitants still consume the water. Recharge of water sources is usually from rainfall, falling directly above and percolating downward to the water table. As the water moves downward it may carry contaminants. Thus, extreme care and periodic water testing are necessary for drinking water which is not the case as observed. Considering the fact that testing water to determine its safety for drinking is too expensive and done by specialized institutes like “Centre Pasteur”, it is a nightmare venturing into the analysis process. This is because it is quite expensive for the population as they explained. Elsewhere, the inhabitants are very certain the tasteless, colorless and odorless nature of their water sources made it potable for drinking. Others decry conflict at water points on who to fetch first. This at times damages pipes, which take time to be repaired. This is a problem for the users who need to contribute money they do not even have and for the repair of the pipes. Some children who come to fetch water use the surroundings as their playground. Debris

ranging from plastic bottles, sticks, papers, leaves of trees is spotted floating below and in the water point where containers are placed to fetch water as seen on Plates 2.2.

Plate 2.2: Malpractices at water points



(a)Bending into a well fetching water (b) bucket fetch water on the ground (c) dirt's littered around a spring.
Source: Ngebung 2016

2.1.6 Conflict at water points

Water point as observed have becomes conflict zones in many ways. Water scarcity is defined as less than 1000 m^3 of water available per person per year, while water stress means less than 1500 m^3 of water is available per person per year. The conflict is over that most precious of commodities - water, as countries fight for access to scarce resources. In many parts of Obili and Etoug-Ebe, water scarcity is part of everyday life. Many families share one water source. A greater proportion of these families very much depend on these water sources, since water resources are scarce. Children are observed fighting and some sustained injuries in order to fetch water. The reason advanced for such fights was that the elderly children, though they came after the younger ones wanted to fetch water before them who came earlier. Such fights often lead to damage of water containers and even water pipes. In the course of such fights, contaminants are introduced into the water rendering it unsafe for drinking. Another conflict is between proprietors and users of water sources. This is because some of the water sources like springs and wells are situated in plots or homes of individuals who often impose conditions of usage. For instance proprietors fix particular hours for fetching water and are very strict on them. There is also exigency on particular age groups expected to fetch water. All these demands are often difficult and at times impossible for users to deal with as their programs conflict with that of water source owners. This paves the way for alternative water sources

which are often questionable. Another conflict arises due to financial contributions to clean the water source. Some individuals refuse to contribute, some contribute less than expected amounts and others turn to different water sources to avoid contributing. All these setbacks leave the proprietor of a water source with the burden of always incurring extra expenses for repairs and water treatment.

Conflict of ownership as was observed mainly with springs was not left out. These springs are mostly found on land owned by individuals who at times carry out their construction projects without notifying the population. This often leads to quarrels and even enmity. Elsewhere, little or no development is envisaged by the community on such water sources as it is situated on peoples land. Potential 'water wars' are likely in areas like these. The UN has proposed monitoring worldwide reserves of drinking water and establishing agreements for the use of water. If this is properly implemented then the problems of conflict at water points will no longer be a cause for concern. However the UN recognizes that water disputes result from opposing interest of water users. Water conflicts simply occur because demand exceeds supply. Some analysts estimate that due to an increase in the consumption of water by humans, conflicts will become increasingly common in the near future (worldwide battle for water (video). August 19, 2008).

2.1.7 Overcrowded water points

From observations on the field, it is realized that water points were overcrowded, leading to long queues. This was recurrent and on Saturdays the crowd was too much as on Plate 2.3. On Saturdays, children wake up very early to fetch water and any delay mean waiting for hours. A resident testified that they have opted to fetch water from this spring because their tap water from CDE is no longer reliable. They pointed out that water from the springs, however, is no longer as it was once since there are many people encroaching on it, contaminating it in the process. The inhabitants fetch water by moving some distance away from their different homes on foot. Reaching their water point, they wait to fetch following the order and time of arrival. This entails a lot of waiting and patience. This is one of the reasons for which immediately after reaching home from school, children hurry to fetch water in order to avoid the long queues. Some households visited expressed the pain they go through to reach their water point especially at springs and boreholes just to be told the owners are not at home. This handicaps their daily chores and activities.

Photo 2.2: Overcrowded water points

Source: Ngebung 2016

During the long dry seasons, the quantity of water reduces due to the decline of the water table. This affects users as some of their springs and wells reduce in volume or even dry up. Some households lamented on how they are conditioned to fetch lower quantities of water by the owners of their water source (wells and boreholes) consequently, leaving them with no option than to go for other sources to meet their daily needs.

2.1.8 Distance covered to fetch water

Water collection points as observed on the field, are far away from homes. Several families acknowledged trekking long distances, at times more than 900 meters to fetch drinking water down the valley; climb up steep hills or over rocks. This is dangerous as there may be snakes or even criminals who wait to rob them. A glaring example was around the Adamou spring ASEC in Etoug- Ebe. Habitually women and children go through the huddles of fetching water for the households. Transportation of water from the source to the home is either by lifting the water container with the hand or placing it on the head while trekking. This process of fetching water is not just difficult, it's a lifelong pain in the neck or back that sometimes cause serious health problems. Wheelbarrows are kept a distance away from the water point due to the rough nature of the terrain descending and climbing the slopes. This process of transportation may also led to contamination of the water as no special precaution is being taken during collection and transportation which involves washing and rinsing container before filling it, and using a pan, bowl, cup or another container to scoop water from the source. All these explain the risk of contamination. Also when transporting by hand, shoes especially slippers

can pick up dirt and drop in water. This is a difficult task as the landscape is undulating, muddy and slippery during the rainy season as well as dusty in the dry season as on Plates 2.3.

Plate 2.3: Distance and rough roads to fetch water and back

Source: Ngebung 2017

2.1.9 Limited education and sensitization on safe drinking water

Educating the inhabitants about the right practices for both treatment and storage is probably the hardest challenge. Without toilets, water sources become contaminated as a result of open defecation and poor waste disposal. This is because behavioral change takes some time to get rid of in a community. With proper hygiene the high level of contamination could be reduced considerably, however it has not been achieved. It will be equally difficult to ensure proper handling and use of any HWTS. The root cause of these problems is the lack of appreciation on the part of households towards the dangers of contaminated water and ways to prevent contamination.

Households had very limited knowledge on the risk involved with drinking water from doubtful sources. An estimated 1.1 billion people worldwide do not have access to an improved water supply, and many more drink unsafe, contaminated water from improved sources. Each year, inadequate access to safe drinking water and improper sanitation causes over a billion cases of diarrhea and 1.9 million deaths in developing countries, mostly among young children (CDC). In addition, waterborne diseases such as; diarrheal reduced resistance to infection, and impaired physical growth and cognitive development in children, hepatitis A, poliomyelitis, helminthes (parasitic worms) and rotavirus are caused by poor hygiene and sanitation. Contaminated water, insufficient household water, latrines and education about hand washing with clean water and soap are very big problems. A greater proportion of households have very

little or no knowledge in improving the quality of their water through household water treatment and safe storage. Elsewhere, the inhabitants were curious to understand and to assimilate the new term HWTS. This is an indication that much work on educating and sensitizing the population on HWTS methods is inevitable. This can be handled with targeted trainings for schools or health clinics, markets, churches, communities, small pilot groups, etc. All these combined with education on behavioral change through communication interventions will be a great relief in ameliorating this recurrent difficulty in the area of study.

2.1.10 Poor enforcement of water laws and regulations

Cameroon runs two legal systems; the Common Law in the English speaking part of Cameroon and the Civil Law in the French section of the country. This bi-jural nature of Cameroon is the effect of two major world cultures inherited from Britain and France. The effective application of the right to water in the Cameroonian law is hindered in the sense that the recognition of the right is not precise. The Water Code to an extent fails to spell out clearly that, access to water is a human right. Also, the code indicates that the State shall only ease access to water, but this does not in any way and can hardly impose on the State to provide water to all. In fact, there is uncertainty in the Code. This renders it difficult for the provision of sustainable access to water for domestic and personal needs.

The real problem with the laws in Cameroon is to apply the laws to realities on the ground. The Ministry of Water and Energy is in charge of supervising the application of the right to water, bringing together representatives from every ministerial department whose activities directly or indirectly relate to water resources in the country. The right to water has been defined as the right of everyone regardless of financial status, to have a minimum quantity of water of good quality which is enough for his life and health. H. Smets, Le Droit à L'eau. www.academie-eau.org(2002). The right to water is also of principal importance in the ongoing battle against poverty. It relates more to the social categories of poor or vulnerable people in urban setting in the area of study as well. Certainly, the poor are those essentially deprived of the right to portable water mainly as a result of their financial and physical inaccessibility. If the Cameroonians Laws are not implemented on the ground, even the Vision 2035 is far from being reached following the sluggish pace of implementation of laws in Cameroon.

2.1.11 intermittent water supply

CAMWATER is the single distribution firm of reliable drinking water in Cameroon although there are other clandestine suppliers. The percentage of the population having access

to drinking water recorded in this area of study is very low. The inconvenience to get a CAMWATER connection translates the sufferings of the population in having access to safe drinking water. This explains the absence of tap water in the quarters (personal subscription, payable public fountains). However, the increased demand for well water, springs, and other sources clearly indicates the rate of subscription to CAMWATER network remains low compared to Abidjan (Coulibaly et al., 2004) in Ivory Coast and other developing countries. This situation is linked to the state of poverty faced by the inhabitants. This is also due to the fact that, the extensions of the water network is not at the same rate with urbanization (Katte et al., 2003). The differences noted between quarters, with respect to the sites of water supply and the level of access to water could be explained by differences in finances and education. In fact from findings, popular quarters are the poorest of the city and access to drinking water increases with income, standard of living and increase in infrastructures.

The intermittent water supply is a major problem affecting the right of the population having access to safe drinking water. Water is recurrently interrupted in some sections and last for several days, weeks or even months. The inhabitants were so inquisitive to know why? Unfortunately no precise answers could satisfy them as no one is usually informed either in advance or during the interruptions or to why such interruptions are necessary. As a result of this constant deprivation of the basic human needs, the inhabitants resort to other water sources for their survival. Although some interruptions may also be as a result of non-payment or delays in the settlement of water bills, many of such argument may be lame. This is backed by the fact that, the problem may be caused by CAMWAER delaying in billing or not bringing the bills on time or even failing to give the bills some months. It however impinges on a basic and fundamental right – the right not only to water but to a continuous supply of it or sustainable utilization. The interruption for non-payment or delays in settlement of the bills may also be due to exorbitant bills or charges per cubic meter of water. This makes water to be seen more as an economic good than a basic need for human survival. This state of affairs renders it difficult to use water sustainably. As a consequence, the urban poor of these quarters resort to other sources of water. These water sources most of the times are certainly not safe for drinking though readily available.

2.1.12 High cost and risk involved in drilling a well or borehole

A well dug well with the assurance of frequent water supply, has as a prerequisite to be deep enough and fortified to ensure access to potable water. Studies have to be done to

understand the hygienic situation, will the yield be sufficient to meet the daily needs of individuals or a population, is there sufficient time to develop the source, is there both talents and expertise existing, how much is the total cost, what are the legitimate, community and administrative rights regarding the source. The time, resources and equipment needed have to be determined. There is need to equate the benefits of using the prevailing sources against the improvement of new sources. Then a choice needs to be made on the best alternative.

Assuming the fact that, the residents are not very viable, digging a well as observed on the field is not an easy task. A diameter for excavating and coating a well is at least 1.5m in unstable soil; and the well is lined as excavation proceeds. In certain circumstances, this is temporal to support the soil at the surface. Wells should be between 12 meters to 30 meters deep. During field studies, it was evident that majority of the inhabitants of these quarters could only dig wells of less than 12 meters deep, which falls below the standards. This might also be because most of the poor construct their houses in marshes where attaining water does not warrant too much digging. Excavating these pits for water is very strenuous and time consuming. Mishaps and even deaths are very common necessitating continual switch of well diggers and surface workers.

However better construction techniques proposed require higher cost. This is a stumbling block for the inhabitants as they complained of cost. Because of this, suitable old-fashioned tools are made use of during excavation. Additional costs are incurred in cases where the well is covered and furnished with a hand pump, as the repairs of the pumps turn out to be a problem.

2.1.13 Color, taste and odor of water

From observation on the field, water users do not test their water with sophisticated equipment to check whether it is safe to drink. Instead, the average consumer judges the quality of their water according to color, taste and odor. If the color, taste or odor of the water changes, consumers immediately assume, that the water has become contaminated.

Unpleasant color, taste and odor are produced in water by chemicals, decaying organic matter, algae, and other bacterial. For instance chemicals like sulfide can cause a rotten egg smell. This alone immediately affects the psychology of the consumer. While a bulk of these colors, taste and smell are not toxic, they emotionally disappoint consumers. The presence of color, taste and odor in water contradicts the fact that, pure water is colorless, tasteless and odorless. However, true color in water is the color of water once all suspended particles

(turbidity) have been removed, and is commonly a shadow of brown, blue, green, greenish yellow or yellow. True color is generally found in surface water although ground water may contain some color if the aquifer flows through buried vegetation. Depending on the sources of the offending taste and odor, a combination of chemical treatment, aeration, oxidation and absorption may be used to lower the odor intensity. This is only attainable through intensive sensitization on HWTS as well as education at all levels.

2.1.14 Impurities in water

These impurities present in water are not necessarily harmful. Most people in fact will find water without certain impurities very distasteful as noted on the field. Some of the impurities are also beneficial to humans, plants, and animals as they provide elements needed for growth. Water containing non harmful impurities is potable water. There are other forms of impurities that enter water that are harmful to human health. Certain microorganisms for example, chemicals, minerals and solid matter can cause disease and other adverse effects on plants and animals. Such water is certainly unhealthy for human, plants and animal consumption. Of course, certain components may be harmful to humans, but not to plants and vice versa. Therefore, water quality is a term that is relative to the intended use of the water. Toxic substances that enter bodies of water pollute them.

The quality of polluted water is inferior and the effects can be seen directly or indirectly as observed on the field. A vast majority of water impurities is as a result of pollution (organic pollution, inorganic pollution, thermal pollution and ecological pollution).However, technical know-how nowadays has generated numerous ways for cleaning and restoring water. A good example is the treatment of polluted water to render it usable for drinking and for agriculture and even the desalination of water to enable saltwater to be used for everyday activities. The best way to ensure a sufficient water supply for life on earth is to stop polluting water. Science cannot undo all of the harm caused by human pollution. Although much can be undone, it requires costly procedures and technology to undo it. Therefore the best approach is creating awareness through massive education and sensitization on preventive measures. This may perhaps be done through recycling of materials and household waste. If this is done at the grassroots level, then the enormous pollution observed in water sources on the field will be significantly regulated as the incidence of water borne diseases will also be reduced.

2.2 EFFECTS OF UNSAFE DRINKING WATER ON HEALTH OF INHABITANTS

Often, people who live in areas without sufficient, safe and clean water, learn to live with diarrhea and other drinking water contamination effects. They take it for granted that they

are just going to be sick periodically and it is just a fact of life. Stomach aches become the norm. Fatigue and pain become common place. But where people live in a continually half-sick condition, their education and livelihoods can never be one hundred percent fruitful and prosperous. So, the condition of the people becomes the condition of the society as noted on the field.

Health units visited on the field provided the information and data on frequent diseases caused by drinking unsafe water. Table 3.10 below summarizes some drinking water contamination effects, and the burden placed on individuals and communities that do not have ready access to clean water, adequate sanitation, and good hygiene. The table shows the abbreviated names of the health centers visited appendix 1 against the diseases and number of cases encountered each month of the year in 2017.

Table 4.1: Probability table for estimating the MPN of fecal coliform bacteria

Statistics of water related diseases in health units visited

	Year 2017																	
	HHC	CSMD	CSND	CSEV	CSCU	Total	HHC	CSMD	CSND	CSEV	CSCU	Total	HHC	CSMD	CSND	CSEV	CSCU	Total
Diseases	Typhoid						Gastro-intestinal						Malaria					
January	21	0	5	0	2	**28**	4	0	14	1	3	**22**	12	0	12	0	1	**25**
February	15	0	9	2	1	**27**	3	0	2	0	0	**5**	10	0	14	8	6	**38**
March	7	0	2	1	0	**10**	0	0	7	1	1	**9**	9	0	17	4	2	**32**
April	24	0	4	3	3	**34**	1	0	7	2	2	**12**	28	0	13	8	4	**53**
May	9	6	4	2	1	**22**	7	1	6	2	2	**18**	19	13	8	7	3	**52**
June	11	1	2	4	0	**18**	0	2	5	0	0	**7**	15	2	9	10	5	**41**
July	3	1	4	11	2	**21**	4	1	10	0	0	**15**	20	4	9	20	5	**58**
August	19	2	1	11	1	**34**	3	3	8	1	1	**16**	21	5	4	17	2	**49**
September	11	3	5	8	0	**27**	4	1	9	3	3	**20**	9	0	10	11	7	**37**
October	3	1	2	5	1	**12**	2	1	14	4	4	**25**	13	1	9	12	9	**44**
November	7	3	1	5	1	**17**	2	3	1	0	0	**6**	10	4	3	9	2	**28**
December	2	1	1	4	1	**9**	3	2	6	0	0	**11**	16	9	5	8	1	**40**
Total						**259**						**166**						**497**

Source: Ngebung 2017

From the data on the table above, it is evident that many inhabitants suffer from water related diseases like typhoid with over 259 cases, 166 gastrointestinal cases, and 497 cases of malaria in the year 2017. This is in conformity with the information from households, suggesting that at least a member of the family had suffered or is still suffering from typhoid or malaria. This affirms the fact that, the water consumed by the inhabitants is highly contaminated and only acceptable for drinking if it is properly treated at household level before consumption.

This statistics was obtained from five health units despite the fact that there are many health units visited in the quarters. Although most of them rejected the request for information on water borne diseases, a handful furnished theirs though with lots of hesitations.

This study further indicates a permanent presence of water- borne diseases such as, diarrhea, dysentery, typhoid fever, skin diseases and malaria within the populations as also mentioned by Wéthé *et al*. (2003) in Yaounde and Dschang (Katte *et al*., 2003). A greater portion of the population suffers from water related diseases. This situation indicates that the water the populations considers fit for drinking is not biologically acceptable for drinking as it is highly contaminated with fecal coliforms and pollutants of all forms. A large proportion of the inhabitants get their drinking water from shallow wells, springs and rain. Infact, it is in ground or surface water that waste from households is often disposed of and drained. (Djuikom *et al*.2006). It very obvious that poor waste management can affect the quality of subsoil waters (David *et al.*, 2005). Pools of stagnant water and even waste water are very common, flowing just anyhow in the quarters. This together with the marshes and disposal of waste in waterways acts as breeding grounds for mosquitoes which bite especially at night and spread diseases like malaria and filarial. These lead to the deterioration of public health in this area of study as indicated in Table 2.1.

2.2.1 Diseases emanating from unsafe drinking water

Diseases caused by unsafe drinking water and sanitation are water borne, water washed, water based or water related

- **Water borne diseases:**

They are illnesses caused by intake of water that has some pathogens in it. This includes diarrheal diseases, rotavirus, cholera, shigella, cryptosporidiosis, hepatitis A and E, poliomyelitis etc. To improve on the situation and prevent these diseases, the quality of water has to be improved through HWTS.

- **Water washed diseases:**

These are those caused by poor hygiene due to lack of water rather than direct ingestion. Most water borne diseases are also water washed because, they can be transmitted through hands or contact with other surfaces. Trachoma is the leading cause of preventable blindness globally and is transmitted through flies which land on peoples' faces. There are also acute respiratory infections which are caused by pathogens through hand contact and other surfaces. Scabies and fungal infection are also water washed diseases. Regular hand wash is very vital for personal hygiene and in handling drinking water no matter the scarcity of water. Regular hand wash with clean water and soap is a prerequisite to prevent diseases.

- **Water based diseases:**

Water based diseases are caused by organisms which live part of their lifecycle in water. Some examples include schistosomiasis (bilharzias) and Dracunculiasis (Guinea worm). Control measures include protecting surface water bodies from contamination and HWTS.

- **Water related diseases:**

They are caused by insects which live in water, for example mosquitoes which cause malaria. Malaria affects and causes thousands of deaths each year in Sub-Saharan Africa and affects children under the age of 5 years, more seriously. The mosquitos are propagated in mostly in stagnant water and the control mechanism is to eliminate their habitat. As observed on the field stagnant water is almost everywhere as well as waste water. This water does not only acts as breathing ground for mosquitoes; it also seeps in to water sources, polluting them. In fact, there are many diseases that are caused by or related to poor water, sanitation and hygiene. However, there are thousands of pathogens that can cause water borne diseases. These pathogens and the diseases they cause are presented in Table 2.2 below. The classes of pathogens are explained with the correlating disease.

