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ACCESS TO POTABLE WATER AND SANITATION IN CAMEROON WITHIN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

CASE STUDY : GENDARMERIE NATIONALE IN MELEN V, YAOUNDÉ

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Engineering (MEng) in ***Environmental Engineering***

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DEDICATION

This piece of work is dedicated to my Family and my beloved husband.

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ABSTRACT

Lack of access to good and safe drinking water is a global problem that affects approximately 663 million people worldwide and more than 18 million people die each year from water borne diseases in developing countries. Studies in Cameroon in 2008 showed less than 50% of the population were connected to the national water network, CAMWATER, and the alternative sources were characterized by high levels of microbial contamination. Understanding the risks and providing an appropriate treatment technology are therefore important because unsafe drinking water quality is directly related to health caused primarily by microbial contamination prevalent in developing countries. This work carried out in the Melen V neighbourhood precisely Gendarmerie Nationale was aimed Assessing the progress of Cameroon in achieving SDG6 precisely target 1 through the evaluation of the potability of the alternative water sources (borehole, spring, wells) provided by stakeholders else than the Government., and propose solutions for better conservation and improvement of the drinking water quality. To attain this objective, a systematic methodology was adopted which comprised a documentary review, knowledge and practice survey through a questionnaire and laboratory analyses of four (04) water samples taken from the locality. Of all respondents to the survey, 40% were linked to CAMWATER and 83% of the total correspondents reported groundwater as their primary source of drinking water with 50% of them who reported treating water before drinking. The results obtained from the water tests on the different most used sources showed faecal coliform and streptococci content of up to 25 CFU/100 mL and 13 CFU/100 mL, an average suspended solids concentration of 1mg/L, values which exceed the maximum permissible limits set by the Cameroonian and WHO norms which ought to be at zero (0). This was due to the non-respect of the protection of source perimeters. Other physicochemical parameters were more or less within the norm limits. A few treatment methods were then proposed to ameliorate the water quality and hence preserve the health of the population.

KEY WORDS: Drinking water, faecal contamination, Melen V, SDGs, water quality, WHO standards

RESUME

Le manque d'accès à une eau potable améliorée est un problème mondial qui touche environ 663 millions de personnes dans le monde et plus de 18 millions de personnes meurent chaque année de maladies d'origine hydrique dans les pays en développement. Des études menées au Cameroun en 2008 ont montré que moins de 50% de la population était connectée au réseau national d'eau, CAMWATER, et que les sources alternatives étaient caractérisées par des niveaux élevés de contamination microbienne. Il est donc important de comprendre les risques et de fournir une technologie de traitement appropriée, car la mauvaise qualité de l'eau potable est directement liée à la santé, principalement à cause de la contamination microbienne qui prévaut dans les pays en développement. Ce travail réalisé au quartier Melen V précisément de la Gendarmerie Nationale avait pour but d'évaluer les progrès du Cameroun dans l'atteinte de l'ODD6 précisément la cible 1 à travers l'évaluation de la potabilité des sources d'eau alternatives (forage, source, puits) fournies par des acteurs autres que le Gouvernement et proposer des solutions pour une meilleur conservation et l'amélioration de la qualité de l'eau potable. Pour atteindre cet objectif, une méthodologie systématique a été adoptée qui comprend une revue documentaire, une enquête sur les connaissances et les pratiques à travers un questionnaire et des analyses de laboratoire de quatre (04) échantillons d'eau prélevés dans la localité. Parmi tous les répondants à l'enquête, 40% étaient liés à CAMWATER et 83% du total des correspondants ont déclaré que les eaux souterraines étaient leur principale source d'eau potable, 50% d'entre eux ayant déclaré traiter l'eau avant de la boire. Les résultats obtenus à partir des analyses de l'eau des différentes sources les plus utilisées ont montré une teneur en coliformes fécaux et en streptocoques allant jusqu'à 25 UFC/100 ml et 13 UFC/100 ml, une concentration moyenne de solides en suspension de 1mg/L, des valeurs qui dépassent les limites maximales admissibles fixées par les normes camerounaises et de l'OMS qui devraient être à zéro (0). Ceci est dû au non-respect des périmètres de protection des sources. Les autres paramètres physico-chimiques sont plus ou moins dans les limites de la norme. Quelques méthodes de traitement ont été proposées pour améliorer la qualité de l'eau et préserver la santé de la population.

Mots clés : Contamination fécale, Eau potable, Melen V, normes de l'OMS, ODD, qualité de l'eau,

SUMMARY

ABBREVIATIONS

ANOR:	Agence des Normes et de la Qualité
CDC:	Centre for Diseases Control and Prevention
CEDAW:	Convention on the Elimination of All Forms of Discrimination against Women
CFU:	Colony Forming Units
EC:	Electrical Conductivity
EPA:	Environmental Protection Agency
FC:	Faecal coliform
FS:	Faecal streptococci
HWTS:	Household water treatment and storage
ICESCR:	International Covenant on Economic, Social and Cultural Rights
IWRM:	Integrated water resource management
JMP:	Joint monitoring program
MCL:	Maximum contaminant level
MDG:	Millennium Development Goal
MeS:	Matières en Suspension
mg/l:	Milligram per litre
MINEE:	Ministere de l'energie et de l'eau (Ministry of water and energy)
mL:	millilitre
nm:	nanometre

ODA: Official development assistance

OMS: Organisation Mondiale de la Sante

pH: Hydrogen potential

SDG: sustainable development Goals

SDWA: Safe drinking water act

SODIS: Solar disinfection

TDS: Total dissolved solids

TSS: Total suspended solids

U.V: Ultra violet

UN: United Nations

UNICEF: United nations children emergency Funds

WHO: World health organization

µS/cm: Micro-Siemens per centimetre

LIST OF FIGURES

LIST OF TABLES

GENERAL INTRODUCTION

BACK GROUND

Our country Cameroon and the world as whole is dealing with the Corona Virus sanitary health crisis. To reduce its spread, many people developed as new mantra “wash your hands”. But one will ask, with which water source?

Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Improved water supply and sanitation, and better management of water resources, can boost countries’ economic growth and can contribute greatly to poverty reduction.

In 2010, the UN General Assembly explicitly recognized the human right to water and sanitation. Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible and affordable water for personal and domestic use.

With time, Potable Water has become less and less accessible in most urban areas and the town of Yaoundé is no exception. According to a study carried out in 2018, the city of Yaoundé with its population of over 3millions inhabitants, suffers a water supply gap of 250,000m^3 daily as stated in a paper published in AFRICA Xinhua news editorial of the 22nd of March 2021 written by Arison Tamfu[1]

Some 842 000 people are estimated to die each year from diarrhoea as a result of unsafe drinking-water, sanitation and hand hygiene. But diarrhoea is largely preventable, and the deaths of 361 000 children aged under 5 each year could be avoided each year if these risk factors were addressed. Where water is not readily available, people may decide handwashing is not a priority, thereby adding to the likelihood of diarrhoea and other diseases.

The accessibility to potable tap water through pipe connection being limited, many people have resulted to alternative water sources like wells, rainwater, boreholes, and springs. Water issues in

[1] http://www.xinhuanet.com/english/africa/2021-03/22/c_139827689_2.htm

some localities have become so alarming to the point where people drink water from questionable sources as long as it appears clear or colourless, odourless and tasteless.

More recently though, more progress has been made globally for the general wellbeing of man and the sector of water and sanitation was not exempted. The UN in 2016 in its agenda 2030 had as aim in its goal 6 to ensure the availability and sustainable management of water and sanitation for all, goal which further had as first target "achieving universal and equitable access to safe and affordable drinking water for all. Cameroon being one of the 193 countries making up the UN, hence subject to this objective has made progress towards it especially in its constitutional level as will be seen in this work, though efforts still have to be made as implementation of the law is concerned.

The responsibility of achieving this goal not being just that of the government, other stakeholders like NGOs and individuals have been great activists in taking actions towards the achievement of this goal through the construction and provision of alternative sources of potable water to that provided by the government (CAMWATER). Nonetheless, there is still a great concern at the level of the quality and the potability of the water from theses alternative sources when compared to the expected standards from WHO guidelines as well as the possible health effect associated to the consumption of this water if no appropriate care is taken.

GENERAL OBJECTIVE

This work had as general objective: Assessing the progress of Cameroon in achieving SDG6 precisely target 1 through the evaluation of the potability of the alternative water sources (borehole, spring, wells) provided by stakeholders else than the Government in the neighbourhood of Melen V precisely gendarmerie National.

SPECIFIC OBJECTIVES

Following our main objective stated previously, we had as specific objectives;

- Have a rundown of governmental progress on implementing water policies in line with SDG6(what has been done so far).
- Evaluate the knowledge of the Cameroonian population in our study area on the characteristic of water safe for drinking.

- Record the main sources of potable water commonly used.
- Evaluate the quality of drinking water used in households as well as the storage system and comparing them to the expected WHO norms.

RESEARCH QUESTION

And we answered to the following

- Does every Cameroonian have access to their daily necessary quantity and quality of potable water?

HYPOTHESIS

In order to carry out this investigation the following tentative assumptions where made:

- An average Cameroonian is ignorant on his right to water and the characteristics of drinking water.
- The alternative sources of water used are not of good quality.

STRUCTURE OF THE PROJECT

This project work is executed as follows:

- A general introduction which is be based on a back ground, a justification of the thesis topic, research questions, hypothesis, main and specific objectives.
- The first chapter gives a literature review, presentation of the area under study and exploration of key terms among which household water treatment method.
- The second chapter gives a rundown of the work done through the collection of samples, survey through questionnaire and lab analysis of data.
- The third chapter brings out results from analysis and compare with the expected WHO norms and ANOR standards.
- The fourth chapter gives solutions through recommendations on the treatment and potabilization of the water from the different sources tested while focusing on low-cost option. Validation of hypothesis and methodology limitations
- Lastly perspectives, general conclusions, references and annex

CHAPTER ONE: LITERATURE REVIEW

For the purpose of achieving our research objective and obtain the validation of this work, a knowledge and an understanding of what characterizes our study area is necessary laying interest on geographical location, relief, demography and climate as well as an understanding of potable water characteristics, treatments and the different institutional norms in Cameroon. Hence, this chapter will be cantered on obtaining knowledge on the area of study, water and the description of its potability.

1.1. PRESENTATION OF AREA UNDER STUDY

A. Geographical location

Our area of interest is commonly known as Gendarmerie National. Though not the formal name of the quarter, the zone is known by that name because of the presence of that administrative facility. Gendarmerie National is found in Melen V district, in Yaoundé 6 sub-division and in the Mfoundi Division. Let us detailly present the zone from a more global perspective narrowing to our specific location. The city of Yaoundé is located between latitudes 3^{o}47’ and 3^{o}56 N of the equator and between longitudes 11^{o}10 and 11^{o}45 East of the Prime Meridian.

The centre region is one of the 10 Regions in the country and is divided into 10 Divisions namely:

- Haute Sanaga,
- Lekie,
- Mbam-et-kim,
- Mbam-et-Inoubou,
- Mefou-et-Afamba,
- Mefou-et-Akono,
- Mfoundi,
- Nyong-et-Kelle
- Nyong-et-Mfoumou,
- Nyong-et-So’o

The city of Yaoundé is the headquarter of the Centre region, the political capital of the country and the second largest city after the Douala, headquarter of the Littoral region and economical capital of the country.

Yaoundé is the headquarter of the Mfoundi Division, which has 7 subdivisions which are Yaoundé I, II, III, IV, V, VI and VII. Yaoundé VI. Our area is located in Yaoundé VI. Figure 1 shows an image of Cameroon and the sub-divisions in Yaoundé VI.

Yaoundé VI whose headquarter is Biyem-assi, has as coordinates 3° 50′ 39″ North, 11° 28′ 32″ East and a surface area of 2 220 ha = 22,2 km². It covers the following quarters:

- Biyem-Assi
- Mendong Camp Sic
- Nkolbikok II
- Etoug-Ebe I
- Melen I, III, IV, V, VI, VIIA
- Mvog-Betsi
- Etoug-Ebe II
- Melen VIIB
- Eba Biyem-Assi
- Melen VIIIC
- Melen IX
- Nkolbikok I

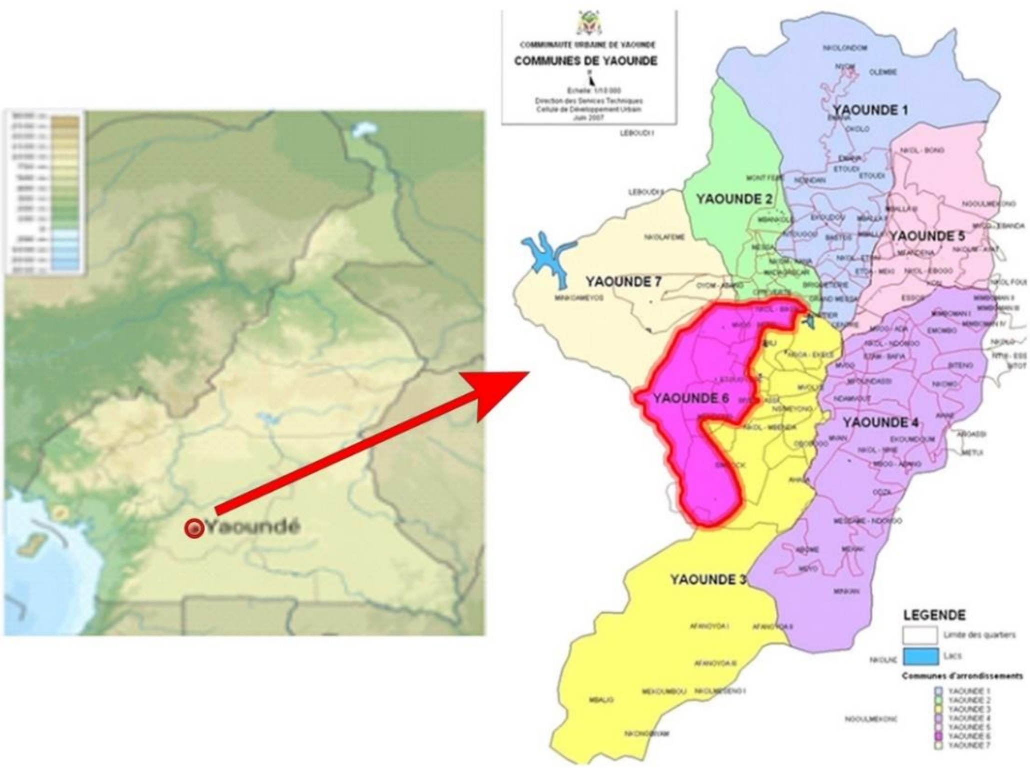

Figure 1: Map of Cameroon showing location of Yaoundé and its 7 sub-divisions source: (C.U.Y, 2008)

Figure 2: Map of Melen V

Source: (google map)

B. Relief

The commune of Yaoundé 6 is located on a collinear site (city of 7 hills). Located at 726 m above sea level, Yaoundé has always been nick-named the town of seven hills due to its very hilly nature. It is made up of several hills whose valleys are characterised by the presence of rivers. This highly oscillatory topography contains high risk areas where construction is dangerous, with slopes of less than 5% whose valleys are often flooded as well as areas of very steep slopes, permanent erosion and landslide. The areas where construction can comfortably be carried out are areas with slopes of 5% to 15%. The seven hills which give Yaoundé its nickname vary in height between 900 m to 1073 m, with an approximate gap of barely 200 m.[2]

C. Demography

As of 2015, the urban development of Yaoundé was such that the town covered a total surface area of 304 km^2, 185 km^2 of it being urbanised with a population estimated at 2,8 million inhabitants (www.populationdata.net/pays/cameroun), thus having a population density of 5,691 habitants per km² (C.U.Y, 2008). Recent data however, indicates a population of 3.4 million inhabitants in 2018 (C.U.Y, 2018).

[2] https://www.universalis.fr/encyclopedie/yaounde/

D. Climate

The climate here is tropical. Most months of the year are marked by significant rainfall. The short dry season has little impact The average temperature here is 23.0 °C | 73.5 °F and temperatures vary from 18 °C to 28 °C during the humid season and from 16 °C to 31 °C during the dry season.

In a year, the rainfall is 1727 mm | 68.0 inch, with the rainiest month being October with an average precipitation of 253 mm| 10.0 inch with precipitation going up to 300mm. January is the driest month with 49 mm| 1.9inch of rain.

The climate is characterized by two dry seasons and two rainy seasons, all of different lengths (en.climate-data.org, 2019). These seasons alternate in the course of the year as follows;

- Long dry season, from mid-November to February;
- Short rainy season, from March to mid-June;
- Short dry season, from mid-June to mid-August;
- Long rainy season, from mid-August to mid-November

March is the warmest month of the year, with an average temperature of 24.6°C. The lowest average temperature in the year occurs in August, when it is around 22.6°C (en.climate-data.org). Figure 3 shows the climatic variation in Yaoundé, by months.

	January	February	March	April	May	June	July	August	Septem-ber	October	November	December
Avg. Temperature °C (°F)	24 °C (75.2) °F	24.5 °C (76.2) °F	24.1 °C (75.4) °F	23.6 °C (74.5) °F	23.2 °C (73.8) °F	22.5 °C (72.5) °F	22 °C (71.6) °F	22 °C (71.5) °F	22.1 °C (71.8) °F	22.2 °C (72) °F	22.7 °C (72.9) °F	23.4 °C (74.1) °F
Min. Temperature °C (°F)	20.7 °C (69.3) °F	21.2 °C (70.2) °F	21.3 °C (70.3) °F	21 °C (69.7) °F	20.7 °C (69.3) °F	20.3 °C (68.5) °F	19.9 °C (67.7) °F	19.8 °C (67.7) °F	20 °C (68.1) °F	20.1 °C (68.2) °F	20.3 °C (68.6) °F	20.7 °C (69.2) °F
Max. Temperature °C (°F)	29.1 °C (84.3) °F	30 °C (86) °F	29.2 °C (84.5) °F	28.1 °C (82.6) °F	27.4 °C (81.4) °F	26.6 °C (79.8) °F	26.1 °C (78.9) °F	26.1 °C (78.9) °F	26.2 °C (79.2) °F	26.2 °C (79.1) °F	26.7 °C (80.1) °F	27.8 °C (82) °F
Precipitation / Rainfall mm (in)	49 (1.9)	63 (2.5)	133 (5.2)	179 (7)	183 (7.2)	161 (6.3)	133 (5.2)	136 (5.4)	192 (7.6)	253 (10)	182 (7.2)	63 (2.5)
Humidity(%)	73%	74%	80%	85%	86%	86%	85%	84%	86%	89%	87%	80%
Rainy days (d)	8	9	15	18	19	18	18	19	20	21	17	10
avg. Sun hours (hours)	6.9	6.7	6.1	5.4	5.2	4.5	3.9	3.6	4.1	4.4	5.2	6.4

Figure 3: Weather by month in Yaoundé

source: (CLIMATE-DATA.org)

Maximum sunstroke duration is between 3 to 7 hours per day, and this counts for about 40 to 60% of days per year. The sunstroke duration below 2 hours accounts only for 10-24% of days per year. The month with the most sunshine is February (with average sunshine of 6.4 h) and the month with the least sunshine is August, with average sunshine being 2.8 h. Figure 3 shows hours of sunlight in Yaoundé. (en.climate-data.org).

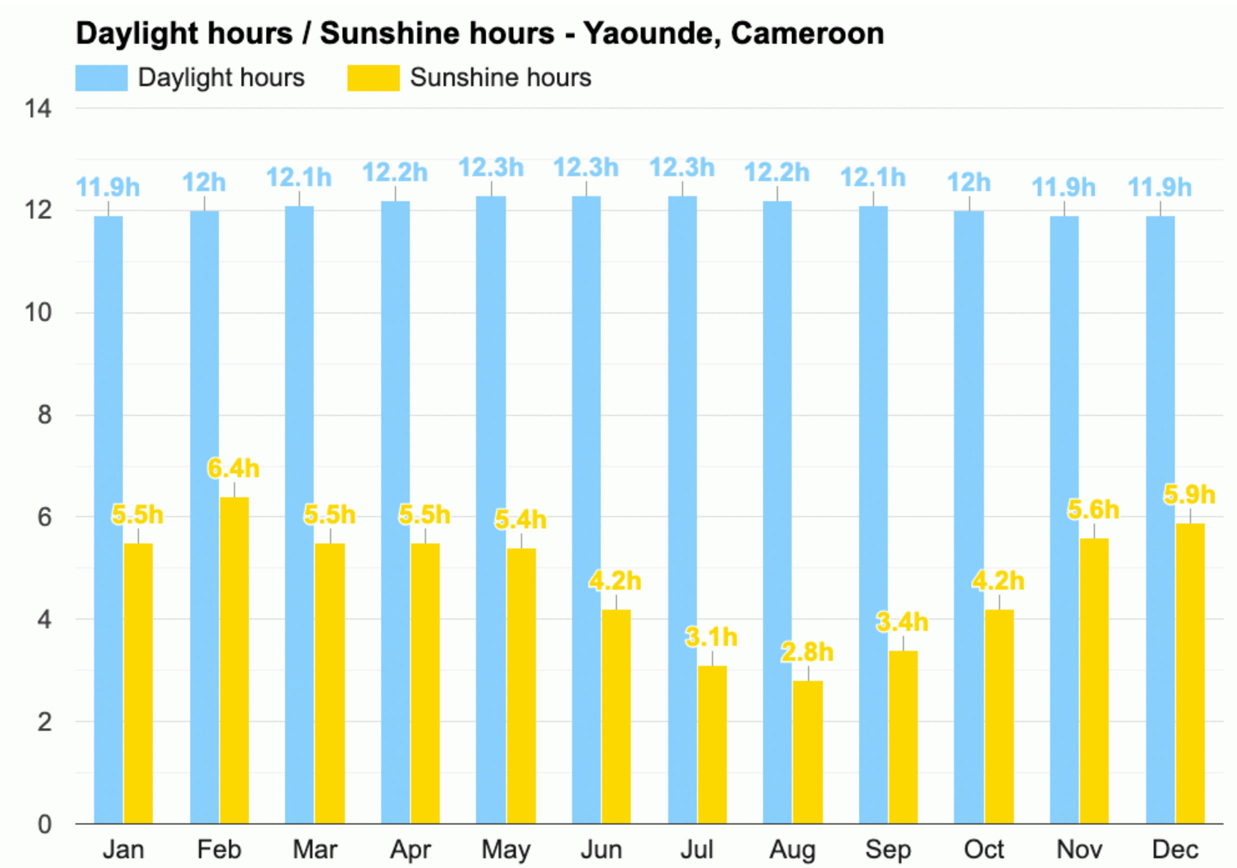

Figure 4: Daylight and sunshine hours in Yaoundé

Source;(weather-atlas[3], 2019.)

[3] www.weather-atlas.com

1.2. POTABLE WATER

1.2.1. Definition

Drinking water, also known as potable water, is water that is safe to drink or use for food preparation. The amount of drinking water required to maintain good health varies, and depends on physical activity level, age, health-related issues, and environmental conditions.

Hence, water that is made fit for human consumption with minimal short- or long-term harm is called potable or drinking water.

Before looking in-depth into the topic "Potable water", let's first of all define water. Water is a substance composed of the chemical elements hydrogen and oxygen and it is the only compound that exists as solid, liquid and gas at the typical temperatures of the Earth's surface. It is one of the most plentiful and essential of compounds. A tasteless and odourless liquid at room temperature, it has the important ability to dissolve many other substances.