Table 2.2: Waterborne pathogens and related diseases

Classes of pathogens	Pathogens	Diseases
Bacteria	*Campylobacter spp*	Diarrhea and acute gastroenteritis
	Salmonella spp	Typhoid fever, diarrhea
	Shigella spp	Dysentery, diarrhea
	Yersinia spp	Gastro-intestinal infections
Viruses	Adenoviruses	Diarrhea, respiratory disease
	Coxsackie viruses	Respiratory, meningitis, diabetes, vomiting, skin rashes
	Hepatitis viruses	hepatitis
Protozoa	*Entamoeba hystolytica*	Amoebic dysentery
Helminthes (parasitic worm)	*Dracunalis medinensis*	Guinea worm
Emerging	*Cyclospora spp*	Abdominal cramping, fever
opportunistic	*Nontuberculosis mycobacteria*	Skin infections
pathogens	*Pseudomonas aeruginosa*	Wound and eye infections

Source: WHO, 2003. Emerging Issues in Water and Infectious Disease

- ✓ **Bacteria**

These are organisms that are a few microns in size and vary in shape. Unlike protozoa, they do not contain a nucleus. They are everywhere such as in water, soil, air, deep oceans and even in acidic hot springs. Litters of water for example can contain several million bacterial cells as was observed during laboratory examination of water samples collected on the field. Most of these bacterial are harmless and some are even beneficial to humans. Very few of them can cause diseases such as salmonella or shegella.

- ✓ **Viruses**

They are the smallest of pathogens (0.1 micron). They do not have an independent metabolism. They can grow or reproduce within a living host cell and cannot multiply within the environment. Many viruses are host specific causing diseases in humans or specific animals only.

- ✓ **Protozoa**

Protozoa are the largest pathogens (10 microns). It has a nucleus unlike bacterial. Some have an egg - like shell to resist harsh conditions such as high temperature, and long periods without water or food. Most of them cause diseases like malaria, diarrhea which affects mostly adults.

- ✓ **Helminthes or parasites**

These are parasitic worms which can invade human intestines or other tissues. Their transmission is due to poor hygiene and sanitation. One particular nasty helminthes (Guinea worm) is transmitted through drinking water. Protection and treatment of drinking water can help eliminate this parasite.

In the area of study, it was noticed that at least one member of a household suffered from one or more water - borne diseases especially diarrheal, malaria, measles or typhoid. They suffered without even being aware of the causes.

Household Water Treatment and Safe storage can reduce the burden of water borne diseases. But this should not be expected to have an impact on other diseases that may be water – washed or water – related diseases.

2.2.2 Disabilities and deaths recorded

Universally, unclean water is a serious problem that can cause severe pain, disability and even death. On the 22 March, as the world celebrates World Water Day, UNICEF urges

governments, civil society and ordinary citizens to recall that behind the data of deaths suffered as a result of unsafe drinking water, are children.

Water having a high level of E.*coli* as noted from analysis of springs in the study area are very risky for consumption as they can cause heart and bone diseases which leads to disabilities.

A typical example is the leg on plate 2.3 below caused by unsafe drinking water as was informed by the parent of the child behind Texaco Obili. Osteomyelitis (OM) is an infection of the bone. The cause is usually a bacterial infection; rarely, a fungal infection. It is often detected by a blood test, medical imaging, or bone biopsy. Treatment often involves both antimicrobials and surgery as was the case of the leg on Plate 2.3 In those with poor blood flow, amputation may be required.

Photo 2.3: Scar of bone infection (Osteomyelitis (OM)

Source: Ngebung 2017

The child parent's made it known that treatment of the leg was very expensive and despite that, the child underwent surgery several times and even missed out two school years because of the leg. The mother said the Doctor told her that children who suffered such predicament rarely survived it. She again said the child also went through a lot of pains. This parent ended her story with tears while thanking God for his mercy on her child. This alone confirms that water considered safe for drinking might harbor dangerous pathogens which are life threatening.

Globally, an estimated 2,000 children under the age of five die every day from diarrheal diseases and of these; some 1,800 deaths are linked to water, sanitation and hygiene. Yongsi, H Blaise Nguendo among various risk factors examined. Water-supply modes and quality of

drinking-water are statistically associated with diarrhea cases. Moreover, levels of diarrhea attacks vary considerably from one neighborhood to the other.

In addition to these, a person infected with an open guinea worm wound, if they enter a pond or well used for drinking water, they can spread the parasite into the water and continue the cycle of contamination and infection which often leads to deformation and disabilities. It is important to take note of sicknesses which can greatly reduce the quality of life as a result of ingesting unsafe water

Nevertheless, people in Obili and Etoug-Ebe attested to the death of some family members especially children below 5 years of age due to diarrheal and even older persons due to typhoid and malaria. All these deaths were analyzed to be associated with the quality of drinking water and sanitation. In this area, numerous persons suffered from one water borne diseases or the other because they consume contaminated water from doubtful sources such as wells and springs which are often faced with pollution and fecal contamination.

2.2.3 Expense incurred on medications and treatments

Households in the area of study decry high expenses on medications and treatments on water borne diseases like typhoid and diarrheal. Untreated waste builds up and poisons river systems, lakes, and other water sources. The lack of sanitation facilities, and training in their use and maintenance, may also provide breeding opportunities in stagnant water bodies for insects that help to spread diseases. Given the fact that, these households are poor, it is often difficult for them to afford treating these diseases in the hospital. A reason for which, they turn to traditional medicine which they believe is cheaper and effective. Some expressed the fact that where they live and their living condition tell their story. These groups of persons live in “elobis” which are flood prone areas faced with a lot of pollution which harbors water borne diseases. This pollution further contaminates water sources which they very much depend on for their livelihood (drinking, laundry, washing and cooking). They are used to unprotected springs as their drinking water source.

In some homes, parents blame their children for fetching water in the wrong sources for drinking. For instance, when children are sent to fetch water in the usual drinking water sources, they get water from nearby wells claiming they got it from the source (a family head explained). To the children, it minimizes the pain and stress involved in getting water from the appropriate source. They do this with ignorance while neglecting the effects on health. Elsewhere the inhabitants said they drink from doubtful sources because they have no option but to do with

what they have. This has led to family heads spending greater parts of their meager incomes on hospital bills and medications.

2.2.4 Delays in household chores and activities due to water

One of the most important tasks here is to improve sanitation and adequate water supply. Due to limited access to safe drinking water in this area of study; household chores were delayed. Cooking which requires clean water was done late. Cloth washing and dish washing was not left out. Inhabitants blame this for lack of appropriate water sources to accomplish their daily chores and activities on time. Some families blame this on the distance to get water and back. Others blame it on the proprietors of their water points as they are given particular time to fetch water especially in wells and boreholes. Others blame it on the government, CAMWATER and CDE for not keeping their engagement to supply potable water even after their request and deposition of some requested sum of money. Thus, they have to move from place to place in search of the precious good. This is often tedious and time consuming. Women faced with a multi tasks were particularly bitter on the situation. This renders things difficult as chores were bound to be delayed.

According to UNDP, most countries or regions have enough water to meet household needs but lack the means to provide it in an accessible manner. This is quiet true with Cameroon as they are endowed with mass water bodies, yet faced with water crisis which leads to suffering and even death.

2.3 Conclusion

This chapter has concentrated on the problems encountered by the urban poor having access to safe drinking water and the effects of such water on the health of the population. It brings out the risks and diseases associated with consuming water from unreliable sources. The chapter opens the way for chapter three which looks at the water treatment standards which are both physical chemical and biological.

CHAPTER THREE

WATER SOURCES AND AFFORDABLE OPTIONS

3. DRINKING WATER SOURCES IN THE STUDY AREA

Introduction:

There are different sources of drinking water that were identified in the area of study. Some of them were; surface water sources, ground water sources and atmospheric water sources as will be reviewed in this chapter.

Drinking water in the study area is obtained from two main sources: surface water and ground water sources. The inhabitants use surface and ground water for a variety of purposes daily. Even though drinking water especially from surface water sources is treated before entering most homes, the cost of treatment and risk to health can be minimized by protecting the water sources from contamination. This is not the case because the water sources are often contaminated with animal and human waste not leaving out various airborne, water borne and insect borne microorganisms which are harmful to the human body. Such contamination is estimated to cause several deaths each year from diarrhea alone. Most of these deaths are among children, the elderly, and those already sick or with compromised immune systems. In cases like these, the immune system is either not developed enough or is too weak to be able to withstand the diseases caused by the microorganisms in water.

In sub Saharan Africa, because of poverty the populations of the large cities with modest incomes are pushed back towards the less developed sites. In such areas, promiscuities and poor living conditions lead to serious sanitation problems. Poor disposal of waste and drainage of waste water and rain water creates ponds. These ponds acts as breeding ground for mosquito vectors causing diseases like malaria. The foremost source of water which is rainfall varies from one part of the continent to the other. Water bodies such as lakes, marshes and rivers which support life for both humans and wildlife are degrading. Other sources of water are as well threatened by desertification, rapid urbanization and depletion. The quest for farmland and felling down of trees, are a threat to the water cycle and a reduction in availability of water. The basis of this water problem is allotted to poverty and urbanization. When water is well managed it can help alleviate poverty and bring about economic growth. Different sources of drinking water are noted on the field.

3.1 Surface water sources

Surface water sources include any fresh water flowing over the surface of the earth that is directly available for water supply. Some examples include streams, rivers, ponds and lakes. Surface water although readily available is exposed to contamination and pollution from numerous sources. The water is contaminated as it flows over the earth's surface. It also mixes with wastewater and other pollutants discharged in to the water. These contaminants include human waste products, as well as dissolved impurities such as metals and minerals which carry disease causing bacteria. Unless surface water is well protected from such contaminants, surface water must be treated before it can be supplied to consumers. After treatment, if the water is stored for extended periods, it must be aerated and chlorinated to kill microscopic organisms that breed in still water before consumption. Different surface water sources will be looked at in the preceding paragraphs below.

a. Pipe borne water from CAMWATER

From December 1st 1968, SNEC was the single State owned company with the monopoly of exploiting, treating and supplying safe drinking water in Yaounde and Cameroon as a whole. The company did not meet her anticipated objectives given the facts that, most households are not connected, the quality of water was and is still poor (color, odor, taste) as observed on the field. Some quarters are completely left out of connection network with others constantly witnessing intermittent water supply, the population is growing at an alarming rate, increase in the number of urban poor (urbanization of poverty), dilapidation of equipment and increase in the prices of inputs due to the effects of the economic crisis, nonpayment of bills by the population and the State and the poor quality of water, all contributed to the shortcomings of SNEC. All these led to the replacement of SNEC with CAMWATER and CDE in the year 2000, following the privatization effort embarked on by the government of Cameroon. Though this has not impacted the situation much. This is justified by the fact that getting drinking water in Yaounde remains a difficult task to the city dweller.

Plate 3.1: Some tap water points

(a) Tap for selling water (b) Sample of water from the tap

Source: Ngebung 2017

Even with the poor quality of tap water and intermittent supply, as observed on Plate 3.1, an effective social discrimination is noticed. (Nuendo Yongsi, 2010a) stated that, wealthy suburbs and housing estates occupied by the rich people are better equipped with safe drinking water structures than municipal plots and informal suburbs (slums) mostly occupied by informal sector workers and by the unemployed. This is very evident in the study area, mostly occupied by the urban poor. All of these irregularities coupled with the liberalization of the water sector in Cameroon have influenced the inhabitants of these areas to turn to doubtful water sources for their daily needs. These water sources as observed are often heavily polluted and contaminated

b. Rivers

Rivers and streams are the principal water source for many cities, and have been since ancient times. When the discharge from a number of streams and a natural spring combines, a river is formed. The quality of the water is not reliable as it contains large amounts of silt, sand, and other pollutants. The amount of water in rivers grows as the river moves forward, because of additional streams flowing into the river. This is the case of the Biyeme which takes its rise from the foot of Mvog – Betsi rocky hills and flows through the area of study and then empties itself into the Mfoundi River. Natural processes in rivers provide the river with self - purification capabilities to remove some pollutants. The water quality in rivers is better in the dry season than in the rainy season though not advisable for drinking as increase flow introduces and stirs up debris in the water. However, rivers here are heavily polluted with wastewater,

feces from open defecation, drainage of toilets, and deposition of household waste. Therefore, rivers are not suitable for drinking as observed in the study zone. Rivers can only be used as a potable water source after purification treatment and HWTS.A case in point is the river between Government High School Etoug – ebe and Presidential Guard fence. This river was visited on the 08/08/2018 by the Israelite Ambassador to Cameroon where he shared advances made in technology vis-à-vis the purification of very dirty water from the river in to safe drinking water. This was done with the aid of a portable manually operated machine (Nufiltration) that produce eight litters of water in a Minuit and a Jerrican suitable for family use. He further explains how technology has paved the way for his country to export water to other neighboring countries. This equipment was said to be donated to some council in the city of Yaounde in the near future.

c. Stream

Streams are depended on rainfall and flow stronger during the rainy season. Some streams contain water only during rainy periods. High runoffs in mountainous areas and waste disposal in streams, renders the quality of water in streams not suitable for human consumption. However, streams contain small quantities of water and can supply only very limited areas.

Photo 3.1: A stream between the Presidential Guard quarters and GBHS Etoug-Ebe area.

Source: Ngebung 2017

As can be seen on Photo 3.1, the streams flowing through the area of study are heavily polluted and dirty and not suitable for drinking. If it must be used as a drinking water source, then treatment must not be neglected even at household level.

d. Ponds

Ponds are depressions in the earth's surface where water collects during the rainy seasons or they are feed with water from marshes. Ponds are occasionally manmade to collect water for varied needs. While similar to lakes, ponds are usually much smaller than lakes. The quantity of water in ponds is very small and contaminated. They are not therefore a recommended source for drinking water as they are exposed and highly contaminated.

Some ponds such as the one in Plate 3.1 were found to contain bilharzia which is a serious threat to human health. This therefore gives reason why such water is not good for drinking.

Photo 3.2: Pond located at "derriere le camp" Mendong

Source: Ngebung 2017

e. Lakes

When water from springs and streams collects in depressions on the earth's surface with an impervious bottom, a lake is formed. The quality of water in lakes is generally good and does not require much purification like rivers. Lakes often possess self-purification capabilities. If the water in the lake is pure, it can be used as potable water without treatment, (INTELITEK, 2011). However, the quality of the water in the lake depends on the basins capacity, the catchment area, the annual rainfall and the porosity of the ground. Unlike groundwater, it is easy to gauge the amount of water available for use in the lake.

Comparing surface water to groundwater around the area of study; surface water though readily available is exposed to pollution in all forms and different sources. For this very reason, surface water must undergo treatment before it can be used as drinking water.

3.2 Groundwater Sources

Groundwater is all the water that is found beneath the earth's surface. Unlike water on the earth surface, water exist almost everywhere underground, not only in concentrated underground lakes or rivers. Just below the earth's surface, in the unsaturated zone (aerated zone) pores between soil particles are filled with air and water. Water in this zone is called soil moisture. Below the unsaturated zone, the pores are filled only with water. This is known as the saturated zone. Water in this zone is called groundwater. Below the saturated zone, the pores are extremely small and hold very little water. The saturated and unsaturated zones are separated by the water table. When the unsaturated zone becomes saturated, the water table rises to the earth's surface. Groundwater is far superior to that of surface water and is often fit for human consumption with little or no treatment, (INTELITEK, 2011). This is because groundwater is protected below the earth's surface and has to filter through layers of soil and sand before reaching the water table. The soil retains pollutants and nutrients so that the water reaches the surface pure and pollutant free. Groundwater can however be damaged by human activities like seepage of agricultural chemicals, pesticides, waste from landfills, household waste, waste water and so on. Ground water includes springs, wells, and aquifers.

i. **Springs**

A spring may be defined as a place where a natural outflow of groundwater occurs. In general, spring water is of good quality. Pathogenic contamination is unlikely if the source meets certain criteria. These include the thickness of the soil layer, the type of soil and the velocity of infiltration of the surface water. The local population, especially women (as drawers of water), but also farmers, hunters and grazers, have a good knowledge of the location of springs and their characteristics. This is the case with a spring named "Adamou" after a hunter who discovered the spring in ASEC Etoug–Ebe.

Some springs form small ponds where animals drink and people may also get water from there as well. The oldest community water supplies were springs and they remain a favored source till date in the study area because the water often has a high natural quality. This suits both the inhabitants and eases the work of engineers and those who assist in designing the water supply system, as well as those in the community who will be in charge of looking after the water source. Given the importance of the springs as observed on the field, most of the natural springs in the area of study have been developed in one way or another as drinking water sources. However, a proper feasibility study, adoption of some basic design principles,

protecting the spring and its catchment area will usually lead to improvements in the quantity and quality of water in springs. Spring water is generally free from contaminants. To remain this way, the spring must be protected at the point from where it exits. Springs supply very small quantities of water and so cannot serve as the supply source for large towns or cities.

However, springs can be used to supply water for small towns and quarters as is the case with the study zone. Most of the inhabitants here depend largely on springs for drinking water. Although the qualities of the springs are uncertain due to pollution and contamination, the inhabitants believe water that is clear, odorless and tasteless is good for drinking. Unless they are sensitized they believe water from their springs is of best quality as compared with pipe borne water from (CAMWATER).

Plate 3.2: some selected springs in the study area

(a) Protected spring,

(b) Unprotected springs

Source: Ngebung 2017

Protected springs in the area of study as observed on the field were constructed with sand, cement, concrete and a pipe in which the water flows through. As shown in Plate 3.2, before this is done, a small well where the water collects before flowing through the pipe is dug. Such springs are still not safe though the quality of water might be good. The reason is that the water is mostly fetched by children who do not pay attention and introduce contaminants in the water in one way or the other. A glaring example is plate 3.2(a) showing a girl washing bottles and placing them on the roof of the spring while the boy is fetching water directly below where contamination from dripping water and soap is evident.

Unprotected springs on the other hand are just left bare or open where a cup, pan or any other container is used to scoop water and fill other containers like on plate 3.2(b). Such springs are susceptible to contamination and pollution in all its forms thus making the water unreliable for drinking. Before such water is used as drinking water, HWTS must be considered. This is not the case as inhabitants drink such water with little or no treatment while bearing in mind that spring water is safe for drinking as noted on the field.

ii. Wells.

A well is a manmade hole or pit in the ground for the purpose of retrieving water from an aquifer. Due to their limited capacity, wells can only feed small communities. However, most of the homes visited use wells as their main source of water. Many types of well were seen in this area of study.

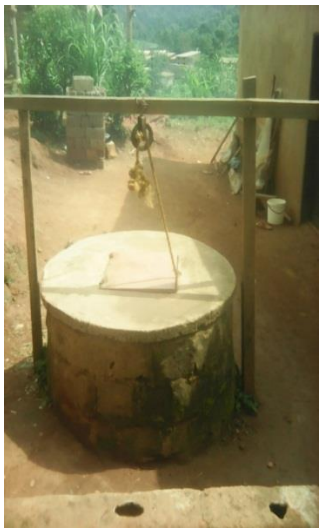
- ✓ Shallow wells which retrieve water from underground aquifers

These shallow hand dug wells are not suitable for drinking. The depth is often about 4 to 10 meters. These types of wells are numerous in the area of study plate 3.3. This is due to the fact that the urban poor are mostly in marshy areas “elobis” where water is easy to get when a well is dug. These wells are prone to contamination and pollution from diverse sources. These render the water unsafe for drinking. This situation is worse during the rainy season as contaminated runoffs drain into the wells, mud from rain also splashes in to the wells as well as leaves and branches of trees. Containers used to fetch the water from such wells are not clean. Dirt from feet and hands of users further worsen the situation. Buckets and ropes are left on the ground under unsanitary conditions.

Plate 3.3: Types of wells

(a) Improved shallow well,

(b) Non-improved shallow well,



(c) Modern well

Source: Ngebung 2017

These wells are not safe for drinking as they are also left uncovered (children, domestic animals can fall into them). They are very risky as they can collapse at any time. On the field, it was noticed that in these quarters, there are two types of shallow hand wells; non-improved and improved shallow wells.

- Non-improved shallow wells

  They are usually very shallow and often left open, with a piece of hard plank at the mouth to bear the weight of the one fetching the water. The water from such wells as observed on the field is brown in color and not psychologically fit for drinking.

- Improved shallow wells

  Improved shallow wells are raised further above the ground surface. Cement blocks are used to construct the mouth of the well. This serves as protection from contamination, runoff, splashes of water and the eroding action of rain water during the rainy season. Water here is not suitable for consumption as noted on the field.