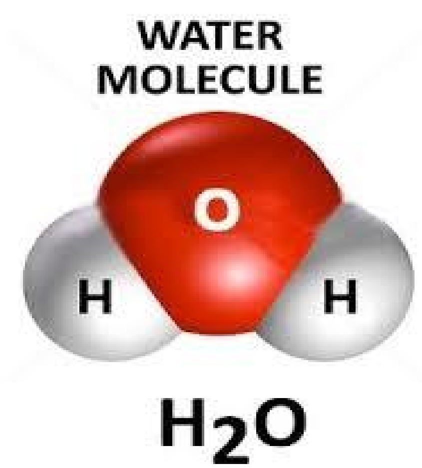

Figure 5: Structure of a water molecule

Water from natural sources is treated for microorganisms, bacteria, toxic chemicals, viruses and faecal matter. Drinking raw, untreated water can cause gastrointestinal problems such as diarrhoea, vomiting or fever.

1.2.2. Sources of potable water (Availability and access to potable water)

It is known that the earth surface constitutes about 70% of water and 30% of ground. Oceans hold about 96.5% of this earth's water. Water resources come in many forms, but the three main categories are saltwater, groundwater and surface water.

Surface water is made of water in lakes and rivers with surface runoff from rain, whereas, water below the ground with rain infiltration and percolation are referred to as groundwater or aquifers. Groundwater and surface water serve as the two major sources of drinking water(Finance). Rainfall constitutes the main source of underground water recharge mechanism.

Drinking water in households are often from these different sources which can further be categorized as improved and unimproved water sources.

a. Improved water sources

The term was coined by the Joint Monitoring Program (JMP) for Water Supply and Sanitation of UNICEF and WHO in 2002 to help monitor the progress towards Goal Number 7 of the Millennium Development Goals (MDGs) which stated in its Target 7.C: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.

The category 'improved drinking water sources' includes sources that, by nature of their construction or through active intervention, are protected from outside contamination, particularly faecal matter. These include **piped water in a dwelling, plot or yard**, and other improved sources which are public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs and rainwater collection(WHO).

The opposite of "**improved water source**" has been termed "unimproved **water source**" in the JMP definitions.

b. Unimproved water sources

As defined by the Joint WHO & UNICEF Monitoring Programme (JMP), an unimproved drinking-water source is one that by the nature of its construction does not adequately protect the source from outside contamination, in particular with faecal matter. Unimproved drinking-water sources include: Unprotected (dug) well; unprotected spring, cart with small tank or drum; tanker truck-provided water, surface water (river, dam, lake, pond, stream, canal, irrigation channel) (WHO).

1.2.3. Laws and agencies regulating drinking water in Cameroon

a. International Bodies and Regulations

At the international level, traditional sources, (conventions, treaties, protocols and covenants) of the right to water feature either explicitly or implicitly in the legal instruments. Firstly, express reference to the right to water has been made in the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW). It is therein provided that "State parties…shall ensure to women the right…. to enjoy adequate living conditions, particularly in relation to housing, sanitation, electricity and water supply." Explicit reference to the right to water is also made in the Convention of on the Rights of the Child. This Convention provides with regards to the right of the child to water that "state parties recognize the right of the child to the enjoyment of the highest attainable standard of health… and pursue full implementation of this right and shall take appropriate measure... through the provision of clean drinking water… Explicit reference to the right to water as a fundamental right of the human person had already been recognized, but, within the context of humanitarian law.

The *Geneva Convention* of *July 27, 1929* and its *Additional Protocols II* of *12 August 1949* on the treatment of prisoners of war, and on the protection of victims of non-international armed conflict, respectively, have clearly imposed on states the obligation to implement the right to water even during war situations. In fact, there are several Conventional legal instruments at the global level alluding to the right to water but with differing weight of obligations on the state parties. The *New York Convention of 1997*, for instance, on the use of International Waters for Purposes other than Navigation is contented with a simple invitation of states to be particularly diligent when it concerns the satisfaction of basic needs of their respective population. This does not seem to impose succinct and concrete obligations on state parties. On the contrary, we find that the three conventions and Protocols just discussed above actually provide for clear and firm obligations on the part of states as concerns the right to water. The question now is how have these obligations been translated on the ground by various countries?

The Convention on the Elimination of all Forms of Discrimination against Women was adopted by the General Assembly Resolution 34/180 of 8 December 1979. See art14. The Conventions on the Rights of the Child was adopted by General Assembly Resolution 44/25 of 20 November 1989. See Art 24 (1), (2) (c). Arts 20, 26, 29 and 46. 24 Arts 5 and 14. 25 Art 10 paragraph 2 8.

In the case of Cameroon**,** these Conventions have been signed and ratified. Cameroon operates the dualist approach to the domestication of international legal instruments. This implies that the right to water contained in these instruments is recognized in Cameroon. As to whether this right is enjoyed by the population is quite another question which shall be examined later in this work. But must the right be explicit for it to impose obligations?

There are also implicit references to the right to water at the global level which impose implied obligations. The most important in this regard is *the International Covenant on Economic, Social and Cultural Rights* (ICESCR). This covenant recognizes the economic and social rights of the human person to an adequate standard of living, to sufficient feeding and a right to health. The right to water is an integral part of these rights universally recognized or which could be considered as an indispensable component to the enjoyment of existing social and economic rights. Within the framework of implementation of the Covenant, the UN Committee on Economic, Social and Cultural Rights recognizes that water is a fundamental right as contained in article 11 paragraph 1 of the ICESCR. However, a more detailed coverage is afforded by the same committee in its General Comment N° 15 on the right to water. It defines the right to water, delimits its boundaries and spells out the obligations which are expected from states in this regard. It should be noted that the provisions of the Committee are not binding as the status of General Comment has been considered as soft law and hence non-binding on states. However, there is no doubt that its provisions are insightful to the understanding and enforcement of the right to water.

Implicit reference to the right to water has also been made by the International Covenant on Civil and Political Rights. The covenant recognizes the right to life. Convention on the Elimination of all Forms of Discrimination against Women was ratified on 15 July 1988 by law N° 88/11; Convention on the Rights of the Child ratified on 17 July 1991, by law N° 91/006 and the Geneva Convention ratified on 16 September 1963; Protocol II of 1977 ratified on 16 March 1984. The dualist approach as opposed to monist approach is one where signature of an international legal instrument does not suffice for it to be applicable in the home or signatory country. It must be followed by a ratification process within the internal legal order which then injects the legal instrument's provisions into the internal legal order making it to become hard domestic law. Cameroon ratified this Covenant on 24 June 1984. General Comment N° 6. This covenant was adopted by the UN General Assembly Resolution 2200A (XXI) of 16 December 1966.

The right to life cannot be enjoyed without the right to water. The right to water is, therefore, a prerequisite for the enjoyment of the right to life. Although implicit, the right to life and hence the right to water is recognized in Cameroon by dint of the fact that the covenant on Civil and Political Rights has been ratified by Cameroon.

b. Regional and National sources of the right to water

The discussion here will be limited to the African continent for obvious reasons. Cameroon is in the African continent and is often referred to as Africa in miniature. Explicit reference to the right to water in African continental instruments is found in the African Charter on the Rights and Welfare of the Child. The Charter recognizes that "State parties to the present Charter… shall ensure the provision of adequate nutrition and safe drinking water…" The fact that Cameroon has also signed and ratified this charter implies that the rights to water of the Cameroonian child are recognized under Cameroonian law. But is it enforced? This question would be answered subsequently.

Another legal instrument at the African continental level with explicit reference to the right to water is the African Convention on Conservation of Nature and Natural Resources. It is therein provided that state parties shall endeavour to guarantee to the population a sufficient and continuous flow of clean water. Although this convention is not yet in force, we may applaud the initiative of having given a place to the right to water. We may also note implicit reference to the right to water in the African Continent in the African Charter on Human and Peoples Rights which protects the right to health and the right to a clean environment. As already argued with regards to global implicit references, the implementations of these rights also imply the recognition and enforcement of the right to water.

What are the elements that make this right to water valid? If access to water for domestic and personal use is to be sustainable, this must entail;

- Access to sufficient quantity of water that is enough water to satisfy personal and domestic water needs according to WHO guidelines, it is at least 20 litres of potable water per day.(Addendum and Third)
- Access to safe and acceptable water meaning the water should be of good quality according to WHO drinking water Quality
- Accessibility is important as well as quality and quantity are not enough but the water should be Physical accessible. accessibility in this context relates to water, its facilities and services being within safe reach of the population. It is also defined as "within the immediate vicinity of households, educational institutions and workplace"
- Affordability To adequately enjoy the right to water, government must ensure that water is affordable by all. The right to water, therefore, does not imply that water is free of charge. n Cameroon, a cross-section of the population does not enjoy access to water either because the cost to connect the water is too high and/or the cost per meter cube is too high (the cost per meter cube has risen from 339FCFA/ m3 to 470FCFA/m3 – about one US dollar/m3). Given the general financial situation of the people, this amount is too high and this partly explains why water cuts for failure to pay or delays are significantly many.(Tamasang)

In conclusion, water right englobes water sufficient, safe, acceptable and accessible. The right also entails water which is affordable.

c. The constitution

The constitution of the Republic of Cameroon does not explicitly provide for the right to water. However, it has a number of preambular provisions relating to economic and social rights. Since it is admitted that the right to water is an integral part of economic and social rights, it could, therefore, be submitted that the constitution makes implicit reference to the right to water through its provisions for economic and social rights. As an integral part of environmental law, the right to water has a comfortable foundation in the constitutional provisions. It is provided in the preamble that *every person has a right to a healthy environment, that the protection of the environment shall be the duty of every Cameroonian, and that the state shall ensure the protection and improvement of the environment*. Therefore, in this light, there is an implicit commitment to protect and improve on the right to water.

d. Water code

The Water Code Just like the constitution, earlier pieces of legislation on the environment have not made any express provision on the right to water. However, probably inspired by the constitutional provision on the right to a healthy environment and the other bundle of economic and social rights, the Cameroonian legislator passed the Water Code within the respect of environmental at management principles and public health protection. In it, it is expressly provided that *water is a public good or utility which the state ensures its protection and management and facilitates access to all*. The measures of protection are clearly spelled out in the Code49 and violators come under heavy criminal sanctions without prejudice to civil claims. To ensure conservation, protection and sustainable utilization, the Code institutes a National Water Committee, an institution placed under the Ministry in charge of water resources. With the above as the major sources of the right to water in Cameroon, a question that further springs to mind is what the nature of the right to water is.(Tamasang)

e. National bodies and regulations

Key drinking-water agencies in Cameroon and Key agencies with a role related to drinking-water in Cameroon include:

The Ministry of Water and Energy (MINEE), whose responsibilities include control of the quality of raw water; monitoring the quality of water resources; and monitoring the quality of drinking-water delivered for consumption.

The Ministry of Water and Energy (MINEE) is responsible for the definition and application of water policies in Cameroon and is the coordinating institution as regards water in Cameroon. It is responsible for the execution of projects on managing pollution, water supply and sanitation in both urban and rural areas in the country. This ministry is responsible for enforcing pollution control measures, determining the sanctions for defaulters and determining consumption of industrial/commercial users to facilitate the calculation of abstraction fees. MINEE has the mandate to issue abstraction and discharge licenses following the text of applications signed in May 2001 to enforce the water law of 1998.(Ako et al.)

Though the MINEE plays a central role in the water sector, other public institutions do intervene into the water sector. They include: Ministry of Urban Development and Housing (MINDUH), Ministry of Towns (MINVILLE), Ministry of Agriculture and Rural Development (MINADER), Ministry of Livestock, Fisheries and Animal Industries (MINEPIA), Ministry of Environment and Nature Protection (MINEP), Ministry of Economy, Planning and Regional Development (MINEPAT), Ministry of Public Health (MINSANTE), Ministry of Commerce (MINCOMMERCE), Ministry of Territorial Administration and Decentralization (MINATD), Ministry of Finance (MINFI) and Ministry of Transport (MINTRANS).(Ako et al.)

The National Standards and Quality Agency, whose responsibilities include the development and certification of standards; the development of proposals for standards to improve the quality of products and services and compliance with standards; and dissemination of information and documentation on standards.

The Ministry of Public Health, whose responsibilities include the certification of water quality standards and the control of their compliance (in liaison with other concerned parties); control and monitoring of water quality; and approval of the technologies used in the treatment of drinking-water (in liaison with other concerned parties).

Other actors like the private sector (the national water utility company (CAMWATER) and that of electricity (AES-SONEL)) and Non-Governmental Organizations (NGOs) play an important role in the mobilization and management of water resources. International aid organizations play an essential role in the financing of hydraulic infrastructures and provide technical and financial assistance in the water sector (MINEE 2005)

The Cameroon Water Utilities Corporation, whose responsibilities include the planning, research, project management and financial management of drinking-water infrastructure; the construction, maintenance, renewal and management of drinking-water infrastructure; and awareness raising among drinking-water users.

Decree N° 2009/296 of 17 September 2009 on the creation, organization and functioning of the National Standards and Quality Agency;

Decree N° 2012/501 of 7 October 2012, organizing the Ministry of Water and Energy;

Decree N° 2013/093 of 3 April 2013, organizing the Ministry of Public Health;

Decree N° 2018/144 of 20 February 2018, reorganizing the Cameroon Water Utilities Corporation.

1.2.4. Characteristics of potable water

Even though water may look clear, it does not necessarily mean that it is safe or otherwise suitable for us to drink.

Water quality is determined by physical, chemical and microbiological properties of water. These water quality characteristics throughout the world are characterized with wide variability. Therefore, the quality of natural water sources used for different purposes should be established in terms of the specific water-quality parameters that most affect the possible use of water. That is why the aim of this section is to provide an overview of water quality characteristics – Physical (temperature, colour, smell, taste and turbidity), Chemical (minerals, metals and other chemicals), and Biological (bacteria, viruses, protozoa and worms.) characteristics.

a. Physical qualities

Temperature: The temperature of water affects some of the important physical properties and characteristics of water: thermal capacity, density, specific weight, viscosity, surface tension, specific conductivity, salinity and solubility of dissolved gases and etc. Chemical and biological reaction rates increase with increasing temperature. Reaction rates usually assumed to double for an increase in temperature of 10 °C. The temperature of water in streams and rivers throughout the world varies from 0 to 35 °C.

Colour: Colour in water is primarily a concern of water quality for aesthetic reason. Coloured water gives the appearance of being unfit to drink, even though the water may be perfectly safe for public use. On the other hand, colour can indicate the presence of organic substances, such as algae or humid compounds. More recently, colour has been used as a quantitative assessment of the presence of potentially hazardous or toxic organic materials in water.

Taste and Odour: Taste and odour are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salty (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However sweet and bitter tastes are produced by more complex organic compounds. Human detect many more tips of odour than tastes. Organic materials discharged directly to water, such as falling leaves, runoff, etc., are sources of tastes and odour-producing compounds released during biodegradation.

Turbidity: Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons.

b. Chemical qualities

The chemical characteristics of natural water are a reflection of the soils and rocks with which the water has been in contact. In addition, agricultural and urban runoff and municipal and industrial treated wastewater impact the water quality. Microbial and chemical transformations also affect the chemical characteristics of water.

c. Biological quality

Water naturally contains many living things. Most are harmless or even beneficial, but others can cause illness. Living things that cause disease are also known as biological pathogens. They are sometimes also known as microorganisms, microbes or germs, depending on the local language and country. The three main classes of biological pathogens that are commonly waterborne and represent the chief threats to health are bacteria, viruses and protozoa. Poor water quality is associated with a variety of infectious diseases transmitted by helminths, protozoa, bacteria and viruses. Some of these diseases include: Diarrhoea (dysentery, cholera), Typhoid and paratyphoid fever.

1.2.5. Maximum contaminant level

It refers to the maximum level of contaminants that is allowed in water destined to Human consumption. Maximum contaminant levels (MCLs) are standards that are set by the United States Environmental Protection Agency (EPA) for drinking water quality. An MCL is the legal threshold limit on the amount of a substance that is allowed in public water **systems** under the Safe Drinking Water Act (SDWA).

Table 1: Maximum contaminant level standards

PARAMETERS	WHO standard	EPA standard
PH	6.5	6.5-8.5
Conductivity(µs/cm)	NS	NS
Colour (HU)	6	15
Odour	U	U
Turbidity (NTU)	6.0	0-5
Total solids (Mg/l)	500	500
Total dissolved solids (Mg/l)	500	500
Total suspended solids (Mg/l)	NS	NS
Acidity	0.3	0.3
Total Hardness (Mg/l)	500	500
Ca 2+ hardness (Mg/l)	75	65
Mg 2+ hardness (Mg/l)	50	50
Chloride	200	250
Iron	0.3	0.3

U = Unobjectionable; NS- No Standard(Purposes)

1.2.6. Methods of household water treatment

Water treatment can be done at different level, communal largescale level, or at household level (point source or in individual homes).

To fit our context, we will be talking of potable water treatment at a household scale. Household water treatment ,(treatment that happens at the point of water collection or use, rather than at a large, centralized location) improves water quality and reduces diarrheal disease in developing countries and in this section, we will be emphasizing on household water treatment and storage(HWTS)(Figueroa and Kincaid). The main focus of household water treatment is on removing biological pathogens. This is because biological pathogens such as rotavirus present the most significant health risk. However, some household water treatment options can also remove chemicals and improve physical qualities of drinking-water. It is important to protect the sources of water and make sure they are in conformity with the norm before ever thinking of treating the water.

Water source protection

Before addressing methods of treating water at the household level, it is important to emphasize the need to use the best possible source of water. There are many ways in which pollution can threaten drinking-water quality at the source, or point of collection. These risks include the following:

• poor site selection,

• poor protection of the water source against pollution,

• poor structure design or construction,

• deterioration or damage to structures,

• lack of hygiene and sanitation knowledge and practice in the community. Protecting the water source reduces or eliminates these risks and can lead to improved water quality and health. Actions that can be taken at the community level can include some of the following:

• regularly cleaning the area around the water source,

• moving latrines away from and downstream of water sources,

• building fences to prevent animals from getting into open water sources, • lining wells to prevent surface water from contaminating groundwater,

• building proper drainage for wastewater around taps and wells,

• stabilizing springs against erosion and protection from surface run-off contamination,

• ensuring watershed use is non-polluting.

As treatment itself is concerned, we did a grouping in 3 main phases; Sedimentation, Filtration, disinfection

a. Sedimentation

Sedimentation is a physical treatment process used to reduce the turbidity of the water. This could be as simple as letting the water settle for some time in a small container, such as a bucket or pail. The sedimentation process can be accelerated or “assisted” by adding special chemicals or native plants, also known as coagulants, to the water. Coagulants help the sand, silt and clay join together and form larger clumps, making it easier for them to settle to the bottom of the container. The common chemical coagulants used are aluminium sulphate (alum), polyaluminium chloride (also known as PAC or liquid alum), alum potash and iron salts (ferric sulphate or ferric chloride). Native plants are also traditionally used in some countries, depending on the local availability, to help with sedimentation. For example, prickly pear cactus and moringa seeds have been used to help sediment water.

Option 1 - Settling

Much of the suspended material can be removed by simply allowing the water to stand and settle for a period of time. This can be done effectively in a small container such as a bucket or pail. Microorganisms like to stick to sediment, so by allowing the sediment to settle out we are removing microbes. Settling, however, can only partially remove turbidity – which is a measure of the suspended solids. The time range may vary from one hour up to two days (the longer the better). Simplicity, ease and Low cost, free if container is already available are the advantages of this option. As limitations it is time intensive and partially removes turbidity.

Option 2 – Coagulation Agents

The sedimentation process can be accelerated by adding special chemicals, called coagulants, to the water. These chemicals help the small particles in water join together forming larger clumps, making it easier for them to settle to the bottom of the container.

It has as advantage availability of chemical and natural coagulants (dried and ground moringa seeds), as well as the simplicity and ease of the method. The costs involved depending on coagulant used, partially removal of turbidity are limitations of this method. Three common chemicals used are aluminium sulphate, polyaluminium chloride (also known as PAC or liquid alum), and ferric sulphate. Each type of chemical has specific directions for using it properly but generally, adding some chemicals to the dirty water, Stirring the water with a stick or spoon and allowing it settle for a couple of hours is enough.

b. Filtration

After sedimentation, the water should then be filtered to further remove suspended material and pathogens. Filtration is also commonly used to reduce turbidity and remove pathogens. Filtration is a physical process that involves passing water through filter media. Some filters are also designed to grow a biological layer that kills or inactivates pathogens and improves the removal efficiency. Sand and ceramic are common filter media, although membranes and other media can also be used. Various types of filters are used by households around the world, including:

• bio sand filters,

• ceramic pot filters,

• ceramic candle filters,

• membrane filters.

Other filters use media such as activated carbon that adsorb and hold contaminants like a sponge rather than mechanically remove them like a sieve. The capacity of these filters is used up once the adsorption sites become fully occupied.

Straining is also considered a form of filtration and because of its cost-free nature, we will look deeper into this option.

A clean, cloth fabric can be used to strain particles out of water. Typically, a cotton cloth is folded 7 to 8 times and used as a filter. Water is poured through the folded cloth and collected in a bucket underneath. The cloth filters are known to reduce the risk of cholera by filtering out particles and plankton which harbour the cholera bacteria.

The time required is minimal, simply the time it takes to pour water through the cloth, Simplicity and ease, reduction of turbidity are the advantages of this option. It is also Known to reduce the risk of cholera.

The only inconvenience is the extra washing of the cloth used.

Figure 6: Cloth Filter/IYCF image bank

c. Disinfection

Another approach to treating water in the home is to kill or inactivate pathogens through disinfection. The most common methods used by households around the world to disinfect their drinking-water are:

- Chemical Disinfection

Chlorination is the most widely used method for disinfecting drinking water. Disinfecting water with chlorine will kill bacteria and viruses, but it does not deactivate parasites like giardia, cryptosporidium and worm eggs. Chlorine must be added in sufficient quantities to destroy all pathogens, but not so much that taste is adversely affected.

Chemical disinfection using chlorine has the benefits of being relatively quick, simple, and cheap and allows a residual amount of chlorine to remain in the water to provide some protection against subsequent contamination. Dosage is product specific

Requires that users purchase chlorine on a continuous basis Determining the right amount can be difficult because substances in the water will react with the disinfectant, and the strength of the disinfectant may decline over time depending on how it is stored (CDC, 2003)[4] and this is a disadvantage to this method. Deciding on the right amount of chlorine to use can be difficult, because the effectiveness of chlorination depends on the quality of the untreated water, which may vary according to the season.

The following table lists common chlorine products and their typical content or percentage strength.

Table 2 Comparison of Chlorine products

Product	strength	Remarks
High Test Hypochlorite (HTH) (calcium hypochlorite)	65% - 70%	Usually in granular form. Stable (≈2% active chlorine loss per year).
Chlorinated lime (bleaching powder)	30%	Usually in powder form. Not stable
Household bleach (sodium hypochlorite)	2.5% – 10%	Liquid form. Not stable; only use if manufactured recently (< 3 months), and stored away from heat and light.
Sodium dichloro-isocyanurate (NaDCC), used in products such as "Aquatabs"	50% - 60% as granules. 5 mg to > 5 g active chlorine per tablet	Usually in tablet form, also available in granular form. Tablets pre-dosed for water treatment. Very stable (shelf life ≈ 5 years).

In terms of accessibility, the most widely used chlorine compound is Sodium Hypochlorite ($NaOCl$).

[4] www.cdc.gov/safewater/manual/sws_manual.pdf

Sodium hypochlorite, commonly known as bleach, is most frequently used as a disinfecting agent. It is a broad-spectrum disinfectant that is effective for the disinfection of **viruses, bacteria**, fungi, and mycobacterium.

Because it easily traceable in compounds due to its scent, it is recommended by the EPA to only use regular, unscented chlorine bleach products that are suitable for disinfection and sanitization as indicated on the label. Scented, colour safe and bleaches with added cleaners are not advised for drinking water disinfection. For regular bleaches, the label may say that the active ingredient contains 4% to 8.25% Sodium Hypochlorite.