✓ **Modern Wells.**

As observed on the field there was a range of wells all through the area of study. This was partly because of the difficulties involved in getting connected to the CAMWATER network in some of the quarters. Coupled with the liberalization of the water sector, this paves the way for inhabitants to seek alternative drinking water sources which resulted to the digging of all these wells. On the other hand, a number of these wells are built respecting part of the WHO

Standards for constructing a good well. Such wells were very few, well managed and used for drinking. Most of the modern wells are built with cement blocks and concrete, a metal cover or concrete casted lid and a lock at the closure, equipped with a rope and a bucket. The surrounding is relatively clean. Those privileged to possess such wells, plate 3.4 determine the periods and time of the day for others to come and fetch water.

Plate 3.4: Examples of modern wells

Source: Ngebung 2017

Elsewhere, such wells are erected with a tank plate 3.4 and equipped with a pump and tap to facilitate their use. Despite these advantages, there are still some disadvantages due to poor hygiene and sanitation with pit toilets noticed at close proximity to some of these wells. This makes the quality of the water doubtful and unsafe as it can be polluted through infiltration.

Well water which is naturally protected beneath the earth's surface has to filter through layers of soil and sand before reaching the water table is often fit for human consumption with little or no treatment. But most often, it is usually poorly exploited leading to contamination and therefore needs treatment at household level before drinking.

However, the quality of groundwater in Obili and Etoug – Ebe is destroyed by various human activities such as seepage of agricultural chemicals like pesticides, waste water from septic tanks, households waste, animals, etc. Groundwater can remain contaminated for centuries. As groundwater flows slowly; contaminants are not carried away and diluted as is the case with streams and lakes. Even though surface water is readily available, and very easy to collect, groundwater is often preferred as a water source because the treatment needed is very limited or minimal compared to surface water.

iii. Boreholes

A borehole is a narrow shaft bored in the ground, either vertically or horizontally. A borehole may be constructed for many different purposes, including the extraction of water, other liquids (such as petroleum) or gases such as natural gas. Boreholes were spotted in the study area. These boreholes were both private and public. Access to water from the borehole was only at given hours of the day and were payable because they are mostly private owned. This in itself is a limitation to having access to safe drinking water. On the other hand, the public boreholes plate 3.3 donated by Chinese to the inhabitants of Manna quarter was said to be accessed twice a day at particular hours. This was to limit usage and breakdowns as it was said to be very costly to repair as experienced by the users.

Photo 3.3: A borehole on private land donated by the Chinese.

Source Ngebungv2017

However, most of the inhabitants could not distinguish between a borehole and a modern well. Some of the modern wells are constructed in such a way that water is pumped in a tank erected on concrete pillars, then flows through a connected pipe to the tap where the water if needed is fetched. Those who are privilege to have such wells sell the water. Those, met on the field, ignorantly believe such wells are borehole. As such, the water they buy is considered to be of superior quality without need for any treatment. This poses a threat to the health of those who drink water from such sources. Some of those who rely on such wells named boreholes explained how they are frequently tested positive of typhoid fever. This leads to spending money they do not even have on medications and treatment. This is the reason why most of those tested positive for typhoid go in for traditional medicine which they consider relatively cheaper than conventional medicine

3.3 Atmospheric water sources

a) **Rainwater**

Rainwater can enormously contribute to water supply but this depends on the regularity, reliability and quality of rainfall. In the rainy season, rain water is directly collected from roof tops to provide a very important source of drinking water to the population. This water is collected by families through the roof. Institutions like clinics, hospitals, churches, and schools collect this water through ponds and small storage reservoirs for their diverse uses.

In areas like these, rain water is collected from the roof of structures and stored in buckets, drums or tanks either on roof tops or on the ground. This water is relatively clean but must be protected from contamination and needs to undergo some treatment before it is used for drinking. But this is not the case here as the water is consumed without treatment. The material from which the roofs, gutters, drainpipes and drums are constructed must be selected with care to ensure the water remains of high quality. For example, acidic rain may cause metallic roofs to release metals into water. If treatment is not available, or the rainwater is collected from storm water, rain that has run over streets and parking lots, the water should only be for secondary uses such as toilet flushing. Rain water tanks can only store limited quantity of water and cannot be used for large scale water supply. As the tanks are closed, they must be disinfected periodically to prevent the growth of algae.

Photo 3.4: Rain water in a plastic bucket.

Source: Ngebung 2018

However, rain water is not suitable for consumption plate 2.10 as even the buckets used to collect the water usually have dark stains (an indication of acidic rain) as observed on the field. This may also be an indication of pollution and contamination which necessitates treatment before consumption.

B. SAFE DRINKING WATER OPTIONS FOR THE URBAN POOR

Tap water may not be safe or readily be available to drink. In these situations, it's important to understand and recognise how to prevent illness from drinking unsafe water. If the quality of water is doubtful or suspected to be unsafe, it is not advice to use the water to drink, wash dishes, brush your teeth, or make baby formula. It is recommended to use bottled, boiled, or treated water for drinking, cooking, and personal hygiene. Follow recommendations from your region, local, or tribal health department for boiling or treating water in your area.

3.2.1. Boiled water

It is seen from results gotten from tested water samples in the area of study that water from all sources need to be treated either by boiling or disinfection to make it safe for drinking. Boiling is the surest method to kill disease-causing germs, including viruses, bacteria, and parasites. After boiling water the taste in most cases is flat. To improve the test of boiled water

pour it from one container to another. It is then allowed to stand for a few hours, flat taste alternatively add a pinch of salt for each quart or liter of boiled water. To boil water for drinking there are steps to follow. If the water is cloudy, first filter it through a clean cloth, clay filter. If all of these are not available simply allow the water to settle. Then, gradually strain the clear water. Bring the clear water to a rolling boil for 1 minute (at elevations above 6,500 feet, boil for 3 minutes). Let the boiled water cool. Store the boiled water in clean sanitized containers with tight covers.

3.2.2. Disinfected water

If boiling and other options are not possible, small quantities of water safe to drink can be gotten. This is with the help of chemical disinfectant, such as unscented household chlorine bleach, iodine, or chlorine dioxide tablets. Disinfectants can kill most harmful or disease causing viruses and bacteria, but most disinfectants are not as effective as boiling for killing more resistant germs, such as the parasites Cryptosporidium and Giardia. Chlorine can kill Cryptosporidium manufacturer's instructions are followed the correctly. If the water has a harmful chemical or radioactive material in it, adding a disinfectant will not make it drinkable that is further treatment would be required.

3.2.3. Using bleach to disinfect water

Bleach water is an option for drinking water. It comes in different concentrations. Check the label of the bleach you are using to find its concentration before you start to disinfect water. It should be noted that to treat water, first filter it through a clean cloth, paper towel, or allow it to settle. Then, draw off the clear water and follow the steps below;

Follow the instructions on the bleach label for disinfecting drinking water. While taking note of the expiring date. If the label doesn't have instructions for disinfecting drinking water**,** check the active ingredient on the label to find the sodium hypochlorite percentage. Then use the information in the tables below as a guide. Add the appropriate amount of bleach using a medicine dropper, teaspoon, or metric measure (milliliters). Stir the mixture well. Let it stand for at least 30 minutes before you drink it. Store the disinfected water in clean, sanitized containers with tight covers. If the water is cloudy, murky, colored, or very cold, add double the amount of bleach as on the table 3.1. and 3.2.below;

Table 3.1: Making water safe with bleach having a 5%–9% concentration of sodium hypochlorite

Making water safe to use with bleach having a 5%–9% concentration of sodium hypochlorite		
1 quart/liter water	**1 gallon water**	**5 gallons water**
If there is a dropper: Add 2 drops of bleach	If there is a dropper: Add 8 drops of bleach	If there is a dropper: Add 40 drops of bleach
If there is something that measures milliliters (mL): Add 0.1 mL of bleach	If you there is something that measures milliliters (mL): Add ½ mL of bleach	If there is something that measures milliliters (mL): Add 2½ mL of bleach
If measuring spoon is available: Add a tiny amount (too small to measure)	If you measuring spoon is available: Add a little less than ⅛ teaspoon	If a measuring spoon is available: Add ½ teaspoon of bleach

Source: Adapted from CDC

Table 3.2: Making water safe with bleach having a 1% concentration of sodium hypochlorite**. If the water is cloudy, milky, coloured, or very cold, add double the amount of bleach listed below.**

Making water safe to use with bleach having a 1% concentration of sodium hypochlorite		
1 quart/liter water	**1 gallon water**	**5 gallons water**
If a dropper is available: Add 10 drops of bleach	If you have a dropper: Add 40 drops of bleach	If you have a dropper: Add 200 drops of bleach
If there is something that measures milliliters (mL): Add ½ mL of bleach	If there is something that measures milliliters (mL): Add 2½ mL of bleach	If there is something that measures milliliters (mL): Add 12½ mL of bleach
If there is measuring spoon: Add ⅛ teaspoon of bleach	If there is a measuring spoon: Add ½ teaspoon of bleach	If you have a measuring spoon: Add 2½ teaspoons of bleach

Source Adapted from CDC

3.3. Using chemical tablets to disinfect water

Water treatment tablets can be used to disinfect water. These tablets are popular. They are available in different sizes and made to treat specific amounts of water. Follow the manufacturer's instructions on the label or in the package. Chlorine dioxide tablets can kill germs, including Cryptosporidium, if the manufacturer's instructions are followed correctly. Iodine, tablets with iodine tetraglycine hydroperiodide, or chlorine tablets kill most germs, but not *Cryptosporidium*. Water that has been disinfected with iodine is not recommended for pregnant women, people with thyroid problems, or those with known hypersensitivity to iodine. It's also not recommended for continuous use. Don't use it for more than a few weeks at a time. If you don't have safe bottled water, water treatment tablets can be used to disinfect water.

These tablets are popular among campers and hikers, as well as in other countries. They are available in different sizes and made to treat specific amounts of water.

3.2.4 Filtered water

Many portable water filters can remove disease causing parasites such as *Cryptosporidium* and *Giardia* from drinking water. If you are choosing a portable water filter: try to purchase or make one that has a filter pore size small enough (absolute pore size of 1 micron or smaller) to remove parasites, such as *Giardia* and *Cryptosporidium*. Portable water filters do not remove viruses, and most portable filters do not remove bacteria either. Carefully read and follow the manufacturer's instructions for the water filter you are about to use. After filtering, add a disinfectant such as iodine, chlorine, or chlorine dioxide to the filtered water to kill any viruses and bacteria.

3.2.5 Other Options

- **Ultraviolet Light (UV Light)**

Ultraviolet light (UV light) can be used to kill some germs. Portable units that deliver a measured dose of UV light help disinfect small amounts of clear water. UV light does not work well on cloudy water because small particles may block germs from the light. **If the water is cloudy, first filter it** through a clean cloth, paper towel, or allow it to settle. Then, draw off the clear water and disinfect it using the UV light. Always follow the manufacturer's instructions.

- **Solar Disinfection**

The sun's rays can improve the quality of water. This method may reduce some germs in the water. To disinfect water using the sun:

Fill clean and clear plastic bottles with clear water. Solar disinfection is not as effective on cloudy water because small particles may block germs from the light. If the water is cloudy, first filter it through a clean cloth, paper towel, or allow it to settle. Then, draw off the clear water and disinfect that water using the sun. Lay the bottles down on their side and in the sun for 6 hours (if sunny) or 2 days (if cloudy). Laying down the bottles allows the sun's rays to disinfect the water inside more effectively. Putting the bottles on a dark surface will also help the sun's rays disinfect the water more effectively. Using the sun. Lay the bottles down on their side and in the sun for 6 hours (if sunny) or 2 days (if cloudy). Laying down the bottles allows the sun's rays to disinfect the water inside more effectively. Putting the bottles on a dark surface will also help the sun's rays disinfect the water more effectively.

3.3. WATER QUALITY

The quality of water is determined according to the intended use for the water. Most often, water treated to meet potable water standards is of good and sufficient quality than all other uses. Raw water quality varies greatly from one source to another at different times of the year as observed on the field. Therefore, the treatment needed to bring the water to the required quality also varies from system to system at different times of the year. The quality of the water source and the quality required for the end user determines the level at which the water is to be treated. In addition to supplying water of good quality, water suppliers must also supply sufficient water to meet the needs of those who are to use the water. This has not been the case in the area of study where water quality is still very poor (having color, odor, and at times taste. With these water quality problems people are resorting to doubtful water sources for their various needs.

In effect, major water related diseases which are amongst the worst killers in less developed countries like Cameroon and amongst the poorest segments of the population (urban poor) are often those hit hardest. For instance, the quality of water for domestic uses is very vital for the prevention of malaria, typhoid, cholera and other water borne diseases. In the study zone it is observed that, very few people understand the relationship between water and sanitation. In effect very few inhabitants wash hands with water and soap after defecating, some people store water in unclean containers, others use containers without lids or they just leave the containers uncovered. Open defecation is common and household waste is spotted around water points which go a long way to pollute the water sources. These poor hygienic conditions enhance the proliferation of water borne diseases. A case in point is Plate 3.5 where children below five years of age are seen fetching drinking water. The common assumption that urban dwellers enjoy better health than rural dwellers does not apply to the urban poor. This is because they rarely have the locational position and purchasing power to access adequate urban sanitation and health facilities (Deborah F. Brycen 2006). This is an ironical situation. Rural areas actually have the better water supplies than the urban poor areas.

Plate 3.5: Children below five years fetching drinking water

Source: Ngebung 2018

These children without the knowledge on how to handle water are spotted fetching drinking water in almost all the sources visited. This alone speaks for itself as contamination is unavoidable. Even the stagnant water where the children are standing is a host for many bacterial that contaminate water while diminishing its quality. This same area acts as a breeding ground for mosquitoes that bite the children when fetching water and later on cause malaria or filarial in the children in the long run. This is one of the reasons for which having safe drinking water in this area of study is not an easy task.

Water treatment standard is concerned with the legal limit for contaminants that reflects the level that protects human health and that water systems can achieve using the available technology.

Guidelines for water treatment are intended to support the development and implementation of risk management strategies that will ensure the safety of drinking-water supplies through the control of hazardous constituents of water, (WHO, 2006). These strategies may include national or regional standards developed from the scientific basis provided in the Guidelines. The Guidelines describe reasonable minimum requirements of safe practice to protect the health of consumers and/or derive numerical "guideline values" for constituents of water or indicators of water quality. They also provide a scientific point of departure for national authorities to develop drinking water regulations and standards appropriate for the nationals. Most often, water treated to meet potable water standards is of good and sufficient

quality for drinking. It is considered safe in terms of chemical constituents. Typically, microbiological hazards are of greatest concern because they are responsible for causing diseases when contaminated water is consumed. Water quality sustainability needs not be neglected. Unfortunately, most of the people in the area of study does not accept the quality of water from CAMWATER as it is frequently noticed to have color, taste and odor.

The water utility company in Cameroon still does not make proper use of the WHO guidelines. This is evidenced by the fact that tap water from CAMWATER frequently has color, odor and taste. Psychologically, this discourages consumers from drinking the water. This is in line with the perception the inhabitants have that spring water is better for consumption as it is odorless, colorless and tasteless compared to water supplied from the utility company. This is also a reason some inhabitants advanced for going to fetch drinking water from springs despite being connected to CAMWATER.

The details of drinking-water standards may vary between countries and regions. There is no single approach that is accepted the world over as far as drinking water is concerned. Approaches that may work in one country or region will not necessarily be accepted in other countries or regions. This is due to diversity in cultures and traditions, differences in geographical locations as well as living standards. It is essential that the needs and capacities in developing a regulatory framework to better manage the water sector be considered in Cameroon. If this is done, the belief that water from CAMWATER is not safe for consumption will be rolled out and the quality of water will be improved upon.

Therefore, the treatment needed to bring the water to the required quality also varies from one system to another at different times of the year. The quality of the water source and the quality required for the end user determines the level at which the water is to be treated. Failure to ensure drinking-water safety may expose the community to the risk of outbreaks of intestinal and other infectious diseases. Some of these diseases are often associated with drinking and bathing with contaminated water as on Table 3.3.

Table 3.3. Diseases associated with drinking water and manifestations

Diseases associated with drinking or bathing with contaminated water	**Manifestation of diseases associated with drinking or bathing with contaminated water**
Cholera	Diarrhea; nausea, cramps, nose bleeding and vomiting
Diarrhea caused by *E. coli*	Severe diarrhea, dehydration, dangerous for young children and elderly persons
Dysentery	Passing feces with blood and sometimes vomiting of blood
Salmonellosis	Diarrhea, fever vomiting and cramps
Typhoid Fever	Sustained fever, profuse sweeting and diarrhea
Adenovirus infection	Cold, pneumonia and bronchitis
Gastrointestinal infection	Diarrhea, nausea, vomiting, fever and abdominal pain

Source: field work 2019

Outbreaks of waterborne diseases are particularly to be avoided. This is because of their capacity to result in the simultaneous infection of a large number of persons and potentially a high proportion of the community as the case may be in future if stakeholders do not assume their responsibilities. This is by making sure they provide basic necessities to the population and urban poor who are very vulnerable as observed on the field.

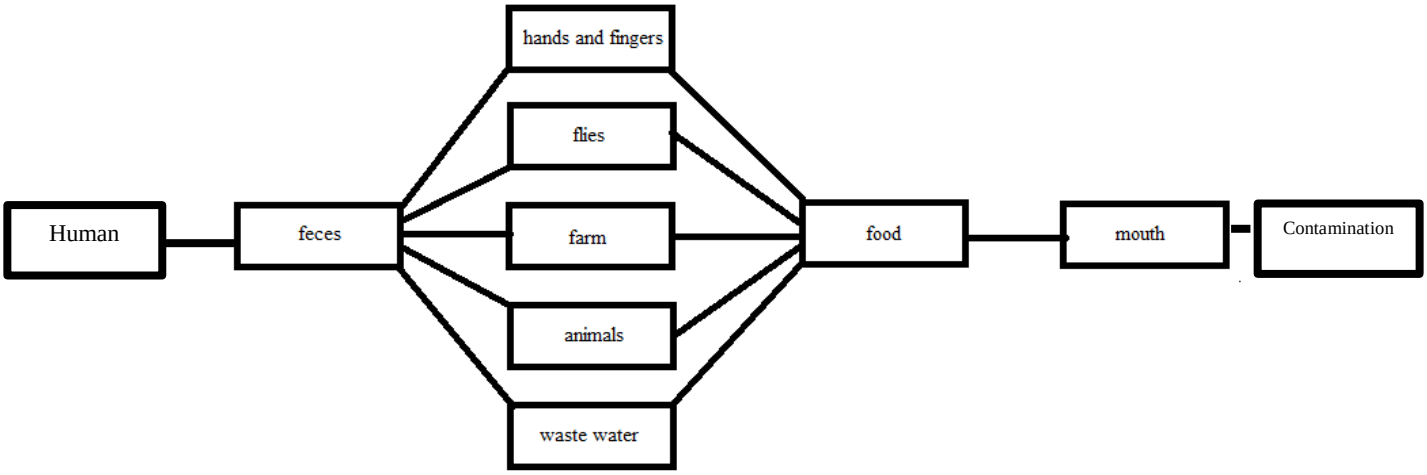
In addition to supplying water of good quality, water suppliers must also supply sufficient water to meet the needs of those who are to use the water. This has not been the case in Obili and Etoug - Ebe where the water quality is still very poor with inhabitants depending upon doubtful water sources for their various needs.

In effect, major water related diseases are amongst the worst killers in less developed countries like Cameroon and amongst the poorest segments of the population (urban poor). Drinking water that is not properly treated or which travels through an improperly maintained distribution system (for example the piping system) may also create an opportunity for contamination. In Obili and Etoug – Ebe, it is observed that, very few people understand the relationship between water and sanitation.

3.1 Relationship between Sanitation and Contamination

Sanitation is an attempt to control the factors of contamination through food, people, places and equipment that have potential factors to cause disease or illness. Water plays a very vital role in human health and wellbeing. Water that does not meet quality and safety requirements is likely to cause health problems or waterborne diseases such as diarrhea, dysentery, cholera, typhoid and many other infections as on figure 2.4.

Figure 3.1: Human sanitation and contamination



Source: Ngebung 2019

From Figure 3.1, there exists an inseparable link between sanitation and water contamination as observed on the field. This is explained by the fact that children who are so much engaged with fetching water leave the toilet and rush to fetch water without washing hands. Others who answer nature call at nearby bushes or farms also fetch water without washing hands. Some even touch animals like dogs while fetching water as noted on the field. All these are fertile ground for contamination and diseases as hand washing is being neglected. It is clear that hand washing is neglected as mostly children are met fetching water without washing hands despite their activities around water points. From the Figure 2.4 above, it is noted that after defecating, children who came fetching water do not wash hands. This is a potential source of easy contamination of water and food which when eaten can cause diseases. Hand washing with water and soap after defecating, before fetching water or handling water needs to be promoted as open defecation is common and spotted around water points. This starts a chain of contamination which ends in the mouth causing diseases. Inhabitants do not make use of basic hygiene and sanitation thus creating an enabling environment for diseases.

Household waste is not left out as it goes a long way to pollute the water sources. “The common assumption that urban dwellers enjoy better health than rural dwellers do not apply to the urban poor, who rarely have the locational position and purchasing power to access adequate urban sanitation and health facilities” (Deborah F. Bryceson 2006:25). These poor hygienic conditions enhance the proliferation of water borne diseases thus tempering with the quality of drinking water in the area of study.

Plate 3.6. Children tempering with water quality

(a) Dirty water that can contaminate clean water (b) Driping dirty water poured by children that enters fetched water

Source Ngebung 2017

Generally, the quality of water in the different sources visited might have been portable but with the presence of young children plates 3.6 at water points, this brings to mind unanswered questions concerning the quality of water. From the behavior and activities of the children around water points, there is no doubt they are not educated on how to handle water to maintain its quality from the source to homes.

At homes, these same children after fetching water and transporting it in very unhygienic conditions, some of them create more room for further contamination by pouring the water in unwashed containers. After pouring the water in the containers, they proceed to using cups they do not really care have been washed or not in filling plastic mineral water bottles. All these habits create room for contamination while posing as a problem to the quality of water in the area of study.

Elsewhere in the quarters, there is no pipe born water leaving inhabitants with no choice than to look for alternative ways to get drinking water. In such cases as noted on the field, the

inhabitants drink water from wells and spring, the quality which is judged with their necked eyes. Water gotten from such sources especially during the rainy season as observed is not good for consumption but the inhabitants are left with no choice than consuming it. In effect, water quality standards are very essential when considering the safety of water for drinking. This is because water for drinking needs to be treated before it is labeled safe.

Water picks up debris such as fecal matter, leaves, microorganisms, toxic chemicals, as it flows through the earth crust. As such, water for drinking needs to be treated in order to remove impurities and pollutants. A distinction is made between potable water that has been treated to make it safe for human consumption and palatable water that is free from unpleasant color, odor, taste, turbidity, but is not necessarily safe for consumption. The inhabitants neglect such differences as they have it at the back of their minds that the clear color of the spring water, is an indication that the water is safe for drinking. With such perception, the population consumes water that is not safe. Such water sometimes is dangerous for human consumption, talk less of babies whose immune systems are still very weak. Portable water quality is not a thing to neglect as it can cause serious health problems and even death at times.

Here successive agencies manage water, for example, a drinking water whole seller with a modern well, a municipal water supplier CAMWATER and a local water distribution company (a Chinese NGO) with two boreholes – each agency takes responsibility for the quality of the water arising from its actions. This is quite contradictory as observed; water vendors get water from doubtful sources. Plate3.6 Shows a well dug and the reservoir erected with concrete pillars equipped with a tank and pump then referred to as “forage”. The owner though located in a marshy area where water is exposed to contamination, sells the water to consumers for drinking without regard to its quality and consequences on health.

Plate 3.7: Well dug in a marshy area, equipped with tank and overhead tank

Those who own these wells lure the consumers to believe that it is a borehole with good quality water. Desperately in need of drinking water, the consumers have no choice than to get the water to satisfy their needs. In such circumstances, it is important to throw more light on the characteristics of safe drinking water quality

3.4. Understanding the test result carried out on some drinking water characteristics

Water quality is determined by assessing three categories of water characteristics: Table 3.4 physical, chemical and biological characteristics. Analyzing test results for different combinations of these characteristics determines the quality of the water and whether further treatment is required before the water can be used for drinking purposes. Water supply in a community should be tested to determine the following characteristics as listed in Table 3.4 below.

Table 3.4: Required Characteristics of Drinking Water

Physical	Turbidity, temperature, color, taste, odor
Chemical	Inorganic (calcium, magnesium, iron etc.) Organic (pesticides, herbicides, petroleum)
Biological	Bacteria, viruses, algae

Source: Ngebung 2018

For the physical characteristics, the water should be colorles, have no noticeable odor or taste (which is not the case in the area of study as observed on the field).

Chemically, the water should be free of salts and minerals (this is known as soft water). The water should be noncorrosive and free from radioactive minerals and offensive dissolved gases.

The biological characteristics require that the water should be free of disease-causing microorganisms, including bacteria, viruses and algae. All these characteristics are interconnected. For example, turbidity a physical characteristic is related to the chemical components in the water.

Despite the dilapidated condition of the existing drinking water supply systems in Cameroon and the study area in particular, rehabilitating and extending them is a better option than building new network. This is due to the fact that the already existing networks are not delivering the desired results. This is due to the fact that supply of drinking water does not meet the demands of the population. This likened to insufficient management skills, limited finances coupled with the lack of will power which all contribute to poor water quality.

3.4. PHYSICAL CHARACTERISTICS OF WATER

The physical characteristics of water relating to the quality of water for domestic use associated with the appearance of water. They include: turbidity, temperature, color and odor.

- ✓ Turbidity

Turbidity is used to measure the clarity or transparency of water. It also expresses the degree to which light entering a column of water is dispersed or scattered by suspended solids. To understand if the water is turbid or not, as was carried out on the field, a glance on the water quickly answers the question. This is because the eye is very sensitive to determine if the water is clear or cloudy. Light entering water scatters because of small particles. This causes the water to become cloudy and to take on the color of the particles. Surface water is generally more turbid than groundwater as observed. Turbidity is particularly present after heavy rains or on windy days as particles are visibly suspended in water more than in normal days. The main particles responsible for turbid water are: silt, organic matter and algae. Though turbidity increases the cost of treating water, it can be effectively treated using physical methods such as sedimentation. This simply involves fetching water in a clean bucket and leaving it to stand still for some time. Then the particles in the water settle below the bucket. Then filtration which is passing the fetched water in a filter or a clean white cloth with very tiny pores to remove

particles or solids that are suspended, is done. The total solids content of water includes all the suspended, settleable, colloidal and dissolved solids in the water. In general, the total solids can be defined as any matter that remains as dry residue when water is evaporated at a temperature. These include leaves, tree branches, sand, papers and even plastic bottles as observed in the study zone. The total solids can be classified into filterable and non-filterable solids. Solids found in water as observed in the area of study are both organic and inorganic.

Organic solids are those that will react with bacterial and other organisms to decompose with time and can be burned. These in the study environment included animal or vegetable matter, wood and paper. While inorganic solids, are those substances that do not react with other organisms and therefore will not decay. They include substances like sand, gravel and minerals left when a water sample is evaporated.

Total suspended solids are those that float or are suspended in water following the analysis shown on Table 3.3. Suspended solids here include insoluble solids that are large enough to remain visible and separated from the water, including debris such as clay, silt, oil, pieces of wood, plastic papers, sand. Suspended solids are the main cause of turbidity.

To better check the suspended solids in the water samples, a filter paper is used. A scale is used to weigh the paper before and after filtration. The readings are then recorded. This facilitated the work as figures for dissolved solids and total solids are gotten as seen on the table. Total dissolved solids also include colloidal solids not large enough to settle readily, nor small enough to dissolve in water. Colloidal solids are mainly organic and decay faster. They also include dissolved solids too small to be physically removed as minerals from the water; such are salts and minerals from disintegrated organic and inorganic matter.

Table 3.5: Analysis of some Water sources in the Study Area

	Areas Sampled								
Parameters analysed	Oumaru spring - ASEC	Spring behind Texaco Obili	Spring last pole (Etoug-Ebe)	Spring ITIE (Etoug-Ebe)	Spring TKC	Well (Behind camp GP)	Well TKC	Well Handicap Center	Normal values
Ph	6	6.8	6.2	7.2	6.6	6.5	6.8	6.8	6.8-7.5
Temperature	28°c	28°c	29.2°c	30	29°c	27°c	28°c	28°c	
Total suspended solids	9mg/L	13mg/L	12.2mg/L	13mg/L	11.3mg/L	9.5mg/L	12.5mg/L	11mg/L	
Total dissolved solids	7mg/L	8mg/L	9.8mg/L	9.4mg/L	8.5mg/L	6.5mg/L	10mg/L	9.5mg/L	
Turbidity	moderate	abundant	scanty	scanty	Very turbid	moderate	scanty	scanty	
Color	colorless	colorless	colorless	colorless	Slightly	Slightly	colorless	colorless	
Total Feacal coliforms	180+	180+	180+	40	150	160+	180+	40	0-10
Feacal streptococci	00	00	00	00	00	00	00	00	0-10
Escherichia coli	108	40	50	06	8	175	5	03	0-10
Shigella	00	00	00	00	00	00	00	00	0-10
Vibrio Cholera	00	00	00	00	00	00	00	00	0-10
Conclusion/ comments	Grossly contaminated	Grossly contaminated	Grossly contaminated	Unacceptable for consumption	Highly contaminated	Highly contaminated	Grossly contaminated	Unacceptable for consumption	

Source: Fieldwork

From the table it is quite obvious that most of the springs in the area of study are grossly polluted and unacceptable for consumption following the laboratory analysis carried out on some springs and wells. As such, it is advisable to look for alternative sources of drinking water. It is also advisable to carry out repair works that are necessary for the springs and wells to make them suitable for consumption. Above all ensure the treatment of water at household levels before drinking is considered. To ensure HWTS are fully implemented education and sensitization is indispensable to minimize risk of infections from water borne diseases.

- ✓ **Water temperature**

Water temperature is easily measured with the use of a simple thermometer.From laboratory analysis, a thermometer is used to determine the temperatures of the water that is sampled. After getting the temperature which ranges between 27°C and 30°C as on Table 3.3, it is recorded and kept aside until all the other parameters are completed. Warm water, (38°C and 40°C and above), negatively affects the quality of water through a reduction of the amount of oxygen. It also encourages the growth of some organisms, which can endanger plants and animal species. This is one of the reasons for which temperature is very vital when analyzing water quality. Sudden introduction of warm water due to runoff flowing over streets causes a rise in temperature. This is known as thermal pollution. Besides the adverse effect of high temperature on water, it also leads to unpleasant odor and taste as observed on the field. However, very cold water is difficult to treat as chemical reactions take place more slowly at

lower temperatures. The optimum temperature for public water supply varies according to the local climate. This is to be taken note of when deciding on treatment processes.

- ✓ **Color**

The population as observed on the field, does not border testing their water with sophisticated equipment to determine if the water is safe for drinking or not. Instead naked eyes are used to assess the color of water. If the water is colorless then it is good for consumption. On the other hand, if the water has color is not good for consumption. This is complicated because, at times the water is colorless but heavily polluted and vice versa as noted on the field. The color, taste and odor in water in the area of study is caused by decaying organic matter. Pure water is colorless. Color in water is also caused by colloids dissolved solids or chemicals that are present in water. Steps are often taken to remove color, taste and odor to improve the water palatability.

3.5 CHEMICAL CHARACTERISTICS OF SOME WATER SOURCES ANALYZED IN THE LABORATORY

Many dissolve chemicals exist in water and many of them are of concern to human health. Chemical characteristics of water involve the organic matter, minerals, nutrients, metals, chemicals and gases in the water.

- ✓ **The required pH value of water**

This is one of the most commonly measured chemical attributes of water. It can range from 1.0 (acidic) to 14.0 (base or alkaline). It is the measurement of the acidity of water using a pH indicator or meter. Following a laboratory analysis carried out on the field, the pH values ranged from 6.0 to 7.2. Pure water is neutral and has a pH value of 7.0. Water with a pH value of more than 7 is considered alkaline and water with the pH value below 7 is considered acidic. Surface water usually has a pH range of 6.5 to 8.5. The pH value of water often determines the effects of other chemicals in water. During the treatment process of water, low pH causes corrosion in pipes and makes chlorination very difficult. To remedy this situation, lime is added to the water in order to raise the pH value. Following findings on the field, the pH value from sampled sources ranges from 6.0 to 6.8 on the field.

✓ **Hardness**

This is the mineral content of the water. For water to be termed hard, it contains great quantities of calcium and magnesium salts although other minerals like iron and aluminum contribute to water hardness. Minerals are significantly predominant in groundwater, as they dissolve in to the water as it percolates through the underground limestone also known as (calcium) and dolomite known as magnesium (according to inspiration drawn from class work). For this reason, surface water tends to be softer than groundwater. Hard water has its own effects. It damage cloths, act in response with soap to form lathering, unfriendly on the skin, leaves marks on baths, and deposits scale in kettles when boiled.

✓ **Chemicals**

- **Chloride**

This is a salt compound present in water. It penetrates surface water sources through wastewater from homes and agronomic runoff. Chloride can alter the salty nature of water and even destroy aquatic life. It also contributes to corrosive effects of water and can affect the taste of food products. Thus, water used for manufacturing food products must be free from chloride. In the case of drinking water, chloride must be kept low to prevent saltiness of the water as is the case in the study area.

- **Metals**

Water contains a variety of metals, such as iron, lead, magnesium, copper and barium. The tolerable concentrations of these minerals in drinking water are limited to prevent harmful effects to human and animal as well as equipment. Iron for example needed by both plants and animals for the transportation of oxygen in the body is often present in ground water in a soluble state in the form of ferric hydroxide. When exposed to air, it is easily oxidized to ferric iron which is insoluble forming deposits on pipes and tanks. These deposits pollute the water and make it not safe for consumption.

- **Nitrogen**

It is one of the most abundant elements on earth. It constitutes about 80% of the air human's breath. Nitrogen and phosphates if introduce to streams and rivers in high concentration may lead to eutrophication. In warm blooded animals, including humans, nitrate reacts with hemoglobin to produce methemoglobin, which inhibit the ability of red blood cells to transport oxygen. This raises concern especially for babies below three months old as their immune system is not yet stable.

- **Dissolved Oxygen**

It is the quality of oxygen gas dissolved in a given quantity of water at a specific temperature and atmospheric pressure. The concentration of dissolved gases in water varies (oxygen, carbon dioxide, nitrogen, methane and hydrogen sulfide). The concentration of dissolved oxygen in water is used as a parameter for testing water quality. Dissolved oxygen enters the water from the surrounding air.

- **Fluoride**

It is a mineral that is commonly found in water essential for human health. It is particularly important to maintain bones and teeth. Due to this, drinking water is always treated to maintain the level of fluoride. A high concentration of fluoride in drinking water can led to teeth decay. High concentration of fluoride can equally be harmful, leading to spotting and discoloration of teeth, brittle teeth and bones. Fluoride is the only chemical added to drinking water for the purpose of medication. All other treatments are added to improve the water quality and safety.

3.5.1 Biological Characteristics of some water sources analyzed in the laboratory

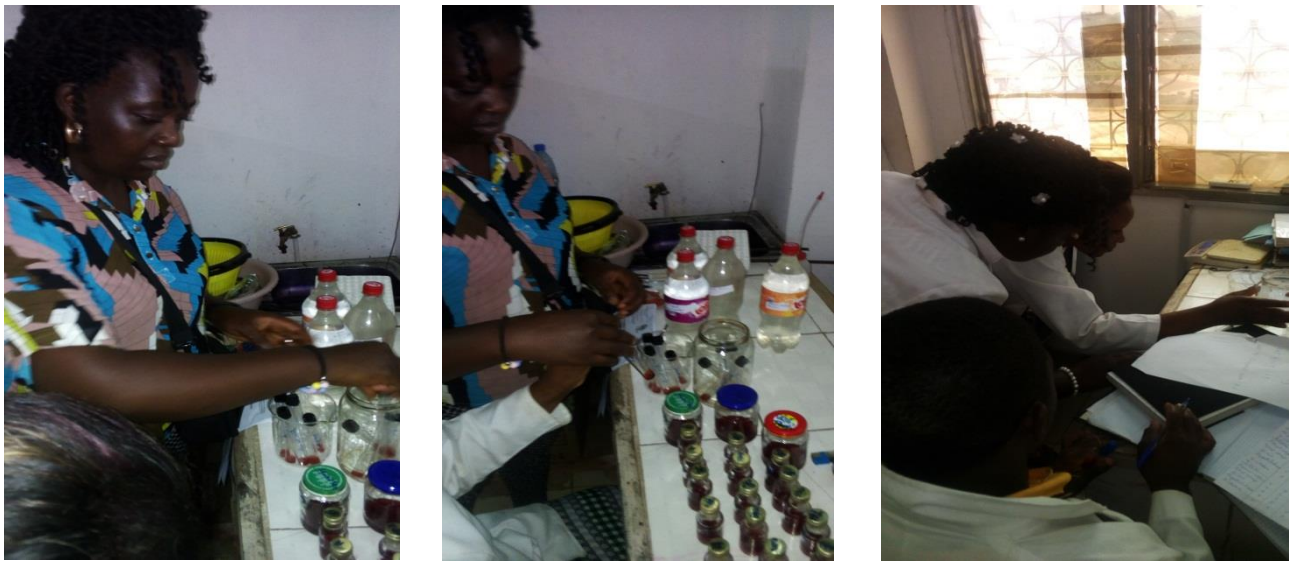
Biological components of water are a number and type of living organisms present in a water body. This ranges from microorganisms to algae, insects, worms etc. A particular type of micro-organisms called bacteria is of specific interest for measuring water quality. As concerns the laboratory analysis carried out to confirm the presence of bacterial in water; Coliform bacteria (that is rod-shaped bacterial) the Most common type of bacteria in contaminated water, found in fecal matter (present in intestines of warm-blooded animals like birds and mammals), Many of them convert lactose to lactic acid and CO_2 gas e.g. Escherichia coli (E. coli), E. albertii, E. vulneris. The Presence of coliforms in water indicate that the water is contaminated and not safe for drinking. Bacterial in this case is classified in to two; pathogenic and non-pathogenic.

Pathogenic bacteria known as pathogens can cause water borne diseases. It gets into water from feces of infected humans or animals. They can cause unpleasant diseases like diarrhea. Water containing such pathogens is not suitable for drinking. The presence of bacterial in water can be detected using multiple tube fermentation or membrane filtration.

The multiple tube fermentation plates 3.8. is used to determine bacterial in water. MacConkey agar (a selective and differential culture medium for bacteria) or broth. It is designed to selectively isolate Gram- negative and enteric bacteria (in intestine of animals or

humans) and differentiate them based on lactose fermentation. Lactose fermenters turn red or pink on macConkey agar and non-fermenters do not change. Multiple sterile tubes five in each sample of water, water samples are needed. A bottle of broth is supposed to have an inverted Durham tube for the collection of gas and to make sure there is no air bubble. In case there is an air bubble, then it must be inverted to permit the air to escape as noted in the laboratory on the plates 3.8 below.

Plate 3.8: Laboratory Analysis of Water



Source: Ngebung 2019

Procedure to measure bacterial in water

Prepare a serial dilution of each water source (except tap water) sterilizing the tubes and bottles (autoclave for 15 minutes until it reaches 121°C) and allow to cool. The cap is removed and the mouth of the tubes and bottles are flamed. In each tube of broth of 1ml, with the help of a sterile pipette 1ml of water is added in the 5 tubes.Stock 1/10 1/100 1/1000 1/10,000 1/100,000 1/1,000,000, (Each dilution: 9 ml clean water and 1 ml of previous dilution, first dilution: 9 ml clean water and 1 ml of stock water), Dispense 1 ml of each dilution onto the 3 Petrifilm count plate, incubate at 35 - 37 °C for 18 -24 hours, without fastening the caps of tubes and bottles which gives room for bacterial to grow.

After incubation each bottle or tube that has the sign of gas is examined and counted (indicated by a collection of bubbles in the Durham tube) or acid (production of acid will alter the color of MacCONKEY broth from purple to yellow).

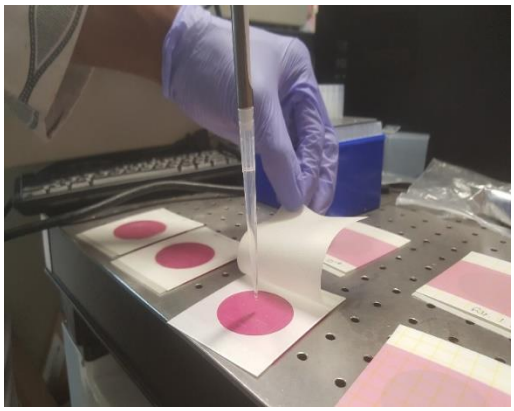
Procedure to count the number of bacterial colonies in each plate;

Bacteria concentration in water sample (litre) = Number of bacterial colonies / volume of sample dispensed x dilution factor

Unit = colony forming units per ml (cfu/ml)

In this case, spring and well water is used. The water is pre filtered using the locally made saw- dust and clay pot filter. Serial dilutions that is in test tubes are used. 1ml is dropped in the paper.