Figure 7: Common bleach label containing 8.25% NaOCl

Figure 8: Bleach label containing 8-10% NaOCl and additional information on usage direction (1 part:1000part of water)

Table 3: Amount of bleach (8.25%) to volume of water (clear water) to be treated

Amount of water	Amount of bleach added
1 quart/liter	2 drops
1 gallon	6 drops
2 gallons	12 drops (1/8 teaspoon)
4 gallons	¼ teaspoon
8 gallons	½ teaspoon[5]

The amount of bleach should be doubled for cloudy water.

The water is stirred and allowed to stand for 30mins before use. If the scent of Chlorine is absent, the dosage should be repeated and water allowed to stand for 15mins more before use. If the taste of Chlorine is too strong, the water is to be poured from one clean container to another and allowed to stand for few hours before use.

Household bleach comes in all sorts of different percentages of sodium hypochlorite. If your bleach has a lower percentage of sodium hypochlorite (such as 5% instead of 8.25%), then you'll need to use more bleach.

The CDC, for example, bases its recommendations for treating water with bleach(ANNEX 3) on a lower percentage (which they don't specify). According to their instructions, you should have 8 drops of bleach per gallon of water.

Given the wide spread of wells used in our area of study, it is important to state the amount of beach to be used for a point source disinfection to disinfect the wells

[5] https://www.primalsurvivor.net/purify-water-bleach/

Table 1. Amount of unscented, household liquid chlorine bleach needed for well disinfection

Water depth in well (feet)	Well diameter (inches)				
	4	6	8	24	36
10	6 cups	7 cups	8 cups	20 cups	2.5 gal
20	7 cups	8 cups	10 cups	2.5 gal	4.5 gal
50	8 cups	10 cups	14 cups	5 gal	10.5 gal
100	10 cups	16 cups	22 cups		
150	12 cups	20 cups	30 cups		
200	14 cups	1.5 gal	2.5 gal		
400	22 cups	2.5 gal	4.5 gal		

4 cups = 0.25 gal; 8 cups = 0.5 gal; 12 cups = 0.75 gal; 16 cups = 1 gal

WARNING: Excessive chlorination can be harmful. Follow table 1 carefully.

Figure 9:Well water disinfection recommendation

• solar disinfection (SODIS),

SODIS is a simple and low-cost technology that uses solar radiation and temperature to destroy bacteria and viruses present in water. Its efficiency in killing protozoa depends on the water temperature reached during solar exposure. SODIS is ideal to treat small quantities of water. Water is filled into transparent plastic bottles and exposed to full sunlight for a minimum of six hours. During the exposure, the sun's UV-A radiation and increased water temperature destroys the pathogens (EAWAG/SANDEC, nd)[6].

[6] www.sodis.ch

Figure 10: SODIS summarized (ethrat.ch)

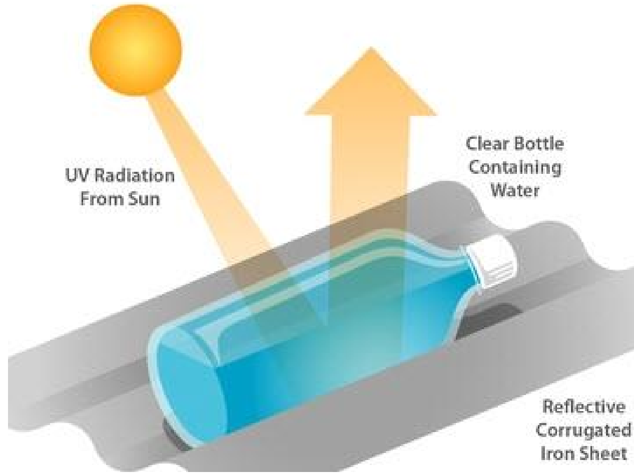

Figure 11: Water purification using SODIS (efxkit.co.uk)

This method effectively kills 99.9% of bacteria and viruses, is Free if plastic bottles are reused ,relies on renewable energy and reduces need for traditional energy sources such as firewood and kerosene/gas , Ideal to treat small quantities of water, and does not change the taste of the water As limitations; Time consuming, requires relatively clear water to be most effective (turbidity less than 30 NTU), requires sufficient solar radiation, therefore depends on weather and climatic conditions and is not useful to treat large volumes of water.

- ultraviolet (UV) disinfection,
- boiling

Household water treatment and safe storage as noted above, when water has high levels of turbidity, pathogens "hide" behind the suspended particles and are difficult to kill using SODIS and UV disinfection. Reducing turbidity by sedimentation and filtration will improve the effectiveness of these disinfection methods. The effectiveness of chlorine disinfection is also impacted by pH, chlorine demand and temperature. The effectiveness of boiling is not impacted by the chemical or physical condition of the water.

Distillation is another method of using the sun’s energy to treat drinking-water. It is the process of evaporating water into vapor, and then capturing and cooling the vapor so it condenses back into a liquid. Any contaminants in the water are left behind when the water is evaporated.

Safe water storage

Households do a lot of work to collect, transport and treat their drinking-water. Even after the water is treated, 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 illness. Recontamination of safe drinking-water is a significant issue. The risk of diarrhoea due to water contamination during household storage, first noted in the 1960s, has since been repeatedly observed by others (Wright, Gundry and Conroy 2004). Distributing and using safe storage containers have shown substantial reductions in diarrheal disease (Roberts et al. 2001). Safe storage means keeping treated water away from sources of contamination and using a clean and covered container. It also means drawing water from the container using a tap or pouring it through a narrow opening in a way that will not cause contamination. The container should prevent hands from touching the water. There are many designs for water containers around the world. A safe water storage container should:

- have a strong and tightly sealing lid or cover,
- have a tap or narrow opening at the outlet for access,
- have a stable base so it does not tip over,
- be durable and strong,
- be easy to clean.

A good safe storage container should also have instructions on how to properly use and maintain it. Other safe water handling practices include:

- using a container for collecting and storing only untreated water,
- using a separate container for storing only treated water,
- regularly cleaning the storage container with soap,
- storing treated water off the ground,

• storing treated water away from animals,

• pouring treated water from the container instead of scooping the water out of it,

• using the water as soon as possible after it is treated, preferably on the same day.

The most important thing is to make sure that people do not put their hands into the water

1.3. SANITATION

1.3.1. Definition

Sustainable development was defined in the World Commission on Environment and Development's 1987 Brundtland report ´Our Common Future` as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. It seeks to reconcile economic development with the protection of social and environmental balance.

1.4. Sustainable development

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1.4.2. Enumeration of sustainable development goals

The Sustainable Development Goals (SDGs) or Global Goals are a collection of 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all". The SDGs were set up in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030. They are included in a UN Resolution called the 2030 Agenda or what is colloquially known as Agenda 2030. The SDGs were developed in the Post-2015 Development Agenda as the future global development framework to succeed the Millennium Development Goals which ended in 2015.[7]

The 17 SDGs are:

1. No Poverty,
2. Zero Hunger,
3. Good Health and Well-being,
4. Quality Education,
5. Gender Equality,
6. Clean Water and Sanitation,
7. Affordable and Clean Energy,
8. Decent Work and Economic Growth,
9. Industry, Innovation and Infrastructure,
10. Reducing Inequality,
11. Sustainable Cities and Communities,
12. Responsible Consumption and Production,
13. Climate Action,
14. Life Below Water,
15. Life On Land,
16. Peace, Justice, and Strong Institutions,
17. Partnerships for the Goals.

[7] https://sdgs.un.org/goals

Figure 12: UN sustainable Development goals

1.4.3. Targets of SDG 6

In this work, our interest will be on SDG 6.

SDG 6 is to: "Ensure availability and sustainable management of water and sanitation for all". It has eight targets are measured by 11 indicators.

This section is an excerpt from Sustainable Development Goal 6

The six "outcome-oriented targets" include: Safe and affordable drinking water; end open defecation and provide access to sanitation and hygiene, improve water quality, wastewater treatment and safe reuse, increase water-use efficiency and ensure freshwater supplies, implement IWRM, protect and restore water-related ecosystems. The two "means of achieving" targets are to expand water and sanitation support to developing countries, and to support local engagement in water and sanitation management.

Goal 6 has as targets :(Bartram, Jamie, et al (2018))

- By 2030, achieve universal and equitable access to safe and affordable drinking water for all
- By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
- By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
- By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

In order to achieve these targets; the 2 means put in place are:

By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

Support and strengthen the participation of local communities in improving water and sanitation management

The Joint Monitoring Programme (JMP) of World Health Organization WHO And United Nations International Children's Emergency fund UNICEF reported in 2017 that 4.5 billion people currently do not have safely managed sanitation. Also in 2017, only 71 per cent of the global population used safely managed drinking water, and 2.2 billion persons were still without safely managed drinking water. With regards to water stress: "In 2017, Central and Southern Asia and Northern Africa registered very high water stress – defined as the ratio of fresh water withdrawn to total renewable freshwater resources – of more than 70 per cent". Official development assistance (ODA) disbursements to the water sector increased to $9 billion in 2018.

CHAPTER TWO: MATERIAL AND METHOD

In this chapter, we will discuss the methods used to achieve the objectives of this research. In it, we shall discuss the tools used as well. Through inductive research, we will be building on already existing knowledge on global water scarcity issues to develop our explanatory work (explaining the possible causes and consequences of poor water management) with the aim of bringing a contribution with practical applicable solutions.

2.1. PREPARATION

In the study for her thesis work, the author went to the different potable water sources in order to make an evaluation of their state as well as that of their environment. This was done during series of visits before and throughout the work duration. Keen observation was also paid at the population's lifestyle so as to collect primary data through interviews, and to understand their water management practices that is, gathering descriptive data and any behavior that could be a potential cause of potable water pollution that will be determined through the interpretation statistics and numbers (mixed study englobing both qualitative and quantitative methods) of as well.

2.2. RESEARCH POPULATION

As concerns study population, our target was the inhabitants on Yaoundé, precisely in the neighbourhood of Gendarmerie National in Melen V that have access to CAMWATER connection but are using a secondary source else than bottled water for the purpose of drinking. The water sources considered during this study were both improved and unimproved sources, namely: spring, well and borehole. Health risks attributed to poor water management being a general affair, every individual in the study location was concerned by this study.

2.3. TOOLS AND INSTRUMENTATION

- Sanitary inspection
- Documentary research
- Knowledge, attitudes, and practices survey, through questionnaire.
- Water sampling
- Water quality test

2.3.1. *Sanitary inspection*

The sanitation inspection phase was done at the early stage of this research. It mainly involved a visit to the different water sources, a keen observation of their surrounding with the aim of comparing their states to the expected Prime Ministerial decree no 2001 / 163 of 8th May 2001. It also involved observation of the population's contribution in ensuring and maintaining proper sanitation state of the different water sources. The aim of this phase being the identification of potential causes of contamination of the water sources, the visual inspection was completed by a proper water quality test.

2.3.2. *Documentary research*

As a matter of fact, this was a permanently existing phase throughout this work. It involved mostly internet research with softcopy publications. The material studied in this phase were obtained from;

- Books
- Articles
- OFFICIAL websites
- Validated thesis work
- Published norms

2.3.3. *Knowledge, attitudes and practices survey.*

A cross sectional and qualitative survey was developed to ask about participants' knowledge, attitudes towards health risks and water obtaining and management practices. This was done through the administration of a questionnaire. Greetings and a general introduction of the project were done on arrival at each participant's house after which the participant's consent was solicited to answer the questionnaire. For those who gave their accord, the questions (APPENDIX 4) were read to them directly from the survey in English language and their answers were written as the interview was conducted. If a study participant did not understand English, as was the case with a majority of the participants, a guide was invited to translate the questions into the local language or French.

Questions were included in this questionnaire about participants' primary sources of drinking water given that they are not connected to the national water supply network. Also, questions were asked about participants' current treatment methods or lack of treatment methods. We furthermore tried to understand how long it takes for a round trip collection and reasons why respondents had resorted to consuming untreated water. The complete questionnaire is included in the appendix section at the end of this work.