Photo 3.5: Pre Dispensing -Filtered and Filtrate onto Petrifilm

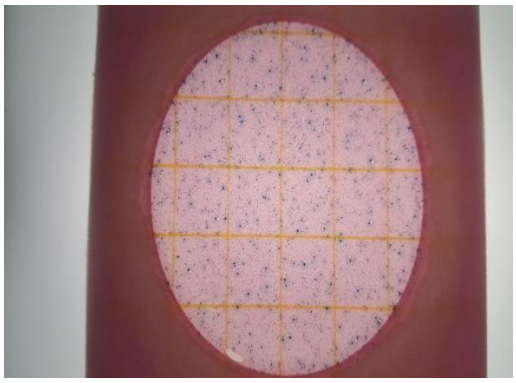


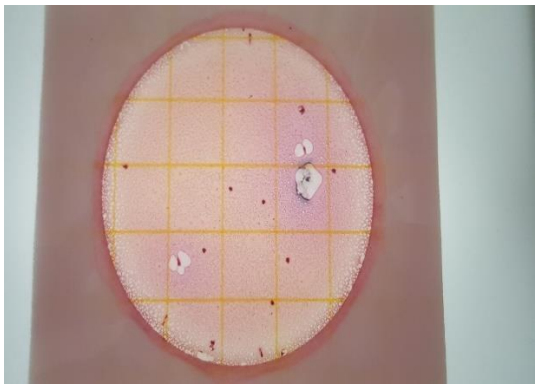
The dilutions plates 3.5 are then put in an incubator where the bacterial will grow and multiply in their numbers. The temperature must be 35°- 37°C and this must be in the incubator for 18 to 24 hours.

Photo 3.6: Incubator, incubating the solutions

After 24 hours, plates 3.6, it is now time to count the bacterial colonies. The papers are then removed from the incubator and placed on a flat surface where the counting is done. When counting the bacterial only those with bubbles should be counted. In this case, only 3 bubbles are visible. So the three were counted and subtracted from the 800000 to have the final result.

Plate 3.9: Petrifilm papers





1/1000 dilution **count = 3**

Dilution factor = **only those having bubbles are being counted**

Now take the 1/ 10, 1/100, 1/1000 dilution from the incubator etc plate 3.9 and count the bacterial with bubbles. Count and average number of squares multiply by 20

160/4= 40 colonies per square

40 x 20 squares = 800 colonies

800 x 1000 = 800,000 cfu/m

Bacteria Removal Efficiency

= (800,000 – 3)/800,000 x 100%

= 799,997/800,000 x 100%

= 99.9996%

This result indicates the fact that after testing the water sample, it is 99.9% free from bacterial. In effect the water source is safe for drinking.

Another way to determine the most probable number of fecal coliform bacteria in a sample, the probability table below is made use of.

Table 3. 6: Probability table for estimating the MPN of fecal coliform bacteria

Volume of sample in each bottle:	50ml	10ml	1ml	
Number of bottles used:	1	5	5	
				MPN/100ml
	0	0	0	0
	0	0	1	1
	0	0	2	2
	0	1	0	1
	0	1	1	2
	0	1	2	3
	0	2	0	2
	0	2	1	3
	0	2	2	4
	0	3	0	3
	0	3	1	5
	0	4	0	5
	1	0	0	1
	1	0	1	3
	1	0	2	4
	1	0	3	6
	1	1	0	3
	1	1	1	5
	1	1	2	7
	1	1	3	9
	1	2	0	5
	1	2	1	7
	1	2	2	10
	1	**2**	**3**	**12**

Source: Ngebung 2019

If the count of most probable number of faecal coliform bacteria is 0, then the water is excellent for drinking. If the count is 1 to 10, the water is also acceptable for drinking but regular sanitation checks are needed. If the total count for faecal coliforms is 10 to 50, the water is

unacceptable for drinking and then treatment is required before drinking as noted on the field appendix 3. If the count is more than 50, alternative sources, carry out necessary repairs and disinfection at household level is advised.

Note that when counting the bacterial only those with bubbles are counted. Therefore, only 3 bubbles are visible. So the three are counted and subtracted from the 800000 to have the final result. It is advised to always use a Petrifilm that is easy to clearly count the colonies of bacterial.

In this chapter, the different characteristics of water which are very vital for safe drinking are examined. Here it is noted that a combination of physical, chemical and biological water characteristics is used to determine water quality. This is contrary to the perception of the inhabitants of Obili and Etoug- Ebe where their necked eyes do it all for them. No single characteristic of water gives a clear indication of water quality as indicated by the laboratory findings. Gaining an understanding on the various variables used to measure water quality and its effects, water treatment options are brought forth in the next chapter. These water treatment options are applied to improve water quality and assist in safety and portability for drinking.

The standards (maximum acceptable concentrations or treatment goals) discusses here are based on a comprehensive review of the known health effects associated with each contaminant. It also emphasis on exposure levels and on the availability of treatment and analytical technologies. Appealing objectives (e.g., for taste, colour or odour) are provided when they play a role in determining whether consumers will consider the water drinkable.

The problem of contaminated water is the single biggest cause of the steep decline in life expectancy in Africa. However, there is also a need to ensure that the water is pure at the point-of-use. As such solutions include the use of locally available materials to aid in the amelioration of drinking water quality. In this light sustainable solutions such as those represented by the Filtròn clay filter in (chapter 4) that integrate technology and entrepreneurship are unavoidable.

B. WHY PEOPLE DRINK WATER FROM DOUBTFUL SOURCES

A recent increase in the urban population of Yaounde has brought forth numerous undesirable effects. This has led to untold increase in cost of living and hardship. Basic necessities are very expensive and difficult to come by following the crisis plaguing the economy. Water being a basic necessity can be very scarce at times. Insufficient supply of water and sanitation services is rampant. Despite the efforts made by water supply agencies to supply these services, the situation still remains deplorable especially in the low class residential areas

like in Obili and Etoug -Ebe. There is usually little or no integration between the poor and the rich. The rich continue to settle in the rich quarters (like Bastos) with all the basic amenities while the poor can only afford to stay in the poor quarters (like Obili, Etoug- Ebe). There are still rampant shortages of water and most often the water is not of good quality because of pollution and contamination. This greatly affects the health of inhabitants of these neighborhoods. Even with the presence of HYSACAM (hygiene and sanitation company), waste disposal is still a problem with heaps of dirt almost everywhere in these poor quarters. Some of the quarters are not well served by roads, so they become inaccessible for the vehicles to collect the waste. To worsen the already bad situation, frequently waste from toilets is being drained into nearby streams. Some quarters like behind Texaco Obili experience permanent stinking odor. This doesn't only affect the atmosphere but also the land and water resources which accounts for the deplorable health condition of the inhabitants. Some of the reasons why people drink water from doubtful origin are:

1. **Natural Environment**

The natural environment around the area of study is a problem to the population. As already said, the area is constituted of marshes which are prone to floods. Toilets drained into streams where waste is dumped. All this dirt further blocks water channels causing flooding and pollution of the environment and water sources. During the rainy season, the roads are slippery while in the dry season, they are dusty. This hinders easy access to water points facilitating the use of water from doubtful sources. Furthermore, the steepness of slopes and the narrow accidental roads in this area of study do not make things easier as descending the slopes to fetch water is tedious and exhausting. Descending these slopes as observed on the field is not a guarantee of getting drinking water (by an inhabitant). Other inhabitants lamented that the young children who go fetching water mishandle the water sources. A reason for which, inhabitants turn to nearby sources where access is easy despite being aware of the associated health risks.

2. **Intermittent Water Supply.**

Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Insufficient investment in the water sector in Cameroon has led to untold consequences. This is evident with the persistent rationing and intermittent water supply in the study environment. Each day, before most of the inhabitants are out of bed in the morning, taps have already stopped flowing. Water returns quiet late in the night (about 10. p.m.). This is

when the population is fortunate enough. At certain moments, water may start flowing at midnight. As such, households which are fortunate enough to stay alert wake up to fetch water at very unholy hours. The quantity of water fetched is hardly enough in a day for large families. The inhabitants expressed their frustrations on how they incur extra expenditure to purchase drinking water out of their little income. This situation is more problematic because there are some individuals who contributed, deposited documents and paid for potable water connection at CDE but have never been connected (said a local chief in Etoug - Ebe). This is an expression by an individual on how they suffer daily to have drinking water. Another individual in Obili, expressed how they queue up in front of taps with very low pressure, desperately waiting for their turn to get some water which is payable. This therefore leaves people with no option but to go hunting for the precious good in doubtful sources to meet their daily needs.

3. Population Increase and Ethnic composition

Yaounde the capital city of Cameroon is comprised of about 180 ethnic groups with the Beti being the largest group. Presently they no longer comprise a majority except in the rural areas. Cameroonians from other parts of the country are slowly occupying the semi urban areas precisely the Bamilikes of the Western Region. This is due to housing problems. Yaounde is made up of different quarters which are characterized by social, historical backgrounds, and ethnicity. Bamelike are mostly in Mendong. Anglophones from North West and South West are mostly concentrated at Biyem-assi, Obili and Melen. In the out skirts of Yaounde are found migrants from other parts of the country. Muslims are in Briketerie neighborhood. The autochthons (the Beti people) live around the city center in quarters such as Mvog Betsi, Mvog Atangana Balla, Mvog Ada, etc which are typical Beti names with Mvog Meaning Mountain. There are also administrative quarters for civil servants, top governments officials as well as military camps. The central town of Yaounde is made up mainly of government offices. Foreigners, especially from developed countries and other diplomats live in high class residential areas of Bastos and this is where all the foreign embassies are located. This population increase and diverse ethnic groups as well as social discrimination play a role in quality and quantity of drinking water in the study zone. This is backed by the fact that different ethnic groups differ in the way in which they handle and store drinking water. Also, the less privileged quarters resort to doubtful water sources while the high class residential areas get tap water, mineral water or can afford water from boreholes contrary to the low class residential areas.

4. Poor Water Supply Engineering.

Water sources are not distributed evenly around the world. Even within a particular country, complex water collection, treatment and distribution systems have been developed to transport water from natural water sources to consumers. As population increases, the demand for water increases. Water supply engineering systems are quiet complex to design, construct and maintain. The purpose of water supply systems is to collect water from a source, treat the water to make it suitable for use and to distribute the required amount of water to consumers. This comprises of four different steps:

- ✓ **Collection works** which involve collecting sufficient water from a source to meet demand with the use of advanced technology.
- ✓ **Conveyance works** where water is being transported from the source to treatment works through pipes.
- ✓ **Treatment Works** in which water is being treated using the physical, chemical and biological means to make it fit for human consumption (potable), as well as other uses.
- ✓ **Distribution works** which is a step for distributing treated water to consumers. This stage is quiet delicate because if the piping engineering is not properly done, then contamination is unavoidable.

It is quiet complex and expensive to carry out these four tasks. For these reasons, when planning water supply systems both the current and the future water demands must be considered. This has not been the case in the study zone as justified by current digging all over the town to replace smaller pipes with larger pipes. Elsewhere as noted on the field, pipes were leaking, deteriorated especially the iron pipes, others broken with the leaking water contaminating the one flowing through the pipes. Some of these pipes are shown in Plate 2.18. The color and odor of water disturb the inhabitants psychologically leaving them with no choice but to get water from other doubtful sources.

Plate 3.10: Exposed and broken pipes



(a) Exposed pipes, (b) Pipe broken because of digging (c) Pipe broken by car exposed.

Source: Ngebung 2018

Water engineering in the city of Yaounde is still very poor as pipes are exposed on roads surfaces. Some of the pipes use to convey water is rusting and psychologically it does not encourage the inhabitants from drinking water in such conditions. At times when these pipes are broken, it takes very long for them to be repaired leaving those connected without water for weeks and sometimes months.

5. Absence of Regulatory Agencies

Many countries in the world today especially the developed countries have set up regulatory agencies for infrastructural services, such as water supply, sanitation and other structures. This is to effect the protection of consumers and boost output. These agencies are entrusted with different responsibilities and task such as:

- ✓ Approval of tariff increases;
- ✓ The management of sector information system; and are
- ✓ Mandated to settle complaints by consumers (mostly those not handled satisfactorily by service providers).

These specialized agencies are expected to be more reliable, efficient and objective in regulating service providers than departments of government ministries. These agencies need to be autonomous. Unfortunately, in most countries like in Cameroon, autonomy is not always exercised because of administrative bottlenecks. It is a bitter peal to swallow that Cameroon does not have agencies which regulate fundamental a sector like water. The service provider for Cameroon is regulated by local government or central government (Progress on Sanitation and Drinking-water: 2010 Update, UNICEF, WHO/UNICEF Joint Monitoring Program for

Water Supply and Sanitation). Following this, the inhabitants of the area of study turn to drink water from uncertain and contaminated sources despite the devastating effects on their health.

6. Urban Poverty

An increase in the urban population of Yaound especially in Etoug – Ebe and Obili has brought forth numerous problems. This is because of the poorly managed nature of the city. Consumption and production patterns are unsustainable. This has therefore led to untold increase in cost of living. It is very difficult to have three square meals a day because life is very expensive. Basic needs as well as facilities are very expensive. Water being one of the necessities of life can be very scarce at times. Keeping a section of the town without water supply throughout for several days, week or months has become the order of the day. Rationing has just become normal. Also since the privatization of the company, water bills have become exceptionally high above the level of the urban poor. Most of them have resorted in stealing water through constant pipe breakage which is a great offence; others turn to contaminated water sources for livelihood. The per capita income in Cameroon is very low. The effects of the structural adjustment program, coupled with the effects of the economic crises, about 48% of the population lives below the poverty line (2011 Human Development Index) of less than a dollar each day. In addition to these the high rate of immigration in to cities by youth from the war infested zones and refugees from neighboring countries have worsened the situation.

7. Development of Spontaneous Quarters

The governance of Cameroon over the years has greatly affected its development. Yaounde being the capital city of Cameroon would have been well developed for other regions to draw their inspiration from. Unfortunately, this is not the case with the city center portraying a colonial architecture and urbanism. This plays a key role in shaping the spatial and social structures of Cameroonian cities during the 19^{th} and 20^{th} centuries. For example, Yaounde developed as a colonial city. The Germans came to Yaounde in 1888 and started changing some areas into urban settlements. Areas occupied by the Europeans at that time were considered urban because they had the necessary services. They build infrastructure such as schools, hospitals, prisons, churches, water points and agricultural warehouses. The transformation of the urban landscape in many African cities involves social production and social construction of the urban space which gives symbolic meanings. Yaounde faced the problem of post-independence centralization, since all the government offices were located in Yaounde. This centralization led to high levels of corruption, mismanagement of government funds, insufficient accountability, insufficient democracy which affected the city and the country at

large negatively. A glaring failure of the Cameroon government is the complete neglect of town planning. Though much effort is put in place, some of these problems still persist. This means that much still has to be done.

To ensure the sustainability of the city, planning should be encouraged at all levels (bottom –top and top bottom approach). The shortage of housing has pushed the urban poor to use their available resources in the construction houses on environmental risk zones (marshes "elobis"), slopes of hills, flood prone zones, restricted zones, with private individuals gradually transforming and rehabilitating the city space to suit their own desires. These mutations especially by the urban poor have negative consequences. The urban poor in quarters like Etoug – Ebe and Obili mobilize their resources to make available their basic necessities like building their own drinking water points, filling potholes on roads which are narrow and accidental, putting street lights at dark corners using poor connection and even organizing anti-gang movements to fight against arm robbery. On the other hand, lack of cooperation in some other quarters has increased the level of slums especially construction patterns and waste disposal around drinking water sources. The rapid emergence of these spontaneous quarters renders it difficult for CAMWATER to provide its services. Also, unauthorized settlement areas and the nature of the landscape is a handicap for the water supply system to reach there. Thus this a reason why people drink water from doubtful sources.

8. Limited Education and Information on Safe Drinking water

Safe drinking water is collected from different places and sources by the water utilities company CAMWATER and distributed to the consumers. These sources include surface water sources like rivers, lakes, canals and reservoirs. When this water has been collected from the source, then, treatment follows. This is to be convinced that the quality of the water is now safe and suitable for drinking. To do this, assessing three categories of water characteristics (physical, chemical, and biological) is very vital. Analyzing test result for different combinations of these characteristics determines the quality of the water and whether further treatment is required before the water can be used. Water treatment involves a number of processes depending on the source of water. Water taken directly from a natural source is known as (raw water). For this water to be distributed for human consumption, suspended particles are removed using pre-treatment processes:

- ✓ Screening (to remove large suspended solids) to improve turbidity
- ✓ Degritting (to remove sand, gravel and other abrasive materials)
- ✓ Chemical treatment (to remove major pathogens and pollutants).

- ✓ Pre- conditioning (to reduce harness and PH)
- ✓ Filtration (to removed additional suspended particles and microbiological contaminants)
- ✓ Disinfection (to remove pathogens).

The, inhabitants use chlorine or chlorine-based disinfectants with very limited knowledge on the quantity and quality of the chemical. This is as a result of poverty and limited knowledge due to limited education and sensitization on the quantity of chlorine to be added to a given quantity of water. The quality of chlorine to be used in the processes, to obtain safe drinking water at household level must also be known. More emphasis needs to be laid on household water treatment methods and safe storage (HWTSS). If this is done, it will go a long way to ease the burden on households getting access to safe drinking water regardless of source. This is to say that if treatment processes are applied and followed up, then the burden of searching for safe drinking water will be reduced on the population. However Limited information and access to education on household water treatment and safe storage renders it difficult for the population to handle drinking water properly without contaminating even if the water is potable.

CONCLUSION

This chapter outlined the different water sources and the reasons people drink water from uncertain and contaminated sources. It also paves the way for the third chapter which will be dealing with problems encountered by the urban poor having access to a reliable and safe drinking water sources. It also elaborates the effects of drinking water from doubtful sources and their subsequent effects on the population.

CHAPTER FOUR

HOUSEHOLD WATER TREATMENT AND STORAGE AS A SOLUTION TO DRINKING WATER PROBLEMS

4.1 Introduction

There is urgent need to handle the numerous problems involved with drinking water from doubtful sources. These problems as seen in chapter two are numerous and varied. Even when water is purified at source, there are often cracks along the water pipeline and those cracks give rise to contamination of the water on route to the taps. In many cases, people don't have confidence drinking the water that comes out of the taps, so the big issue then is how the water can be purified at the point of use. This brings to mind the motivation about alternative solutions now that water that is drinkable has to be water that is not contaminated with e coli other bacteria and chemicals. There is therefore an urgent need to think about ways in addressing these problems and its potential impact on the health and well-being of society. So looking at these problem and putting it into context it's interesting to look at just the number of lives lost per day due to problems of contaminated water where children across Africa and many parts of the world go and fetch water from streams and ponds.

The implementation of appropriate, simple, effective and affordable methods to treat and safely store non-piped water is a suitable response to these problems as will be discussed in this chapter. Household water treatment is the one that is done at the point of water collection or use, rather than at a large, centralized location. Household Water Treatment and Safe Storage (HWTS) is an important public health intervention. It improves the quality of drinking-water and reduces water borne diseases, particularly among those who rely on water from unimproved sources, and in some cases, unsafe or unreliable piped water supplies in the area of study. Different methods and strategies of household water treatment and safe storage are examined here.

4.2 Household Water Treatment and Safe Storage Methods

An important requirement in maintaining an effective and sustainable drinking water system is having sufficient knowledge about HWTS. It is quiet glaring from the field that inhabitants possess very limited knowledge on these methods. This therefore brings to mind the need for HWTS. In this light, different methods to treat water and make it safe for drinking at home that if given a chance will be implemented in the study area to solve these problems. HWTS provides a solution, if employed correctly and consistently.

For managing water safely at home, Clasen (2008) presented his results on the status of HWTS in 54 countries based on the data from the Joint Monitoring Program. HWTS practices – like boiling, chlorination, and filtration, provide an interim solution for managing water safety at home if carried out consistently and correctly.

This is therefore an indication that, these methods used for treating water at home and safely storing it can be examined and applied in the area of study. People have been treating drinking water through filtration, boiling and coagulation for centuries. However, in recent years, the availability and promotion of diverse HWTS products has increased remarkably. Despite the introduction of diverse products, boiling and chlorination stand out as the only HWTS practices literally known in the area of study to achieve encouraging results.

Some of the methods which if properly applied can aid in solving the persistent problem of drinking water from unknown sources in this study include: physical processes such as sedimentation, filtration, disinfection and distillation (Figure 4.2); biological processes such as slow sand filters; chemical processes such as flocculation and chlorination; and the use of electromagnetic radiation such as light. At this point the physical processes on figure 4.2 are going to be examine.

Figure 4.1: Physical processes for HWTS

Source: Ngebung

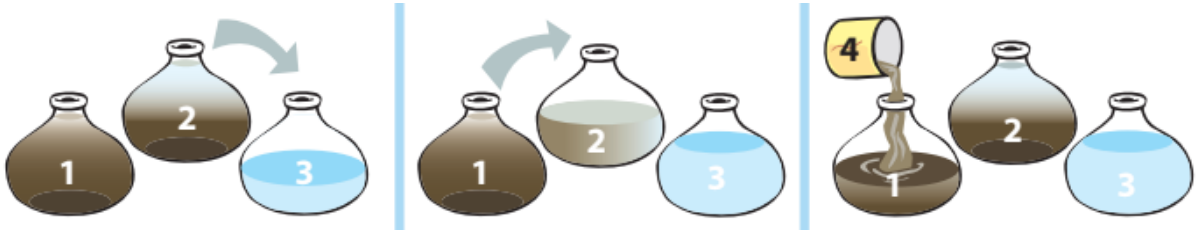
4.2.1 Sedimentation

Sedimentation is a very easy, practical and cheap physical process in making water safe for consumption. It requires a clean container or a bucket preferably with water from a source. The container of fetched water is made to sit without moving for 24 hours. Then the clear water is poured into a clean container. The process can be repeated for 2 to 3 times depending on the clarity of the water. The water will look significantly cleaner than when it was fetched. The dirt in the water settles at the bottom of the bucket leaving the water clearer. By simply letting the water settle for some time, all the heavy contaminants get accumulated at the bottom. This reduces turbidity to a great extent. There are different methods of sedimentation as in the subsequent paragraphs.

- **The three-pot method**

This method figure 4.6 is a very easy way to reduce risk and contamination in household water as it is generally faster and less expensive to implement. Before starting each of these processes, hand washing with clean water and soap is highly recommended. A clean cloth and four clean pots or buckets are needed. After the water is collected from the source, it is strained with a clean cloth before the three-pot treatment begins. A fourth pot or bucket, is always used to collect water from the source.

Figure 4.2: The three-pot treatment system



Source: Adapted from International Federation of Red Cross and Red Crescent Societies (2008)

Each day when water is brought to the house:

- ✓ Drink the water from pot 3.
- ✓ Slowly pour the water stored in pot 2 into pot 3.
- ✓ Wash pot 2 with clean water.
- ✓ Then pour water collected from the source (bucket 4) into pot 1.
- ✓ Use a clean cloth to strain the Water through if possible.
- ✓ Allow the water to settle for a day and then repeat the process.

Only drink water from Pot 3. This water has been stored for at least 2 days, and the quality has improved. Periodically this pot will be washed out and may be sterilized by scalding with boiling water. Using a flexible tube to siphon water from one pot to another disturbs the water less than pouring.

The three-pot method has positive and negative aspects. The three-pot system greatly reduces dirt and disease-causing germs in water. This method is low cost, easy to use, and is something people can do themselves with local resources. This method reduces, but does not totally remove, disease causing germs. Boiling, chemical, or solar disinfection is still needed to completely remove all risk of disease.

- **Chemical sedimentation**

Chemical sedimentation is achieved with the use of chemicals to speed up the removal of dirt from water. The most common chemical sedimentation products used in the area of study is Aqua tabs. These chemicals are useful, especially in floods, because they remove dirt from water and disinfects it. Both are suitable for household water treatment in emergencies. These products contain two chemicals. One chemical act like a glue and makes small particles stick together. This creates bigger particles, called floc, that fall to the bottom of the container faster. Then another chemical disinfects the clear water.

To treat water with Aquatabs:

- ✓ Open a sachet and add the contents to an open bucket containing 10 liters of water (1 sachet of is to treat 10 liters of water).
- ✓ Stir for 5 minutes, and let the solids settle to the bottom of the bucket.
- ✓ Strain the water through a cotton cloth into a second container, and wait 20 minutes.
- ✓ Then the water is safe for consumption.

These products can make muddy water safe to drink. There is a residual effect of disinfection, which gives protection against contamination after treatment. These products are more complicated to use and require more training and follow up. They are significantly more expensive per liter of water treated than other chemical disinfection products and should only be used when water is muddy or no other product is available. More than one container that is at least three is usually needed to properly use these chemicals.

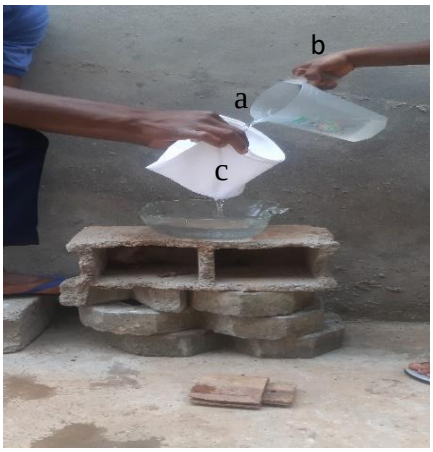
4.2.2 Filtration

Filtration is a rapidly growing field in water treatment. Filters are to remove dirt from water by physically blocking them while letting water flow through. Water passes through a material such as sand or ceramic and harmful material is caught in the filter. There are different processes involved with filtration which all have an impact on the quality of the filtered water. Different types of filters are available and include; Cloth Filter, Candle and ceramic filter, Sand filtration, filtron clay filter.

- **Cloth filtration**

Straining is a simple method of filtration. It requires a white thick cotton cloth to properly retain impurities in the Water. The cloth to be used should not be too thick so as not to take a longer time to strain through. A bowl or bucket and a clean cup is used to scoop water from a recipient. The mouth of the bowl or bucket should not be very wide depending on the size of the cloth. If the cloth is smaller than the bowl, then one person can hold the edges of the cloth in a funnel shape while the other pour the water in the cloth to avoid drops of unstrained water to seep in, as shown in Plate 4.25.

Photo 4.1: Cloth Filtration



Source: Ngebung

In this plate, a – is a clean white cloth used to strain water through, b – is a clean jar used to scoop water and pour into the cloth for straining, and c – is a recipient of strained water. This kind of filtration will eliminate the main solid and impurities from the water as well as any insect larvae that it may contain.

- **Candles and ceramic filters**

Candle and ceramic filters Plate 4.2 are the most commonly used filters as observed on the field. The operation of a ceramic filter is very simple. All it takes is to purchase one, wash it with clean water and soap, and fill it up with water. The water then passes through the ceramic in to a storage container below. This also acts as a safe storage. The filtered water is then collected through a tap attached on the filter. Most of these filters require constant and proper cleaning as the filtered particles can obstruct the proper functioning of the filter.

The process of filtering water through a home filter do not require extra effort as it is quite easy. Ceramic filters need constant and proper cleaning without which it will clog and be slow. Cleaning such filters requires dismantling as on plate 4.26. After dismantling each segment of the filter is washed.

It is scrubbed clean with a brush or soft sponge, clean water and soap as on plate 4.2. If possible, the filter should also be boiled to kill germs that cause disease that are caught in the filter. The dirtier the water is, the more frequently the filter will need to be cleaned. Eventually the candle will be worn away from scrubbing and must be replaced.

Plate 4.1: Candle filters and cleaning

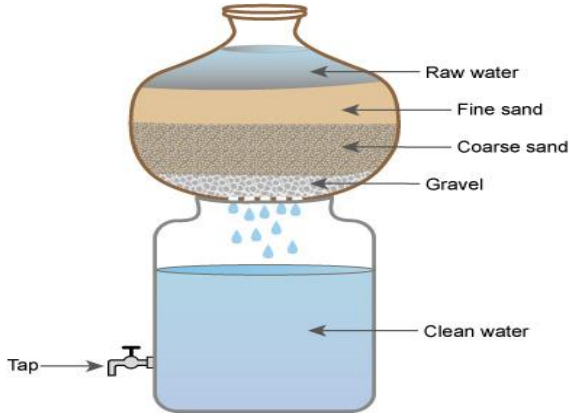
Source: Ngebung

In Plate 4.2, a – shows a clog ceramic candle filter, b – shows the washing of the candles of filters with clean water and soap, while c - shows washed filter and candles. After cleaning the filter, it is assembled and again ready for use. When mounting the disintegrated filter proper care is needed as it is very fragile. If it falls, then it can be broken and useless. With the absence of ceramic filters others like sand filter can be manufactured and used.

Sand filtration

Filtration through sand is a fast and simple pre-treatment option that reduces the amount of dirt in water and makes disinfection more effective.

Figure 4. 5: Household sand filter system



Source. Adapted from Red Cross

Users pour water from one container through a container of sand with gravel and an opening or tap at the bottom. It also comprises a pot or plastic bottle and a storage vessel as in Fig 4.7. The water to be filtered flows into a storage container. This method is not expensive as the sand; gravel, containers and other materials are readily available in the environs. It is also simple and fast to use. It is effective at removing dirt and some germs that cause disease. This can make the other methods of treating water work better. Filtron clay filters is also an alternative to get safe drinking water.

- **Filtron clay filters**

The Filtròn water filter is a point of use water filter. The Potters for Peace is a nonprofit organization that helps communities to develop ceramic water filter like the Filtròn in Africa figure 4.8. It has impacted the livelihood of inhabitants in more than 30 countries in Africa. And why not Cameroon. Filtron filter is together with a tap and bucket.

Figure 4. 6: Filtròn Water filter

Source. Adapted from the Sustainable Engineering workshop series

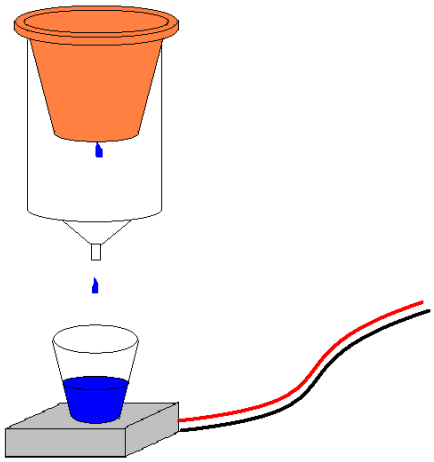
This filter is developed in Latin America and has been shared with many countries in Africa. Here a vessel is needed to collect the water. Inside it is a permeable ceramic made of clay and saw dust. Due to the fact that this ceramic is porous, when water is poured in, it fills the structure then, sieve through the pores and collects at the bottom of the filter. This process often takes time but during that time, the bacterial are excluded and collected at the bottom of the filter and the end result is purified water safe for drinking. In this light a sustainable solution such as that represented by the Filtròn clay filter that integrate technology are unavoidable. This is because it kills 99% bacteria as tasted and proven, Stress-free to use, easy for transportation, maintains taste of water, culturally acceptable, Self-made water container which permits serving, made with locally available materials, works all year round 24 hours a day and is cheap and affordable.

However, this filter has its own constrains; Cost, 4,938.2 FCFA to 16,460.65 FCFA (depending on country), Heavy compared to the other systems, fragile, easy to break, periodic cleaning is required (turbid water clogs the filtering element), burning for the production process, have to be replaced after two years and how to get people to use it. On the other hand, this can be handled through education and sensitization in communities, churches, Mosques, schools, Markets, clinics/hospitals, NGO and Distributors.

To Produce such filters, Mix clay and sawdust dry, Mix in water, Press, Dry, Fire, Soak and Test, Coat with Colloidal Silver. After this the quality of the filter is confirmed through a test.

To understand if the quality of filter and flow rate is good, figure 4.9 needs to be tested and measured to be certain. This is done with the aid of measuring cylinder, bucket and filter, and it is done as on the plate below.

Figure 4. 7: Filtron water filter and measuring scale



Source: Adapted from the Sustainable Engineering workshop series

Procedure of measurement;

Collect water at the bottom of the bucket every 15 minutes and measure the volume using a measuring cylinder.

Table 4. 5: Table showing time, volume and flow rate of water

Time (minutes)	Volume (L)	Total Volume (L)	Flow Rate (L/h)
15	270	270	1.08
30	255	525	1.05
45	240	765	1.02
60	230	995	0.995

After conducting the experiment, the results of some samples are satisfying though with some minor setbacks table 4.12.

- Purification of water at point-of-use into potable water
- Good flow rates of water is essential
- High pathogen removal efficiencies are necessary

- water-borne diseases can be essentially eliminated
- filters can improve on the health and wealth of people

Minor setbacks

- Education needed to avoid misconceptions associated with filter use
- Five people per filter ratio needed to ensure that all family members have access to potable water
- Balance up possibilities of larger filter numbers

- **NUFiltration**

While on field, the Israeli Ambassador to Cameroon Ran Gidor was on the field at Obili with the Mayor of Yaounde VI to share developments made in recent years in water purification in Israel. He came with a water purification unit NUFiltration.It is a water purification unit and demonstrated how it is used for water purification. With simple, cheap Israeli technology those communities in Cameroon that are plagued with poor quality of drinking water problems, can be saved. One of these technologies, meant especially for hard-to-reach areas of developing nations, is a portable tank-operated machine capable of taking water from a polluted source such as river and purifying up to 500 liters per hour – enough to supply all the daily water needs of 300 to 400 people. It could be noted that over 60% of Israel is desert, but thanks to technological advancement, they export drinking water. Cameroon is richly blessed with water resources, but unfortunately, access to safe drinking water is still very difficult. The equipment on Plate 4.3 was introduced to the population that was in attendance.

Photo 4.2: Water treatment equipment (NUFiltration Unit)

Source: Ngebung

In Plate 4.27, a – shows water in a running stream, b – is already purified water used for washing the filter, and c – is dirty water after back- wash of the NUFilter. The NUFiltration system purifies 8 liters of water per minute, which is enough supply for 300 to 400 persons daily. It eliminates germs and microorganisms as well as dirt and is a perfect solution for areas affected by cholera outbreaks. The equipment functions in a similar manner as a dialysis machine. A bucket of dirty water (black bucket on Plate 4.4) representing water fetched at a source was used. Another clean bucket (white bucket on Plate 4.4) to get the purified water was also used. A pipe connected to the equipment is then put in the black bucket where it pumps the water in through the equipment into the white bucket. This is done with the aid of someone exerting pressure to and fro on the handle of the instrument. This action is done until the water is completely purified.

Photo 4.3: Water purification process using NUfiltration system

Source: Ngebung

After every 8 liters of water, the equipment is back-washed. This is done by switching the pipes in the different buckets and the water is pumped to flush out the dirt. This equipment can be of great relief to drinking water from doubtful sources if donated to the population as promised by the Ambassador.

Photo 4.4: Purification and drinking of stream water

Source: Ngebung

This process of treatment was in a stream that runs across the area of study. After passing the water through the NUFiltration unit, the water comes out very clear and was even use for drinking on the spot as on the Plates 4.29. Here, the pipe was put in the running stream, and then the black bucket was used to collect the purified water. a – is purified water in glasses about to be consumed.

Water filtration systems from Israeli company NUFiltration were donated to Cameroon to help fight a cholera epidemic. According to ReliefWeb, a cholera outbreak in Cameroon has claimed at least a dozen lives and sent hundreds of people, many of them children, to hospitals since May 2019. The Ambassador rounded up his visit by stressing that their aim is to share their technological advances in the domain of water purification with their Cameroonian partners. With simple, cheap Israeli technology those communities in Cameroon that have been afflicted by cholera can be assisted.

4.2.3 Disinfection

The next step in household water treatment is to remove or kill any remaining pathogens. This is done through disinfection. There are different methods to carry out this process of disinfection. Boiling, solar disinfection as well as chemical disinfection are some of the methods.

- **Boiling**

Boiling is a traditional and the oldest method of treating water. It is the simplest, most common, and highly effective technique in disinfecting water in the area of study. It is highly effective in fighting all classes of pathogens, bacteria, viruses and protozoa (WHO, 2015). Everywhere in the world it is understood that boiling makes water safe. It requires a small clean pot with a lid which traps heat inside the pot making the water boil faster. It also needs firewood or other cooking fuels. Fetched water from a source is poured in to a pot but if the water is cloudy, it is first made to settle and filtered through a clean cloth or coffee filter before boiling. The water is left on the fire until complete rolling boiling. It is the heat from the boiling at this point that kills the microorganisms in the water.

Boiling has positive and negative aspects. Boiling will kill all germs that cause disease. It is something people can do themselves. It has no residual effects, though improper storage can lead to re-contamination. Therefore, boiled water should be stored safely and used within a few days.

Plate 4.2: Water boiling on a firewood kitchen

Source: fieldwork and inspiration from class work

In Plate 4.30 a – is a pot of water on firewood, b - shows vapor coming out of the water, and c – shows when the water has reached a rolling boil point. Without a thermometer, to ascertain the temperature needed is reached is through a rolling boil like on Plate 4.30 which is the only precise way to say how hot the water is. Wait until the water is steaming and mixing. Further, let the water cool naturally and store it in clean containers with covers or lids. If the water tastes flat, then it should be poured in a gallon washed with boiled water or household bleach. Even after cooling, the boiled water will be safe to drink but tastes flat when compared

with ordinary water or fresh water from the source. This is because some of the air inside it escaped in the course of boiling.

To improve on the flat taste, simply pour the water back and forth between two clean containers. The water will trap more air as it falls. Else shake the container forward and backward to get the desire taste. Heat up time and cool up time contribute to pathogen reduction. So, it is not very necessary to bring water to full boil point before getting effective treatment. The problem here is to know when one has reached an effective boiling point. Boiling is highly effective as some pathogens such as cryptosporidium, a leading cause of diarrhea disease that is very resistant to other types of water treatment processes is very vulnerable to heat.

Though boiling has some challenges, like high energy consumption and also time consuming, it is advantageous in killing pathogens, not affected by turbidity, simple to operate, no special equipment is needed, widely acceptable, understood and promoted all over the world. All these benefits overshadow the problems of boiling water. It is therefore recommended in this study that boiling water be made known, properly handle, and applied. This will go a long way in curbing down the problems and health risks involved with drinking water from doubtful sources, in the urban poor neighborhood of Obili and Etoug – Ebe.

- **Solar Disinfection (SODIS)**

Solar disinfection (SODIS), is a type of portable water purification method that uses solar energy to make biologically contaminated (e.g., bacteria, viruses, protozoa and worms') water safe to drink. It is a simple and cheap method of treating contaminated water. SODIS has been repeatedly made known to be effective for eliminating microbial pathogens and reduce diarrheal morbidity. It uses heat from the sun to heat water to about 70–100 °C within a short period of time. Cameroon is blessed with abundant sun light which can be exploited for this purpose. Ultra-violet rays from the sun will destroy harmful organisms present in the water. It is an ideal method for use especially when economic and sociocultural beliefs in the community do not recognize other treatment or disinfection alternatives, such as boiling or chlorination even though these are also acknowledged to be simple and inexpensive.

SODIS is a thermal process which consists of raising water temperature for a long period of time in containers that have been prepared to absorb the heat generated by solar radiation. These containers are made of a heat-conducting material which can absorbs heat better as shown on Plate 4.30.

Plate 4.3: A boy filling plastic bottles with water and placing them on the zinc (SODIS)

Source: Ngebung

In Plate 4.31, a – shows water filled in plastic bottles, and b – the bottles on a roof top. SODIS method, entails simply taking transparent, non-colored glass bottles and filling them with clear water and placing them in direct sunlight. They are left there for approximately 6 hours on a sunny day or for up to 2 days during cloudy weather. The ultra violet radiation of the sun will kill the pathogens in the water and make it safe for drinking. The suggested schedule for SODIS treatment is seen on Table 4.31. When the desired treatment time is reached, the water can be used directly from the bottles to avoid re-contamination. It should be noted that, it is ideal to use clear glass or food grade plastic bottle which are littered everywhere in the area of study. With this method it is advisable to use clear water (water that has undergone post sedimentation or filtration) which will make it easy for the water to be treated within a shorter period of time. Bottles which are old with lots of scratches are not recommended for use in this process. This is because it may slow down the process of SODIS and the desired result. To speed up the process, fill each bottle three quarter-way with water and shake it vigorously. Then top up the bottle completely and proceed by exposing it to sunlight.

SODIS is advantageous as it is simple and cost effective. It is good for disinfecting water in small quantities with low turbidity. It provides safe storage which prevents re-contamination. However, this method is not efficient on cloudy days and cannot be used on rainy days and at night. This gives reason for which other HWTS can be applied while waiting. The table shows suggested hours for effective SODIS treatment Table 4.13.

Table 4. 6: Suggested hours for effective SODIS treatment

Suggested Treatment Schedule	
Weather conditions	**Minimum treatment duration**
Sunny (less than 50% cloud cover)	6 hours
Cloudy (50–100% cloudy, little to no rain)	2 days
Continuous rainfall	Unsatisfactory, other water treatment methods advised.

Source: Adapted from CDC

The World Health Organization considers SODIS to be a valid option to improve the bacteriological quality of water. Thus, it is recommended in the area of study as it has proven its worth elsewhere in similar circumstances.