2.3.4. Water sampling

With the aim of obtaining physicochemical and bacteriological parameters of the drinking water used, samples were collected from the following sources

- Two wells from two different family compounds used by many other inhabitants
- A spring in the neighbourhood
- A borehole widely used by the population.

The instruments used for sample collection and their uses were;

- Four 500mL plastic polyethylene bottles (figure 6),
- An isothermal flask (figure 7) with a cool pack in it to keep the sample temperatures at about 4°C.
- An inkjet pen and stickers for labelling the samples.

Prior to use, the bottles were properly washed and rinsed with distilled water. Keeping the sample at low temperatures was a measure taken in order to slow the rate of chemical reactions and phase changes, and microorganism activity which could result to changes in pH and solubility of chemicals of interest.

The temperature of the different water sources was measured on-site with the use of a thermometer and the values were recorded.

Other parameters such as the odour and aspect were taken by visual and sensorial observations and noted on-site at the time of sampling.

The samples conserved as stated above were then carried to the laboratory for proper analyses.

Figure 13: Labelled 500ml water bottles containing water samples

Figure 14: Flask containing ice for transporting samples at appropriate temperature

2.3.5. Water quality test

In the laboratory, tests were conducted on the samples that were previously collected and transported under adequate conditions. The water samples were tested for their respective physical, chemical and bacteriological characteristics. Below are the procedures used in investigating different water parameters and the procedure in using them.

a. Physicochemical parameters

i. Determination of Temperature

The temperatures of the different water sources were recorded on site using an ORP meter (figure 9) and later confirmed by a second reading taken in the laboratory using a water quality test multimeter of the brand Voltcraft. Using the ORP meter, the electrode was introduced in the beaker and readings taken in degree Celsius after stabilizing, then was rinsed with distilled water. In the lab, the meter was calibrated accordingly, inserted in the water sample and readings taken, rinsed using distilled water and next reading taken.

Figure 15: Water quality test multimeter

Figure 16: Temperature recording onsite using an ORP meter

ii. Determination of pH

Measures of pH were determined using a pH meter (figure 10) of the Hach (HQ11d) mark. After pre-calibrating the pH meter using buffer solutions with pH values 7.00 and 4.01, the electrode was introduced in 100 ml of the sample waters and the values projected on the digital screen were recorded after the treading stabilized. After the previous recording was done, the electrode was rinsed with distilled water then inserted into the next sample for further recording. This procedure was repeated for all the samples.

Figure 17: Measurement of PH using a Hatch (HQ11d) pH meter

iii. Determination of conductivity

Measurements of the electrical conductivity (EC) of water, which is the ability of water to conduct an electric current due to the presence of dissolved salts or other chemicals. Measurements were carried out using a Hach conductivity meter. This apparatus is equipped with a standard probe which is vertically immersed in the solution whose concentration is to be determined. The conductivity value is read on a digital display (figure 10 above)

iv. Determination of Total Dissolved Solids (TDS)

Total Dissolves Solids is the measure of all inorganic and organic substances dissolved in water. The meter was calibrated accordingly, the water slightly stirred and recordings taken after about 10seconds of stabilization.

v. Determination of Suspended Solids

Total suspended solids (TSS) are determined by the so-called "photometric" method. Twenty-five (25) ml of wastewater sample is introduced into a spectrophotometric cell and placed in the Hach DR/3900 spectrophotometer (Figure 11). The TSS content by reference to a control, which is distilled water, is read directly on the digital display in mg/L, at wavelength 810 nm.

Figure 18: DR 3900 spectrometer

vi. Determination of Nitrates (NO_3^-)

Nitrate ions were determined by the cadmium reduction method with the aid of the Hach DR/3900 spectrophotometer. After the introduction of 10 mL of sample in a spectrophotometric cell, a sachet of Nitraver 5 was added therein. The mixture was then homogenized and allowed to settle for 5 minutes (reaction time). The coloration developed in the presence of NO3 - was subsequently read on the spectrophotometer at a wavelength of 500 nm. The concentration of the parameter under study were read on the digital screen of the apparatus with reference to a control consisting of 25 mL of sample. The results are expressed in mg/l.

vii. Determination of Cation Ammonium (NH_4^+)

Ammonium ion concentrations were determined using the Nessler method. Three (03) drops of mineral stabilizer and three (03) drops of 'Polyvinyl alcohol dispersing agent' and 1 mL of Nessler's reagent (alkaline Potassium Iodo-Mercurate) were added in turn to 25 ml of distillate and 25 ml of control (distilled water). These reagents respectively allow the formation of a hard complex and contribute to the formation of a yellow colour during the reaction of the Nessler reagent with Ammonium ions. The intensity of this colour is proportional to the concentration of Ammonium ions in the sample. The reading is taken with the DR/3900 spectrophotometer and the results are expressed in mg/L of NH_4^+.

b. **Determination of bacteriological parameters**

Faecal Streptococci (FS) and Faecal Coliforms (FC) present in the samples were determined using the Membrane Filtration Technique and counted in conformity with standard protocols as described by Rodier et al (2009) on Water analysis. The culture medium used for FS is the BEA medium (Bile Esculine Azide agar) while that for FC is the TTC lactose agar plate and Tergitol 7 medium. After decimal dilution of percolate samples using sterilized dilution water, the samples were filtered on membrane with the aid of a vacuum pump. Next, the filter membranes were placed in the respective culture media.

The Faecal streptococci medium was placed in an incubator (Figure 12) at 37 ^{0}C and left to incubate for 24 hours. The faecal coliform medium was also placed in an incubator at 44.5 ^{0}C for a period of 24 hours.

Figure 19: Oven incubator for FS and FC

After incubation, the presence of faecal coliform and faecal streptococci respectively were counted and their total effluent loads were estimated using the formula below:

$$\frac{\mathbf{CFU}}{\mathbf{mL}} = \frac{(\mathbf{number\ of\ colonies} * \mathbf{dilution\ factor})}{\mathbf{volume\ of\ culture\ plate}}$$

With CFU= Colony Forming Units for 100 m

CHAPTER THREE: RESULTS AND INTERPRETATION

This chapter shall be about the presentation of results obtained from water samples collected and statistics gotten from survey. Also, we shall have a visual presentation of the sanitation state of the area under study using pictures.

3.1.AREA DESCRIPTION

The presence of many water facilities was recorded though not in an exhaustive way throughout our area of study. They were mainly hand dug wells, boreholes and springs.

The wells in this study were for the vast majority uncased (unmanaged) hand dug wells equipped with buckets and ropes for drawing water, with an additional pully system for some.

Boreholes were cased and drilled systems equipped with hand pumps and an outlet for collecting water.

The spring which is a natural flowing source as observed had modest improvements done to it such as the addition of a cemented discharge points and outlet pipes.

3.2.DRINKING WATER MAIN SOURCE

Borehole

Figure 20: Location cite of borehole

As observed during our time of study time there is one main borehole source of drinking water, located by the road side, opposite Camp Yeyap and the population in the neighbourhood of Gendarmerie National all fetch drinking water from there for those not able to afford bottled mineral water or treat their tap water. The community borehole is situated in front of a mosque. In order not to perturbate during hours of prayers and for better management, it is opened 2types in the day. Water collection at the community bore hole is totally free and does not involve any financial requirement. The scarcity of water has made the majority of the population in this vicinity to have this borehole as main source of drinking water. This is problematic cause it results in scramble for this precious resource. More than often, many return with their water containers empty as a fix number of people are allowed to carry the water per day to avoid the source from drying up due to over pumping. In an attempt to favour and satisfy all, individuals are not allowed to carry more than 20L per round.

3.3.OTHER WATER POINTS

Aside tap water, the most used source in this vicinity is from hand dug wells. Due to the difficulties encountered in the obtaining water from the community borehole, most locals have resorted to consuming well water. However, water for drinking purposes is not collected from all the wells. Due to past trends, they consider only a few wells fit for drinking water collection while the others water for carrying out domestic activities such as laundry, cooking, cleaning and bathing.

The wells which retained our attention due to their highest percentage of use and their locations are presented below.

Well 1.

Situated in a compound of 5houses having in total of 22inhabitants, it was the one with the highest number of users. The oldest tenant in that compound reported that the well was created years ago. The location of the area around a slum area justifies why this water source has a depth of just about 2meters. There is no latrine upstream in proximity this this well. The well has some grass by it but the nature of the environment is well cemented. The clarity in appearance of the water from this source tricks many in being tempted to use it for drinking when faced to scarcity of borehole water. From the population reply from questionnaire, many use it for cooking and cleaning.

Figure 21 : Well1 situated in a family compound equipped with a metallic lid

WELL2

Situated in a compound of 2houses and having a total of 6inhabitants, this water facility is equipped with a pully system. Its date of creation is 2015 meaning the well has been in use for about 6years. It is worth noting that the proximity of the well with the latrine is less than 1m (precisely 6footsteps as per my count). Though the inside was full of grown grass and really not appealing to the eyes, it does not stop its inhabitants and neighbourhood to use this water source for cooking, cleaning of dishes, laundry and bathing.

Figure 22: Measurement of distance between well2 and pit toilet

Figure23: Location of well 2 and its surrounding

Spring

The spring was constructed more than 15years ago and according to the population in this area, at the time of construction and few years after, it was still a properly managed source and this was the main source of drinking water for the population in its vicinity. The spring is covered with concrete, and has 2outlets for water collection. If is rather unfortunate though that the canalization or collection system of the excess water was not well thought cause as shown on the picture below, the site is often flooded, passing the level of the collection pipes hence making complicated the collection of water. Users always have to empty the site using buckets and ensure the water level gets below the pipe level to be able to carry water.

Figure 24: General view of site of location of the spring

Figure25: Emptying of the carrying region from excess water

3.4.COLLECTION AND TRANSPORTATION OF WATER

Water collection from wells, spring and borehole is Not always easy for the population. The main challenges faced come from the long distances they have to trek to fetch the water, braving the poor state of the road, persevering patiently on the long que while waiting to use enough strength to handpump or pull with rope for the needed water quantity. The containers used in collecting water are mostly buckets, recycled 10L mineral water containers, plastic basins. These are usually smaller than the storage containers in the homes so as to ease transportation. Because those in charge of fetching water are usually children who are in school during the day, the water points are crowded mainly in the mornings and evenings. At the source, the collection containers are rinsed and filled with water. For the wells, people make use of a permanent 10L bucket and rope attached to the side of the well (figure 14 and 15). The filled containers are then transported to the houses on hand or carried on the head (figure 23). The locals face the problem of slippery roads and ascents and descents especially those who rely on the ponds. This makes the activity very strenuous. The problem of access paths poses a problem too. Most paths leading to the sources are very narrow and bushy hence, collection times usually varies but often exceeds 20 minutes for borehole source.

Figure 26: Collection of water from spring through the 2 pipped outlets

Figure 27: Collection of water from the well using a pulling rope

Figure 28: Collection of drinking water from borehole

Figure 29: Transportation of water

Figure 30: Transportation of water

3.5.CONSERVATION OF COLLECTED WATER

Water is often stored in more voluminous containers back at the homes of the population. The storage method is not always meticulous especially for water not to be used for drinking. Usually, it is stored in or out of the house depending on where it is to be used for the day. If used for cooking, then it is conserved where the kitchen is situated. To this effect, the population often makes use of large plastic basins and in this case where the water is not meant for drinking, there is less care whether the storage container has a lid or not. For drinking water however, more care is taken as the containers used are always having lids if buckets are used and the bottles or gallons used for transportation of the drinking water serve as conservation tool too and they are always covered (fig 24 and 25)

Figure 31: Typical water storage containers for Drinking

Figure 32: Typical cooking water storage container

3.6. KNOWLEDGE, ATTITUDES AND PRACTICES SURVEY FROM QUESTIONNAIRE

Forty (40) surveys were administered in forty (n=40) different homes. Of all the respondents who reported, about 40% of them had access to the CAMWATER supply network at their homes. All the respondents (n=50) indicated they were using alternative sources for their drinking water of which 83.33% reported using groundwater (well, borehole) as their primary source of drinking water and 16.67% were using bottled mineral water for drinking.

Of the 83.33% who made use for groundwater for drinking, fifty percent (50%) reported treating their water before consumption, half of them by filtration method and the other half by sedimentation. These statistics confirm the WHO statistics on facts and figures stating that 3 out of 10people lack access to safely managed potable water services.

The rest of the 50% respondents who reported not treating their water at household level before consumption, when asked to give reasons for their actions, had the following reasons:

42.86% had as main reason that according to them, the water was clean, ready for consumption and needed no further treatment. Some said if other people drink og that that water and don't die, then it will surely not kill them as well.

28.57% said they were not willing to put in more time to the the one fetching the water already entails in treating it again. Hence their reason was that further treatment will be time consuming.

14.29% of the respondents not treating their water raised had as main concern the cost involved in going in for any further treatment.

The rest of the 14.29% doubted the efficiency of further treatment.

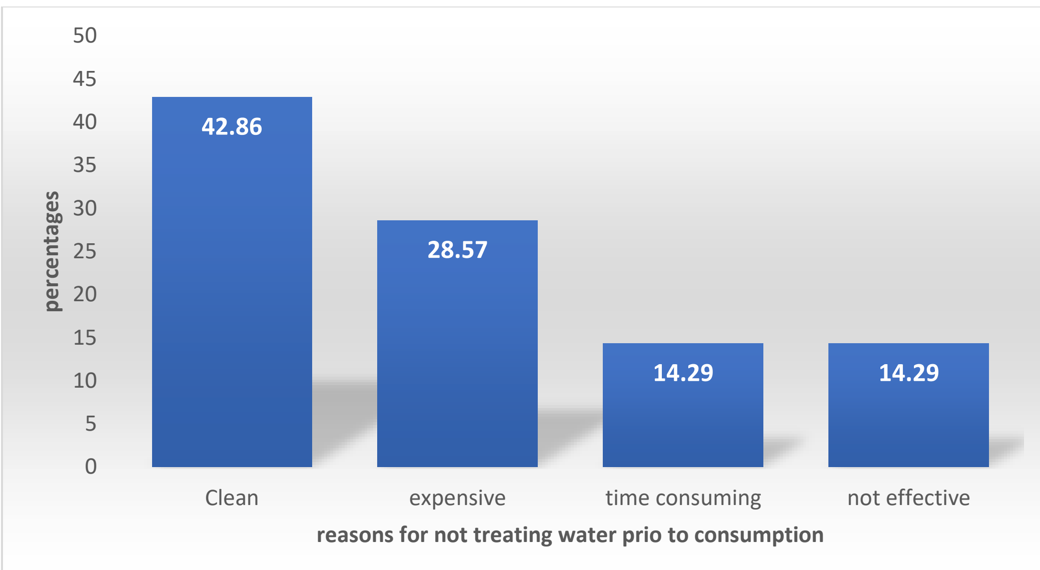


Figure 33: Bar chart showing the trend on reasons for not treating drinking water

Evaluating the cleanliness of the water sources and their environments on 10, 16.67% of the correspondents gave a mark below 5 for dirty environment and water source unprotected, 33.33% for the environment clean but the sources unprotected hence gave marks with a range of 6-8 and the remaining 50% of correspondents gave a mark range of 8-10 describing the water sources as clean and protected as well as its environment.

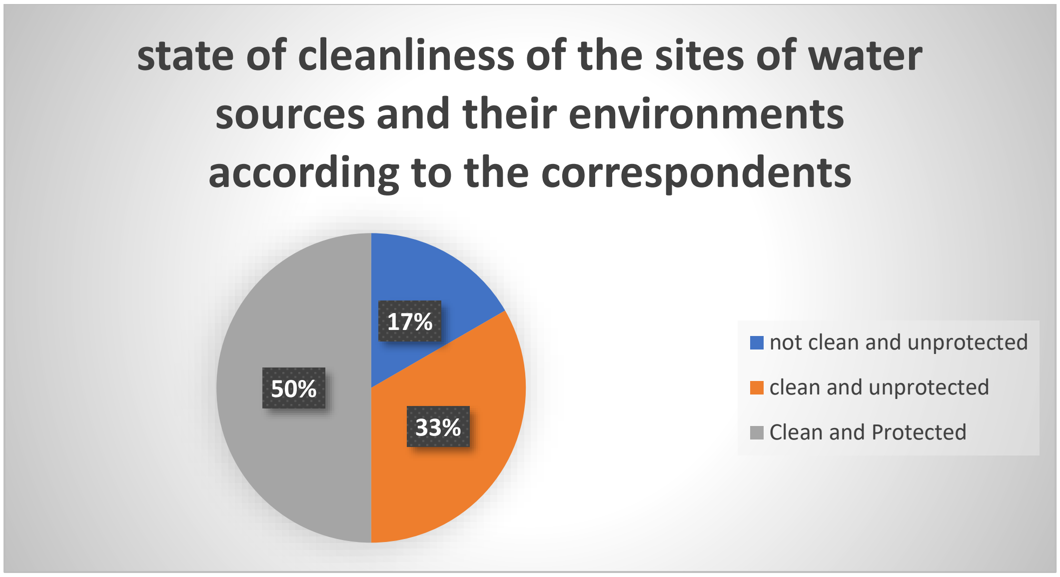


Figure 34: Pie chart illustrated the state of the environment of the water sources according to respondents

Given the replies of correspondents on the sanitation state of the water sources and the its environment and the lack of treatment reported by 50% of them, it is not a surprise that 66.7% of household members are affected by disease related to the water they drink mainly diarrhea and typhoid. From our questionnaire, the only people that were not affected by these diseases were those using bottled mineral water.

It was alarming though that only 33.33% of our correspondents were aware of their rights to potable water, with the rest reporting they have never heard about rights to potable water. Nonetheless, the high percentage of the use of right recipient transportation and storage of drinking water was encouraging, with just less than 10% using opened containers and the remaining 90% using clean and closed water bottles for the collection and storage of the drinking water used in their homes.

3.7.RESULTS OF THE WATER QUALITY TESTS

3.7.1. Results of the physicochemical and bacteriological tests of the well 1 sample.

The first well from which is located in a compound with 5differnt households was dug at the time the houses were built. This well is equipped with a metallic lid which nonetheless is used only on rainy days. It was reported by those who live in the compound that the well is cleaned average once every 2years. The vicinity of the well is cemented and there was no sanitary latrine recorded upstream on a circumference of 10meters round the well. It was recorded that this well had the highest percentage of users in the quarter due to its accessibility, the clear aspect of water and the shallow nature of the well.

The water analysis results from the lab are tabulated below.

Table 4: Physicochemical and bacteriological analyses of the **well 1** water

Parameter	UNIT	RESULTS W1	Cameroon standard (ANOR)	WHO standard
Physicochemical parameters				
Temperature	°C	26.9	≤25	≤25
PH	/	7.5	6.5-9	
Conductivity	µS/cm	1702	1000	1000
Total dissolved solids (TDS)	mg/l	851	/	300[a] ≤TDS<900[b]
Suspended solids(MES)	mg/l	1	/	
Color	Ptco	23	≤15	
Odor	/	absent	absent	absent
Nitrates (NO_3^-)	mg/l	7	≤50	50
Ammonium (NH_4^+)	mg/l	0.36	≤0.5	0.5
Biological parameters				
Faecal Coliform (FC)	UFC/100ml	15	Absent	0
Faecal Streptococci (FS)	UFC/100ml	5	Absent	0

[a]*The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste.*

[b]*Rated poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre.*(Shepherdson)

3.7.2. *Results of the physicochemical and bacteriological tests of the well 2 sample.*

The second well from is found in a family compound with 2houses. The well has no lid but equipped with a pulley system. There is a sanitation facility less than 1m from the well and the water is used for cleaning, bathing and cooking. The dirty and unkept nature of the well doesn't seem to be enough to discourage the users who are rather comfortable with the shallow nature of the well.

Water analysis results from the lab are as follows;

Table 5: Physicochemical and bacteriological analyses of the water from well 2

Parameter	UNIT	RESULTS W2	Cameroon standard (ANOR)	WHO standard Maximum permissible limit
Physicochemical parameters				
Temperature	°C	27.8	≤25	≤25
PH	/	4.91	6.5-9	6.5-8.5
Conductivity	µS/cm	2340	1000	
Total isolved solids (TDS)	mg/l	1185	/	$300^a \leq TDS < 900^b$
Suspended solids (MES)	mg/l	3	/	
Color	Ptco	24	≤15	15
Odor	/	absent	absent	absent
Nitrates (NO_3^-)	mg/l	4.5	≤50	50
Ammonium (NH_4^+)	mg/l	3.58	≤0.5	0.5
Biological parameters				
Faecal Coliform (FC)	UFC/100ml	25	Absent	0
Faecal Streptococci (FS)	UFC/100ml	7	Absent	0

[a]*The palatability of drinkingwater has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste.*

[b]*Rated poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre.*

(Shepherdson)

3.7.3. Results of the physicochemical and bacteriological tests of spring sample

Though completely covered with concrete with just 2outlet openings, the surrounding of this water source was not desirable at all. There is no adequate canalization system to flush out the excess flowing water hence the surrounding is often flooded. There are agricultural activities in its vicinity as the population takes advantage of the swampy nature of the lamp to naturally water the crops planted. Because of the numerous houses around this water source, though not visible, we can be sure there are sanitation facilities upstream.

The spring water analysis results from the laboratory are as follows;

Table 6: Physicochemical and bacteriological analyses of the **spring** water

Parameter	UNIT	RESULTS of Spring	Cameroon standard (ANOR 2013)	WHO standard Maximum permissible limit
Physicochemical parameters				
Temperature	ºC	27.4	≤25	≤25
PH	/	7.89	6.5-9	6.5-8.5
Conductivity	µS/cm	2670	1000	
Total dissolved solids (TDS)	mg/l	1361	/	$300^a \leq TDS < 900^b$
Suspended solids (MES)	mg/l	0	/	
Color	Ptco	0	≤15	15
Odor	/	absent	absent	Absent
Nitrates (NO_3^-)	mg/l	5.5	≤50	50
Ammonium (NH_4^+)	mg/l	0.37	≤0.5	0.5
Biological parameters				
Faecal Coliform (FC)	UFC/100ml	20	Absent	0
Faecal Streptococci (FS)	UFC/100ml	13	Absent	0

[a]*The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste.*

[b]*Rated poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre.*

(Shepherdson)

3.7.4. Results of the physicochemical and bacteriological tests of Borehole sample

This is the main source of drinking water for the inhabitants of the gendarmerie national neighbourhood. The environment is tarred and always kept clean, no apparent sanitary facility in the neighbourhood as seen on fig13 and fig 21.

The results from borehole water analysis as follows;

Table 7: Physicochemical and bacteriological analyses of the borehole water stored in households

Parameter	UNIT	RESULTS of borehole(forage)	Cameroon standard (ANOR)	WHO standard Maximum permissible limit
Physicochemical parameters				
Temperature	^oC	28	≤25	≤25
PH	/	7.5	6.5-9	6.5-8.5
Conductivity	µS/cm	579	1000	
Total dissolved solids (TDS)	mg/l	281	/	$300^a \leq TDS < 900^b$
Suspended solids (MES)	mg/l	0	/	
Color	Ptco	1	≤15	15
Nitrates (NO_3^-)	mg/l	2.2	≤50	50
Ammonium (NH_4^+)	mg/l	3.3	≤0.5	0.5
Biological parameters				
Faecal Coliform (FC)	UFC/100ml	0	Absent	0
Faecal Streptococci (FS)	UFC/100ml	0	Absent	0

[a] *The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste.*

[b] *Rated poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre.* (Shepherdson)

3.8.GENERAL COMPARISON OF SAMPLES AND NORMS

A comparative table for all the tested parameters for the different recorded samples and the respective norms is shown below

Table 8: Comparative table of all samples and WHO and ANOR standards

Parameter	UNIT	Cameroon standard (ANOR)	WHO standard Maximum permissible limit	RESULTS of borehole (forage)	RESULTS of Spring	RESULTS W2	RESULT W1
Temperature	ºC	≤25	≤25	28	27.4	27.8	26.9
PH	/	6.5-9	6.5-8.5	7.5	7.89	4.91	7.5
Conductivity	µS/cm	1000		579	2670	2340	1702
Total dissolved solids (TDS)	mg/l	/	$300^a \leq TDS < 900^b$	281	1361	1185	851
Suspended solids (MES)	mg/l	/		0	0	3	1
Colour	Ptco	≤15	15	1	0	24	23
Nitrates (NO_3^-)	mg/l	≤50	50	2.2	5.5	4.5	7
Ammonium (NH_4^+)	mg/l	≤0.5	0.5	0.3	0.37	3.58	0.36
Biological parameters							
Faecal Coliform (FC)	UFC/100ml	0	0	0	20	25	15
Faecal Streptococci (FS)	UFC/100ml	0	0	0	13	7	5

A graphical representation of the variation of some alarming parameters are as follows.