4.2.4 Water Purification Tablets and Chemicals

The WHO Guidelines for drinking-water quality (WHO, 2004) covers a significant amount of potential chemicals for water treatment or disinfection, but only a few of these chemicals (aquatabs, chlorine and salt) are of practical significance and use in the area of study. It is noted that a limited number of households use these chemicals. This is because some of the inhabitants are ignorant on how to use these products properly to get decent results. While others do not have sufficient money to buy them. However, when used properly, they kill all viruses and bacteria, although some species of protozoa and helminths resist these products. Some of these chemicals and products include:

- **Aquatabs**

Water purification tablets otherwise known as Aquatabs kill micro- organisms in water to prevent cholera, typhoid, dysentery and other water borne diseases which are rampant and recurrent in the area of study. Aquatabs are very convenient, lightweight, easy to use and portable when pure water is not readily available. It is very easy and practical to use these tablets. It simply involves fetching water in 20-liter containers, then dropping a tablet in each container of water. Stir the water well with clean utensils and leave it for 30 minutes before drinking as instructed on the packet (Plate 4.8). After this, it is advisable to drink the treated

water the same day it is treated. In effect, a tablet size of each Aquatab is formulated to treat a specific volume of water depending on the clarity or cloudiness of the water.

If the water to be treated is clear, one tablet, plate 4.32 in a 20liters container is enough to make the water safe for drinking. But if the water is cloudy, two tablets are advisable in a 20liters container. This is to be certain the water is up to standard to be considered safe for drinking. There are times some inhabitants of the area of study are reluctant or in a hurry and have no resources to filter or boil the water available nearby. In such circumstances, water purification tablets are an alternative.

Plate 4.4: Aquatabs

Source: Ngebung

However, when using aqua tablets, a lot of precaution and care must be taken. This method is quite unsafe in situations where the users are not very educated on the dosage. The risks associated with this method of treatment is recontamination of water after a longtime and energy has been used to improve on the quality. Therefore, this is rarely recommended unless it is really necessary in emergency situations.

- **Iodine salt**

Iodine can be in liquid or tablet form. To use liquid iodine for purifying water, add 5 to 10 drops through an eyedropper to every one liter or 20-40 drops in a 20liter gallon of water. Shake up the water, and let it sit for 30minutes. On the other hand, when using iodine tablets drop in one tablet for one liter of water. The correct amount of iodine needed varies on the conditions of the water. Clear, running water will require less iodine than water that is cloudy or stagnant. It is an effective, simple, and cost-efficient means of water disinfection for people where municipal water treatment is not reliable as in the area of study.

Iodine kills many, but not all, of the most common pathogens present in natural fresh water sources. An advantage of using iodine is that only a small amount of it is dissolved from the iodine crystals at each use, giving this method of treating water a capability for treating very large volumes of water. However, these tablets sometimes change the taste of the water, which may be unpleasant for some consumers. In such cases a little patience for about thirty minutes will be enough to clear the taste. The large quantity of water that can be purified with iodine crystals at low cost makes this technique especially cost effective for the population of the area of study.

It should be noted that some of these water treatment tablets are not suitable for pregnant women as too much drops of the tablets can make the water poisonous for the unborn baby. This is written on the leaflet in the tablets' packet. It is always advisable to read and understand instructions of any medication before consumption as some may have a negative side effect or even lead to death. Therefore, it is important that inhabitants properly manage any chemicals that they use for water treatment. This is to ensure safety as these chemicals are poisonous if mishandled.

- **Chlorination or ¨Javel Water¨**

Chlorine is one of the most commonly used disinfectants in the study zone. It is also the most used by households around the world to disinfect drinking water. Water Guard also known as (Sûr'Eau) is liquid chlorine. It has the same effect as the tablet. Usually, it is used as a residual disinfectant to purify drinking water.

To achieve this, simply introduce chlorinated products (chlorine tablets, bleach solution, etc.) into the water in order to kill the microorganisms that it contains. After allowing it to act for about 30 minutes, the water is normally fit to drink. It will remain so for a few hours or a few days according to the storage conditions. Not only does chlorination help prevent the spread of infections such as E. coli, it also destroys bacteria, algae and mold that can grow on the walls of water storage systems, and it removes unpleasant tastes and odors from drinking water. While chlorination is effective at sanitizing drinking water, it can be difficult to handle without knowhow and experience. The concentration of free chlorine in the treated water must, according to WHO, be from 0.2 to 0.5 mg/l.

For treatment of water with chlorine to be effective, add 1 cap to 20 liters of water, stir well. Close the container and let it stand for 30 minutes. The Water is now safe and ready for consumption. The water should have a slight chlorine odor. If it does not, repeat the dosage and

let it stand for another 15 minutes before use. If the chlorine taste is too strong, pour the water from one clean container to another and let it stand for a few hours before use. Chemical disinfection is not as efficient when used with dirty or cloudy water. If the water looks dirty or cloudy, use a double dose of chemical.

Enough chlorine must therefore be used so that there remains a sufficient quantity once the water is treated, except in cases of immediate consumption. The most common chlorine-based bleaches are: Sodium hypochlorite (NaClO), usually as a 3–6% solution in water, called "liquid bleach" or just "bleach", historically called "Javel water". It was noted on the field that despite the use of this chemical in the treatment of water by some households, they are not very versed with the doses for different quantities of water. Table 4.2 shows the volume of water and amount of bleach to add.

Table 4.5: Volume of water and amount of bleach to add

Volume of Water	Amount of 6% Bleach to Add	Amount of 8.25% Bleach to Add
1 quart/liter	2 drops	2 drops
1 gallon	8 drops	6 drops
2 gallons	16 drops (1/4 tsp)	12 drops (1/8 teaspoon)
4 gallons	1/3 teaspoon	1/4 teaspoon
8 gallons	2/3 teaspoon	1/2 teaspoon

Source: Association for Professionals in Infection Control and Epidemiology, 2009.

Regarding the safe storage of water, disinfection with chlorine has an advantage over the other methods, as chlorine has an outstanding effect. Care should always be taken when working with chemicals. Do not allow the chemicals to come into contact with the eyes. Chemicals should be stored out of reach of children, in a dry place and out of direct sunlight. Using chlorine in a suitable way will help ameliorate some of the problems linked to drinking water from doubtful sources. But Table 4.14 will also answer the usual questions of what

amount of bleach to be added to a given volume of water. Although chlorine was long-believed to be the best method for treating water, new studies prove otherwise.

- **Lime**

Lime has numerous applications in water treatment. It is abundant, cheap and affordable for water treatment. A team of researchers from the Johns Hopkins Bloomberg School of Public Health reports that adding lime juice to water before placing it in the sun removes detectable levels of harmful bacteria such as E. coli, significantly faster than solar disinfection alone. Lime can be used to treat water to improve on the hardness and also reduce the levels of toxins in the water in the study area.

Apart from being a far less expensive treating agent, lime has the additional benefits of removing some unwanted compounds from stream water. It also improves the taste, smell and color of drinking water which often plays on the psychology of the inhabitants. Among other benefits, suspended matter is eliminated, and therefore any cloudiness is eliminated.

4.2.5 Plants

Sustainably, in recent years, a good number of studies have investigated the role of plants in water purification. Although many water purification methods exist, they are far beyond the reach of common people because of unaffordable cost or lack of technical Know-how for operation. A new simple and cost-effective method for purification of water with some plants by poor communities has been developed and tested. Plants are natural water filters both above ground and in the water. Hikers and other outdoor adventurers use plants in the woods to get clean drinking water. A wide variety of plants can be used at home to make water safe for drinking.

Cilantro is one of the most common plants in the household that can purify water. This herb may even remove heavy metals as effectively as charcoal filters. Lemon peels, the core of a cactus and pine tree branches, moringa seed powder are also used as natural coagulant and flocculent to clear turbid water. They are also a kind of antibacterial agents used to destroy pathogens like E. coli to produce clean drinking water.

To purify drinking water with these plants, collect raw water samples from nearby water sources. Add the plant powder prepared from locally obtained seeds or leaves to the water. After about 4 hours, the water is filtered and is within accepted levels for drinking water. The technique is cost effective and capable of producing clean drinking water for domestic use,

without any power source or technical assistance. It can be practiced with little effort in community households. Being a Point–of–Use method, it is exceptionally useful in providing drinking water as an immediate solution in disaster areas affected by floods. It is also advantageous because it is used, without any power source or technical assistance. It can be practiced with little effort in poor community households.

4.3 Safe Water Storage and Handling

Households do a lot of work to collect, transport and treat their drinking water. When the water is safe to drink, it should be handled and stored properly to keep it safe. If it is not stored safely, the treated water quality could become worse than the source water and may cause people to get sick. Already treated or purified water has to be stored properly to prevent recontamination. Safe storage means keeping treated water away from sources of contamination. It must also be stored using a clean and covered container. This equally means that drinking from the container should be done in a way that cross-contamination should be avoided.

HWTS begins with sterilizing containers used for fetching and storing water. It is very vital to note here that, vessels for fetching water need to be sanitized and freed from contaminants, before using them to fetch and store safe drinking water. It is advised to use boiled water to shake and rinse drinking water containers. An alternative is to use bleach that does not have an added scent like lemon. Otherwise, add 1 teaspoon of household liquid bleach to about 1 liter of water. Then this is poured into a clean storage container and shaken well, making sure that the solution covers the entire inside of the container. The liquid is left in the container for at least 30 seconds, before pouring out the solution. The vessel is rinsed with clean water that has already been made safe, if available or it air is allowed to dry the container.

There are several containers and ways to store water. They range from very small covered buckets to large tanks. Another possibility is to store water in plastic bottles that are easy to get as the case is with a majority of households in the study area. Storage containers for safe treated water usually have many designs and qualities: strong and tightly fitting lid or cover, tap or narrow opening, stable base so it does not spill over, durable and easy to clean. Fetched water should be transported in covered containers and stored in clean vessels which are covered and regularly cleaned. Drinking water should be stored in a separate container from other domestic water, wherever possible. Water treatment procedures should be carried out at household level if the source is not clean and water is not stored properly. Drinking water should

be taken from the storage vessel with a dipper having a handle so that hands, cups or other objects cannot contaminate water. Latrines should be used instead of open defecation. Latrines should be located away from water sources and be kept clean. Pits need to be emptied or replace to eliminate possibilities of contamination.

But during field work a number of households were found using drinking water containers with loose covers that were not properly cleaned. This quickly brings to mind the question of the quality of the drinking water in such utensils or containers. Furthermore, a good hygienic condition in a household is very important as long as handling and storing water is concern. Some of the hygienic conditions to consider are: careful storage of household water and regular cleaning of all household water-storage facilities. Construction, proper use, and maintenance of latrines close to water sources. Regular hand washing, especially after defecation and before handling drinking water. The container should prevent hands, cups and dippers from touching the water, so that the water does not get re-contaminated.

Household Water Treatment and Safe Storage (HWTS) is particularly suitable in places where people are using contaminated drinking water sources. It is also applicable relying on potentially contaminated centralized water supply systems. HWTS is also suitable for urban poor communities such as slums of Obili and Etoug-ebe where households are very likely to use unprotected water sources.

When promoting campaigns for storing water safely at home, in the area of study the population needs to know that water sources should be used with care and maintained in good condition. There should be no risk of contamination from nearby latrines, wastewater drainage, animals, or objects falling into the well or water source. Drinking water should be collected in clean vessels, without coming into contact with hands so as to prevent further contamination.

Treating water at household level, allows households to adapt to the temporal and seasonal changes in their water supply. In some cases, HWTS may be the only way out for safe drinking water provision as in the area of study. Remote and urban poor homes, as well as homes in unplanned urban settlement, are those with very little prospect of receiving pipe borne water or services. Price alone has an influence on the use of water and selection of water sources. Households with the lowest levels of income often pay more for their water than those connected to CAMWATER. This alone pushes households to use alternative sources of water which are often of inferior quality.

HWTS can be a low-cost option for households as different strategies have been proven to improve drinking water quality in the laboratory and in field trials in developing countries as in (Clasen *et al*., 2007, WHO 2011). Due to limited public network coverage in Yaounde and the urban poor quarters of Obili and Etoug-Ebe, activities of informal operators (or water vendors) in the drinking water sector are rapidly growing. They play an important role in providing households with potable water.

Although this concept of HWTS is not new, it is recognized as a dynamic approach for the improvement of public health, according to the CDC. Ages before the theory of germs was well known, several societies stayed educated on the need to boil water or put it under the sun. These were all in a struggle to improve on the quality of water. It has been noted that the best way to reduce the risks associated with drinking unsafe water is through HWTS. By this means, water is protected from the source, treated and safely stored at homes. This consequently, increases the chances of protecting water against contamination at all levels. HWTS is an important intervention to improve the quality of drinking water. In the area of study, families use either unimproved drinking water sources or improved sources that are contaminated (tap water).

Hygiene promotion is very vital in HWTS. The advantages of improving and providing safe drinking water will be useless if those handling the water are not aware of the benefits. Creating awareness on changing unhygienic attitudes is comparably as important as the provision of clean water to the inhabitants. To ensure good quality water supply and sanitation, it is very important to promote the practice of hand washing. There are some people who do not know how to wash their hands properly. Showing them and educating them on the risk they run if hands are not properly washed before handling water, is recommendable.

4. 4 Recommendations and Suggestions

Most rural and urban communities in Cameroon have serious difficulties getting portable water due to limited infrastructure and low per capita income of a significant portion of the population. It can also be associated with limited application of locally available materials in the search for solutions to these problems. Therefore, there is a need for alternative approaches in the development of sustainable solutions to problems of access to clean water in rural and urban areas in Cameroon.

Drinking water from doubtful sources has several effects on the consumer as discussed throughout this work. These effects constitute huge challenges for the sustainability of the actions being taken to redress the situation. To improve upon the situation, the different

stakeholders tasked with the provision of drinking water in the area of study need to do more than what they have been doing. Despite the relentless efforts of the government and CAMWATER to provide safe drinking water to the population, the policies are seemingly insufficient. This is evidenced by the fact that the population, most especially the urban poor still drink water from doubtful sources without regard to the health consequences. Therefore, purification of water at point-of-use into potable water is necessary in order to eliminate water borne diseases.

4.4.1 Recommendations

Some of the solutions and recommendations envisaged are already being implemented at household level. However, measures to support household water treatment efficiency proposed here are drawn from the field study. These proposals can go a long way in improving the livelihood of the urban poor - requirements for water saving devices, amending water codes, awareness and education campaigns, and social marketing tools to encourage the involvement of communities and community organizations in matters of local water governance. Some of these strategies include:

- **Amelioration of the livelihood of the urban poor**

Large cities in Cameroon such as Yaounde and Douala have been the centers of economic growth over the last few decades, but the excessive demand for basic amenities is resulting in deterioration in the physical environment. The quality of life has thus suffered due to continuing influx of migrants and, consequently, widening of the gap between demand and supply of essential services and other infrastructure in these areas.

In ameliorating the lives of the urban poor, a participatory approach to upgrading housing conditions and related support infrastructure in slums in the area of study are necessary. Relevant institutions and mechanisms for effective implementation of appropriate policies by different stakeholders can greatly improve the situation. These objectives can be attained through strategies that deal with, the supply of affordable basic services. Developing a slum sensitive urban planning framework through the (construction of modern wells, springs, boreholes, public taps, extension of CAMWATER and CDE distribution network, etc.), financing of slum upgrading projects, inclusion and participation of slum residents and other stakeholders in the development of these areas. If these proposals are implemented, the problems of basic needs such as portable drinking water can be solved to an extent.

- **Sensitization and education campaigns**

Drinking water in the area of study is gotten from different sources in different homes (as discussed in Chapter One). After collecting the water from the source, it is transported to homes where the water needs to be treated to make sure that it is free from contaminants and suitable for drinking. This can be done through improving the (physical, chemical, and biological) characteristics of the water. The purification of water at household level is very simple and involves different processes which if explained through sensitization campaigns will ameliorate this situation. Sensitization and awareness campaigns can help dispel misinformation while promoting precautionary measures like household water treatment and safe storage.

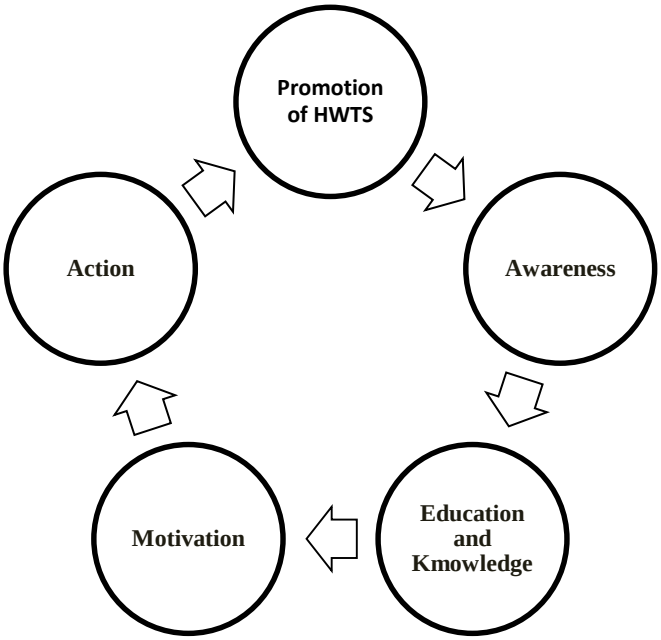
Physical and chemical methods can be used to disinfect water at household level. As noted in the field, very few households have knowledge on HWTS. This brings to mind the need for education and sensitization on methods and techniques of HWTS. In some quarters, chlorine, hydrogen peroxide, lime, salt, aqua tabs are used to disinfect water. Therefore, it is very crucial to pass on the correct knowledge to those who need it. This can be done through awareness campaigns.

Participatory approaches are widely used to engage and actively involve everyone in the training. Effective learning often comes from shared experiences and participants learning from each other. Most of the course contents can be delivered through interactive presentations, case studies, demonstrations and group discussions. Other strategies may include:

- Demonstration projects used to create awareness on HWTS (awareness and action).
- Engage community leaders, women and children (in the promotion of HWTS). In most societies women and children play a major role in fetching and handling water. Therefore, the role of women needs to be recognized and made use of if the situation must be improved upon.
- Provide positive reinforcement to households so as to guarantee continuity or sustainability of HWTS at household level (motivation, education and knowledge).

Theses sensitization campaigns will also educate the population on the need to constantly clean their water points, maintain basic hygiene and sanitation, always wash hands with clean water and soap before handling drinking water especially in the mists of COVID 19.

Figure 4. 8: Increase awareness and knowledge on HWTS



Source: Fieldwork and inspiration from classwork

- **Reinforce Government's Role**

At the present state of affairs, it is recommendable for the government to intervene in this struggle of getting drinking water by ensuring the enforcement of the right to water and guarantee sustainable utilization. The Government should provide subsidies where the provision of water for domestic and personal use is expensive for the urban poor. This way, the rates will be reduced and the affordability ingredient of the right to water would be guaranteed.

Nevertheless, the issue is not that simple, for the countries that find themselves with the bulk of their poor living in urban areas, eradication of poverty as well as meeting the basic needs of the people is the primary goal of the government. However, this is not the only goal that the government is trying to attain. Poor households are experiencing a constant state of deprivation with very little change over the years. All these are as a result of very weak governance and political will. A participatory process could be used involving local stakeholders, elected representatives, the administration, CAMWATER and MINEE, to ensure sustainability of outputs which is farfetched as noted in the field.

- **Put in Place a Regulatory Agency**

Many countries in the less developed as well as developed world have regulatory agencies for basic needs, services and infrastructures which often take in to consideration

potable water supply as well as sanitation as top priorities. An effort to best protect consumers and make sure efficiency is achieved, is usually through these agencies. The regulatory agencies are often entrusted with different tasks, (acceptable tariffs, approve, decrease or increase in tariffs, settle complaints between service providers and unsatisfied customers, regulate the service providers and make sure these sectors are managed efficiently in every aspect). They also need to be competent, and autonomous.

Following these facts, if a regulatory agency on safe drinking water is put in place with proper and efficient management, then, it will go a long way through its actions to assist. This will help the population to refrain from drinking water from doubtful sources. This will also ameliorate the health of those drinking water from doubtful sources while reducing health cost.

In Cameroon, other network industries have regulatory agencies to protect the consumers and improve upon the quality of service. Some of these agencies include ARSEL (Electricity Sector Regulatory Board), ART (Telecommunications Regulatory Board) and ANTIC (ICT Regulatory Agency). So, there is need to setup a Water Sector Regulatory Agency.

4.4.2 Testing and Validation of Hypotheses

Field data collection was done with the use of questionnaires, investigations, consultations, and direct field observation. This aided in verifying the hypotheses set before field investigations. After testing each hypothesis, analyses and discussions of the results of the test were done. In the preceding section, the processes used for testing the hypotheses are enunciated.

1. Increase sensitization campaigns on safe drinking water options, hygiene, sanitation, durable urbanization, improvement of education of households on water treatment and safe storage methods is easily carried out (through telephone messages, Television, Radio, Schools and hospitals).

2. CAMWATER should expand and ease water distribution or adapt new ways of reaching the urban poor with safe drinking water.

3. The government through CAMWATER can write a National Policy and follow up on HWTS if the situation must be improved upon.

4. Eradication of poverty as well as meeting the basic needs of the population should be top priorities of the authorities.

Sensitization on social behavioral change should be communicated and intensified. Poor sanitation contributes to the spread of disease by means of contaminating drinking water as well as untreated waste which builds up and infects water sources. The lack of sanitation (even simple latrines) can dramatically pollute water; provide breeding opportunities in stagnant water bodies for insects that help to spread disease. Open defecation is not left out as was noticed around water sources.

Also, training a team to proceed with information campaigns with community leaders and volunteers will greatly be of help here. Working through social groups will also break barriers in this case. Water supply systems can be isolated from sewage to prevent people and insects from contacting human excreta. The African Development Bank Group carried out a sanitation project in Yaounde in 2006. This was because the city experiences poor drainage systems especially around the squatter areas where about 9,000 households were affected by flooding with devastating effects.

HWTS are proven, low-cost interventions that are sustainable and have the potential to provide safe drinking water to those who do not have access to safe drinking water. Significantly, this has reduced mortality due to waterborne diseases and improved the quality of life. HWTS implementations can be developed from small pilot projects into national-scale programs to remedy the persistent problems of getting access to safe drinking water nationwide.

Conclusion:

Water as seen in some sections of this work reveals unsafe drinking water is responsible for many infectious diseases. This chapter therefore emphasizes on proposed methods that if implemented will go a long way in ameliorating the problem of drinking water from doubtful sources.

GENERAL CONCLUSION

The study "sustainable safe drinking water options for the urban poor of Yaounde: case of Obili and Etoug – Ebe" has as objectives to investigate the sources of drinking water, problems encountered by the urban poor accessing drinking water and their effects on health, water quality and treatment standards, and household water treatment and safe storage as a solution to drinking water problems. With these objectives, four research questions and hypothesis were brought out and developed for this research. The very first objective was to fine out the water sources and why the inhabitants drink water from doubtful sources in Obili and Etoug – Ebe. The hypothesis guiding the findings was that; a majority of the inhabitants of Yaounde and its environs drink water from doubtful sources. People drink from different sources of water with tap water as the most convenient water source. Although some households are connected to the water utilities company, most of them complain that the water has odor, color and taste. This plays on psychology and discourages the population from drinking tap water. This was tested and validated by collecting water samples and testing in the laboratory to determine its quality and safety for drinking. However, not all tap water is safe to drink. It may have contaminants, such as pathogens, metals, or even chemicals as indicated by the laboratory results. With this state of affairs, HWTS comes in to help in ameliorating the situation.

The factors leading people to drink water from doubtful sources were also investigated. Some of them were due to the accelerated demographic growth, negligence on the part of stakeholders and inhabitants, the unplanned nature of the city of Yaounde and its environs. These have led to sustained poverty and hardship in spontaneous quarters as in the area of study. With all these, private individuals have transformed the city space to suit their own desires. This anarchical transformation especially by the urban poor has both negative and positive impacts. These negative features outweigh the positive aspects. This is vividly noticed in the behavior of inhabitants in the way solid waste, toilets, waste water are discharged on roads and nearby streams. This mode of disposing of liquid and solid waste exposes water sources to serious pollution and contamination. If such water is consumed, it can lead to the emergence of diseases like osteomyelitis, typhoid, hepatitis A, diarrhea, etc. that can eventually lead to serious health problems as confirmed by some health units in the study area.

This work also investigated water quality and the role it plays on the health of the inhabitants. Sustainable safe and adequate quantity and quality of drinking water is very vital

for human survival. However, the Government of Cameroon through its utility company and other organizations' has put in much efforts to satisfy the water need of the population. Despite these, the water sector has been in to a lot of problems which are both natural and manmade such as deterioration in water quality, poor operation and maintenance practices which are entangled with demand and supply factors. These problems have led to a serious decline in quantity and quality of water in the area of study in recent years. This in effect has serious implications on the health of the population. Faced with these problem that put to question the quality of water, the inhabitants turn to alternative water sources to meet their everyday needs. In order to ensure the population stays safe from drinking water of doubtful quality, training and education on methods of HWTS comes in as a solution in ameliorating the situation. A single water quality – testing agency should be promoted for both the rich and urban poor. This is possible with equipment such as NUfiltration and HWTS. The active, diverse, and expanding community of researchers, private companies, faith-based organizations, international and local NGOs, and donors interested in solving these problems can play a major role in helping the world achieve the Sustainable Development Goal to halve the proportion of people without access to safe drinking water.

Achieving these goals, and surpassing them, will require continues collaboration, investment, research and development. It is however in the benefit of all to rapidly adapt to HWTS in reducing waterborne diseases and deaths in developing countries. This is achievable with the aid of proposals made in this work and other research works. Therefore, in a context where the authorities embark on a permanent fight against poverty, it would be necessary to have a rethink on the aspects proposed in this work, if the desired objectives are to be achieved.

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APPENDIXES

UNIVERSITY OF YAOUNDE I

DEPARTMENT OF GEOGRAPHY

Dear Respondent, this research questionnaire is for the study of Sustainable Safe drinking water options for the urban poor: Case of Etoug-Ebe and Obili of Yaounde VI municipality. The purpose of this research work is solely academic. Your respond will be treated confidentially and highly appreciated.

QUESTIONNAIRE FOR INHABITANTS.

SECTION A: IDENTIFICATION OF RESPONDANT

1. Quarter OBILI ☐ ETOUG-EBE ☐
2. Nationality _____
3. Region of origin _____
4. Sex. Male☐ Female☐
5. Age group. <15☐ 15-24☐ 25-34☐ 35-44☐ 45-55☐ 56+☐
6. Marital status married☐ Single☐ cohabitation☐ divorce☐ widow☐ widower ☐
7. What is your religious background? Catholic☐ Presbyterian☐ Baptists☐ Animists☐ others ☐
8. Number of persons in the household _____
9. Number of children in your household >5☐ 5-10☐ 10-15☐
10. Profession _____
11. Educational level Primary FSLC☐ Secondary O/L ☐High school A/L☐ Degree☐ Post Graduate☐ Others☐
12. What is your status in the house? Landlord☐ tenant ☐care taker ☐family house ☐others☐
13. How many members of the household are employed? _____
14. In which of the monthly income brackets does your household belong? <30,000FCFA☐ 30-49,000FCFA ☐ 50-100,000FCFA ☐ <100000FCFA ☐

SECTION B: SOURCES OF DRINKING WATER AND PROBLEMS ASSOCIATED TO THE SOURCES.

15. Where does the water you use come from? private tap ☐ Public tap ☐ bore well ☐ spring☐ stream☐ community well☐ rain☐ others☐
16. If private tap, what are the problems you encounter?
17. How frequent do you have access to the water in a week? Daily☐ once☐ twice ☐thrice ☐others ☐
18. (a) Does the frequency meet your needs? Yes☐ No☐

(b) In your opinion, how often will you like to get water? _____

19. In your opinion what are the problems encountered around and in your water point?

20. (a) At the level of accessibility? Enclave☐ accidented relief☐ others ☐
Specify_____

(b) At the level of type of water? Poorly treated☐ others☐
specify_____

(c) At the level of quality? Dirty water☐ low pressure☐ price☐ others
spcify_____

(d) At the level of surrounding? Toilets☐ close to dumping ground☐ others☐
Specify_____

(e) At management level? Bad management☐ others☐

21. (a)What means do you use in transporting the water? _____

(b) Why? _____

22. How long does it take you to fetch water and back? _____

23. How do you store the water? _____

24. Are there toilets around your water points? Yes☐ No☐

25. Is garbage disposed around your water point? Yes☐ No☐

26. Do you wash your hands before handling water? Yes ☐ No ☐ (b) Why?

27. Do you buy drinking water when there is shortage? Yes☐ No☐

28. If yes, which type? Sachet☐ Bottle☐ tap water ☐ well ☐ others ☐

29. How much do you spend on drinking water daily? _____

30. (a)Has your source of water has a breakdown lately? Yes☐ No ☐

(b) If yes why? _____

31. How long did it take for it to be repaired or fixed? _____

32. What alternative did you use while waiting for it to be repaired? tap water ☐ spring ☐ stream ☐ bore well ☐ sachet ☐ bottle ☐ rain ☐ others ☐

33. Do you often experience water cuts in your quarter? Yes ☐ No ☐

34. If yes, how often? _____

35. How often do you clean your water source or well? Once a week ☐ once in two weeks ☐ once a month ☐ never ☐

SECTION C: WATER QUARLITY AND ITS EFFECTS ON THE POPULATION.

36. (a) Are you sure of your water quality? Yes ☐ No ☐.

(b) If No do you treat the water before use? _____

(c) If yes what do you usually do with the water to make it safe for drinking? _____

37. Can you tell me all the possible ways you know to make your water safe for drinking?

_____

38. (a) Do you know some or all of the products in purifying water? Yes ☐ No ☐

(b) If yes, name them please; _____

39. Do you know where to get these products or instruments or their replacements parts?

_____

40. Does the water have a taste ☐ color ☐ odor ☐?

41. (a) Have you ever analyse your water quality in the laboratory?.Yes☐ No☐

(b) If yes or No why._____

_____

_____

42. (a) Do you think the quality of water is important for the health of your family? Yes☐ No ☐

(b) If yes why? _____

_____

(c) If No why? _____

_____

43. (a) Are you satisfied with your water quality? Yes☐ No ☐

(b) If No explain why? _____

_____

SECTION D: ACTORS IN THE SECTOR

44. Who are the actors responsible for the provision of safe drinking water in your quarter? Government☐ individuals☐ NGOs☐ community☐ municipality☐

45. In your opinion, who should be responsible for safe drinking water quality? Civil society ☐ municipality☐ government☐

46. (a)Do you think actors involved in the provision of water are concerned about the quality? Yes☐ No ☐

(b) If yes what is their contribution_____

_____

_____

_____

47. (a) Have you ever receive any training on your household water treatment methods? Yes☐ No☐

(b) If yes where did you get it? Household visits ☐ Group training ☐ Media ☐ from children through school☐ Religious Centers☐ others☐ none ☐

48. Have you ever suffered from any water related disease Yes ☐ No☐

49. (a) If yes which disease? typhoid☐ diarrhea☐ cholera☐ bone infection☐ respiratory infection☐

(b) How did you resolve it? _____

_____

_____

SECTION E: WHAT ARE THE MEASURES PUT IN PLACE TO HELP THIS SITUATION

50. (a) Are any measures put in place to help resolve the problem of water in your quarter? Yes☐ No☐

(b) If yes what measures have been put in place?_____

_____

_____

(c) By who?_____

_____

_____

51. How successful have these measures been? _____

_____

_____

_____

52. If not successful why? Embezzlement ☐ corruption ☐ mismanagement ☐ disorganization ☐ disobedience☐ lack of good will☐ others☐

53. (a) Do you have any suggestions to help this situation in future? Yes☐ No ☐

(b) If yes, explain_____

_____

_____

_____

_____

54. Do you have any questions or remarks to make? _____

_____

_____

THANK YOU VERY MUCH FOR YOUR CO-OPERATION

LABORATOIRE APEX

ANALYSES MEDICALES ET IMAGERIE MEDICALES

Situé à la rue Messa à côté de la pharmacie Messa - Yaoundé

Tél. 674199796/699189929

Sortie le : 10/04/2018

Examen demandé par : Dr WIRKOM

Renseignements cliniques :

Nom(s) : Omam Spring ASEL

Prélevé le : 06/04/2018

Tel :

CULTURE WATER	Valeurs	Valeurs normales
Ph	6	6,8 - 7,5
Temperature	28°c	
Total suspended solids	9 mg/L	
Total dissolved	7 mg/L	
Turbidity	moderee	
Color	colorless	
Total feacal coliform	180 +	0 - 10
Feacal Streptococci	00	0 - 10
Escherichia coli	180	0 - 10
Shigella :	00	0 - 10
Vibrio cholerea	00	0 - 10

Conclusion: ***Grossly contaminated.***

Dr Wirkom Venasius Kihdze
Biologiste
(PhD)
FELLOW NCMLS

LABORATOIRE APEX

ANALYSES MEDICALES ET IMAGERIE MEDICALES

Situé à la rue Messa à côté de la pharmacie Messa - Yaoundé

Tél. 674199796/699189929

Saisie le : 10/04/2018

Examen demandé par : Dr WIRKOM

Renseignements cliniques :

Nom(s) : Spring Behind Texaco Obili

Prélevé le : 06/04/2018

Tel :

CULTURE WATER	Valeurs	Valeurs normales
Ph	6,8	6,8 - 7,5
Température	28°c	
Total suspended solids	13 mg/L	
Total dissolved	8 mg/L	
Turbidity	Abondant	
Color	colorless	
Total feacal coliform:	180 +	0 - 10
Feacal Streptococci	00	0 - 10
Escherichia coli	40	0 - 10
Shigella	00	0 - 10
Vibrio cholerea:	00	0 - 10

Conclusion : ***Grossly contaminated***

Dr Wirkom Venasius Kihdze
Biologiste
(PhD)
FELLOW NCMLS

LABORATOIRE APEX

ANALYSES MEDICALES ET IMAGERIE MEDICALES

Situé à la rue Messa à côté de la pharmacie Messa - Yaoundé

Tél. 674199796/699189929

Sortie le : 10/04/2018

Examen demandé par : Dr WIRKOM

Renseignements cliniques :

Nom(s) : Well TKC

Prélevé le : 06/04/2018

Tel :

CULTURE WATER	Valeurs	Valeurs normales
Ph	6,8	6,8 - 7,5
Temperature	28°c	
Total suspended solids	12,5 mg/L	
Total dissolved	10 mg/L	
Turbidity	....scanty	
Color	colorless	
Total feacal coliform	180 +	0 - 10
Feacal Streptococci	00	0 - 10
Escherichio coli	5	0 - 10
Shigella	00	0 - 10
Vibrio cholerea	00	0 - 10

Conclusion: ***Grossly contaminated.***

Dr Wirkom Venasius Kihdze
Biologiste
(PhD)
FELLOW NCMLS

LABORATOIRE APEX

ANALYSES MEDICALES ET IMAGERIE MEDICALES

Situé à la rue Messa à côté de la pharmacie Messa - Yaoundé

Tél. 674199796/699189929

Sortie le : 10/04/2018

Examen demandé par : Dr WIRKOM

Renseignements cliniques :

Nom(s) : Well Handicap Center

Prélevé le : 06/04/2018

Tel :

EXAMEN(S) RESULTAT(S)

CULTURE WATER	Valeurs	Valeurs normales
Ph	6,8	6,5 - 8,5
Température	28°c	
Total suspended solids	11 mg/L	
Total dissolved	9,5 mg/L	
Turbidity	Scanty	
Color	colorless	
Total feacal coliform	40	0 - 10
Feacal Streptococci:	00	0 - 10
Escherichia coli:	03	0 - 10
Shigella:	00	0 - 10
Vibrio cholerea :	00	0 - 10

Conclusion : unacceptable for consumption.

Dr Wirkom Ignasius Kihdze
Biologiste
(PhD)
FELLOW NCMLS

LABORATOIRE APEX

ANALYSES MEDICALES ET IMAGERIE MEDICALES

Situé à la rue Messa à côté de la pharmacie Messa - Yaoundé

Tél. 674199796/699189929

Sortie le : 10/04/2018

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Escherichia coli:	03	0 - 10
Shigella:	00	0 - 10
Vibrio cholerea :	00	0 - 10

Conclusion : unacceptable for consumption.

Dr Wirkom Ignatius Kihdze
Biologiste
(PhD)
FELLOW NCMLS

MINISTRY OF PUBLIC HEALTH

NATURE ET DURÉE

FICHE DE NOTIFICATION HEBDOMADAIRE DES MALADIES À POTENTIEL ÉPIDÉMIQUE

Région: CENTRE

District de Santé:

Nombre d'AS opérationnelles:

Nombre d'AS ayant notifié à temps:

Nombre de FS fonctionnelles:

Nombre de FS ayant notifié:

Nombre de FS n'ayant notifié à temps:

Semaine épidémiologique: N°2 Du: 16-10-17 Au: 22-10-17 Année: 2017

N°	MALADIES	NOMBRE DE CAS	DÉCÈS
1	Charbon	0	0
2	Chikungunya	0	0
3	Choléra	0	0
4	Dengue	0	0
5	Diarrhées sanglantes (Shigellose; campylobacter, Yersinia)	0	0
6	Onchocercose	0	0
7	Envenimation (autres)	0	0
8	Fièvres hémorragiques virales(Ebola, Marburg, Rift valley, Lassa, Crimée)	0	0
9	Fièvre Jaune	0	0
10	Fièvre Typhoïde	1	0
11	Gastroentérite aigue sévère	0	0
12	Méningite	0	0
13	Paludisme	2	0
14	Paralysie Flasque Aigue (PFA)	0	0
15	Peste	0	0
16	Morsure de chien	0	0
17	Morsure de serpent	0	0
18	Rage	0	0
19	Rougeole	0	0
20	SRAS (Pneumopathie atypique)	0	0
21	Syndrome grippal	0	0
22	Tétanos Néo-Natal (TNN)	0	0
23	Variole	0	0
24	Accouchement assisté	0	0
25	Décès maternel	0	0
26	Décès néonatal	0	0
27	Autres événements (spécifier):	0	0

Nom, Signature, Cachet

Date d'envoi:

UNIVERSITE DE YAOUNDE I
UNIVERSITY OF YAOUNDE I

FACULTE DES ARTS, LETTRES
ET SCIENCES HUMAINES

DEPARTEMENT DE GEOGRAPHIE
B.P 755 Yaoundé
Tél. 22 22 24 05

FACULTY OF ARTS, LETTERS
AND SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY
P.O BOX 755 Yaoundé
Tel. 22 22 24 05

ATTESTATION DE RECHERCHE

Le soussigné, **Pr. PAUL TCHAWA**

Chef du Département de Géographie, atteste que

Mademoiselle : NIBALUM ELISABETH NGUEBUNG

Matricule: **08J840**

Est inscrit(e) au cycle de : MASTER II

Spécialité : DYNAMIQUES URBAINES ET RURALES

Il prépare une thèse sur le sujet : SUSTAINABLE SAFE DRINKING WATER OPTIONS FOR THE URBAN POOR OF YAOUNDE VI MUNICIPALITY.

A cet egard, je prie toutes les personnes ressources et tous les organismes sollicités de lui réserver un bon accueil et de lui apporter toute l'aide nécessaire à la réussite de cette recherche dont la contribution à l'appui au developpement ne fait pas de doute.

Yaoundé le 16/10/2019

UNIVERSITE DE YAOUNDE I
FACULTE DES ARTS, LETTRES ET SCIENCES HUMAINES
Département de Géographie
Le Chef de Département

CHEF DE DEPARTEMENT

Prof. Paul Tchawa
HDR de Géographie
Université de Bordeaux 3

REPUBLIQUE DU CAMEROUN
Paix-Travail-Patrie

DEPARTEMENT DU MFOUNDI

COMMUNE D'ARRONDISSEMENT DE
YAOUNDE 6ème

B.P : 3759 Yaoundé –Messa | E-mail :
pmlolo@yahoo.fr
Tél : (237) 231 34 95 | Fax : (237) 231 34 95

REPUBLIC OF CAMEROON
Peace-Word-Fatherland

MFOUNDI DIVISION

YAOUNDE 6TH COUNCIL

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pmlolo@yahoo.fr
Tél : (237) 231 34 95 | Fax : (237) 231 34 95

Yaoundé, le 22 FEV 2016

AUTORISATION DE RECHERCHE

N° 0004 /AR/16/CAY6/SG/SAG

Le Maire de la Commune d'Arrondissement de Yaoundé VIè ;
Chevalier de l'Ordre du Mérite Camerounais ;

Autorise Mlle NIBALUM Elizabeth NGEBUNG, étudiant en Master II, Département : Géographie, Option: Dynamiques Urbaines et Rurales à l'Université de Yaoundé I, à effectuer ses recherches dans la Commune d'Arrondissement de Yaoundé VI du 01 Mars au 29 Avril 2016 sur le thème : « SUSTAINABLE SAFE DRINKING WATER OPTIONS FOR THE URBAN POOR OF YAOUNDE VI MUNICIPALITY».

L'Intéressée prendra attache des responsables suivants :

- Chef service Technique de l'aménagement et du développement urbain
- Chef service d'Hygiène, Salubrité et Environnement.

En foi de quoi la présente autorisation lui est délivrée pour servir et valoir ce que de droit. /.

LE MAIRE

RÉPUBLIQUE DU CAMEROUN Paix - Travail - Patrie Commune de Yaoundé VI Le Maire Département du Mfoundi RÉGION DU CENTRE

Paul Martin Lolo
Maire

Ampliations :

- SG/Ydé 6e
- SAG/ Ydé 6e
- ST/Ydé 6e
- SHE/Ydé 6e
- Archives/ Chrono
- Intéressée