Faecal Coliform.

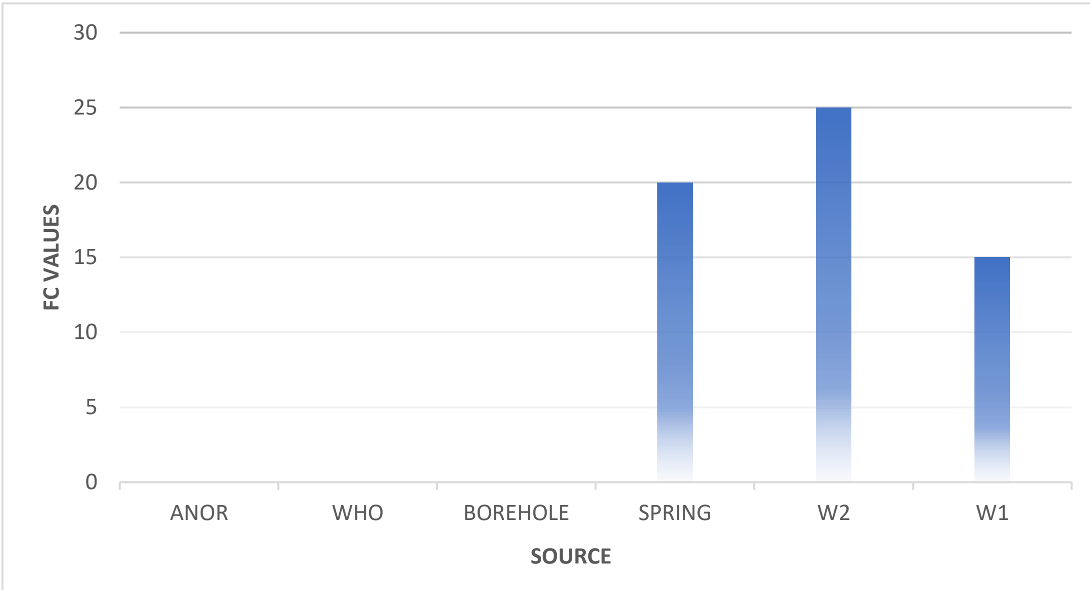


Figure 35: A bar chart comparison of FC in different water sources and WHO and ANOR

Comment on the effect of FC

Faecal coliform is a collection of relatively harmless bacteria living in large number in the intestine of man, warm- or cold-blooded animals and aid in food digestion. They grow in the presence or absence of oxygen and are themselves not pathogenic but indicate the presence of other pathogenic bacteria, given that pathogens are typically present in such small amounts it is impractical to monitor them directly.

The presence of FC is an indicator that the water has been contaminated with faecal material of man or animals. Typical waterborne pathogenic disease is typhoid and as seen from most answers received from our correspondents, most reported having family members affected by typhoid.

Given that the wells are not permanently covered, it is possible for birth defaecation to contaminate the water and specifically for W2, the proximity with the sanitation latrine system makes it easy for the untreated human waste to contaminate the water.

Faecal streptococci

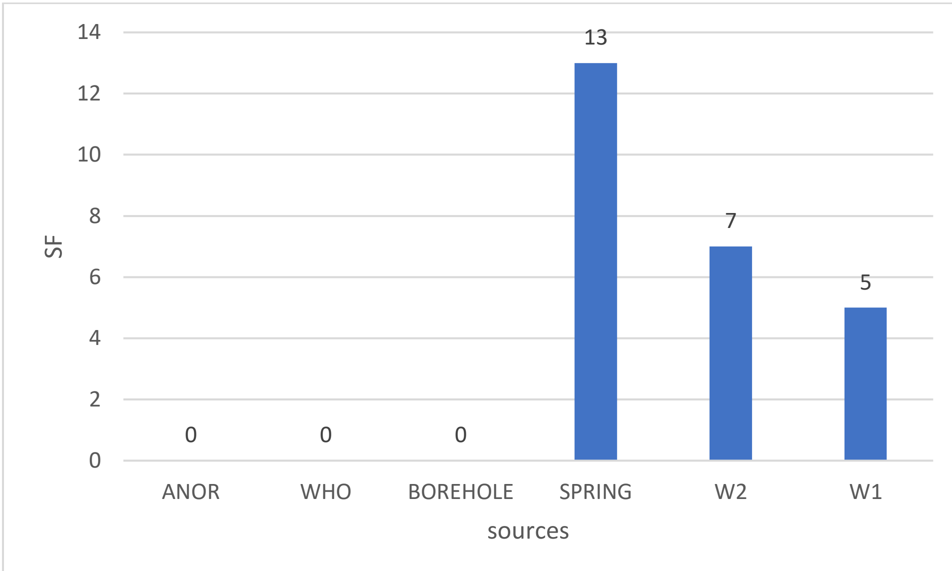


Figure 36: Comparative bar chart of FS of different water sources and WHO and ANOR norms

Total Dissolved Solids

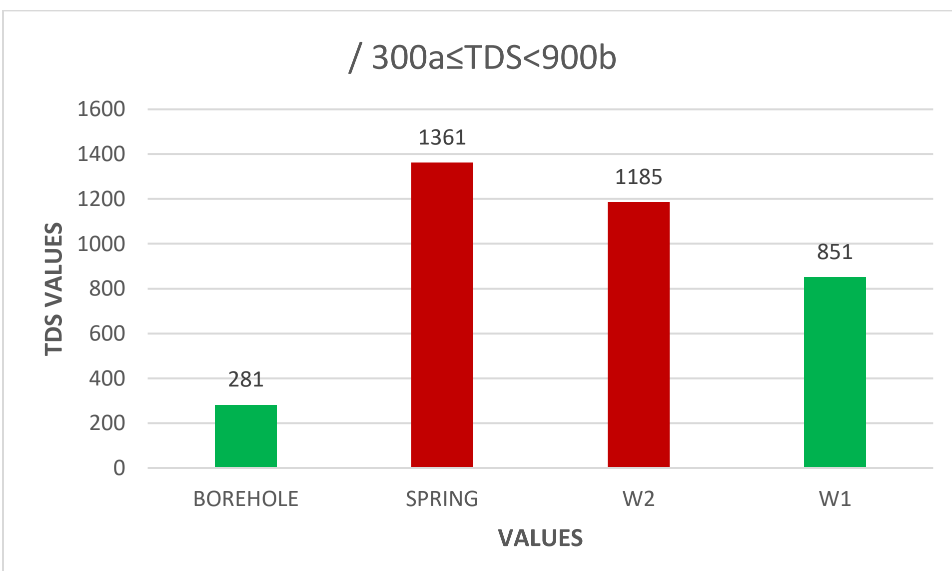


Figure 37: Comparative bar chart of TDS of different water sources and WHO and ANOR norms

3.9.DISCUSSION INTERPRETATION OF RESULT

3.9.1. Physical parameters

Temperature values were all above the WHO guideline range which is 15 to 25°C. Looking at the health Aspect, the values were above the permissible range and it should be noted that high water temperature enhance the growth of microorganisms and may increase problems related to taste, odour, colour and corrosion.

pH of the water sources was found to be within the acceptable range of 6.5-8.5 and termed weakly basic but for that of W2 sample that was quite acidic with a pH value of 4.5.

The EC and TDS values in the borehole sample which were low suggest low mineralization of the freshwater source.EC actually measures the ionic process of a solution which enables it to transmit current. The positive correlation observed between EC and TDS could be justified by the fact that EC arises from dissolved ionic matter. The WHO report on TDS in drinking water points out that reliable data on possible health effects associated with TDS in drinking water is not available but according to the EPA secondary regulations(Solids et al.), TDS is an indicator on the purity or impurity of the water and their recommended maximum TDS for drinking water being 500mg/l, the high values from the 3 other sources makes it not fit for drinking according to their recommendation. Also, the high TDS in these sources indicate water hardness and can cause aesthetic problems such as bitter or salty water.

The low Nitrate found in the water for all the samples suggest the absence of nitrate producing bacteria and low or no infiltration from waste discharges and fertilizers in the water sources. The level of Nitrate being below that of the WHO guidelines which is mg/l is good news because its high level in water is responsible for the “blue baby” syndrome and typhoid.

Ammonium found in the water sources is assumed to be from biological breakdown of domestic and agricultural wastes, and its presence is an indicator of bacterial, sewage, and animal wastes contaminations. However, its low concentrations far below the permissible limit of 0.5mg/L prescribed by the WHO suggested no associated health risk. W2 makes an exception to this conclusion with its ammonium value being 3.58mg/l

3.9.2. *Bacteriological Quality*.

The presence of faecal coliforms (Figure 25) in wells and spring sources suggests recent contamination of the water sources by human or animal faeces and the possible presence of other pathogenic organisms which could have been confirmed through the identification of specific bacteria, namely, Enterobacteria spp., Escherichia coli, Streptococcus spp., Salmonella spp., and Shigella spp. Based on the WHO guideline that recommends no bacteria of faecal+ origin in drinking water, all the sources were unfit for domestic uses such as drinking and bathing with the exception of the borehole water source.

According to Kuhn et al., domestic water with faecal coliform content above 100 CFU/100 mL will lead to serious health effects if used for drinking and cooking and will possibly cause infections if used for bathing and laundry. The presence of faecal coliforms and the abundance of specific pathogenic bacteria in the studied water sources can be associated with poor hygiene and sanitation. The spring and wells were located in areas with free access to animals, at proximity to latrines and were not properly taken care of. The water catchment of the spring is found in a valley, our samples being collected in the month of June, during which we have a light rainy season that goes from May to June,[8] mud, leaves, and other foreign objects are introduced into the catchment. The high occurrence of faecal coliforms and other pathogenic bacteria in the wells maybe due to the construction of the wells near septic tanks as it is clearly the case with W2(fig 15).

From questionnaire, it was observed that the population of the gendarmerie National neighbourhood, which is our study area often judged their water for domestic uses based on organoleptic parameters such as appearance, taste, and odour. This not being enough to measure the potability of water, it exposes them to water-related diseases such as typhoid, diarrhoea, and dysentery.

[8] (https://www.britannica.com/place/Cameroon/Climate),

The water sources were of bad quality and thus not suitable for drinking and bathing but had insignificant effect on laundry and cooking.

3.10. CONCLUSION

This study focused on the quality of domestic water sources in Gendarmerie National, Melen 5, based on the WHO guidelines. The results of physical parameters showed that all the water sources had temperatures above the WHO acceptable limits and the pH ranged from moderately basic to weakly acidic with high mineral content. The results of chemical parameters indicated that the samples had below average concentrations of nitrates and ammonium. The results of bacteriological analyses indicated that faecal coliforms and other specific bacteria were also found in the sampled waters, suggesting recent contamination of the sources by human or animal faeces. Prevalence of water-borne diseases in the neighbourhood is major public health concern. Given the poor bacteriological quality of the water sources, home treatment methods such as chlorination, filtration, boiling, and solar disinfection should be implemented prior to consumption.

CHAPTER FOUR: RECOMMENDATIONS

None of the stated norms is new to the population as it has been widely spread through different communication means by the WHO already. The steps for HWTS include

- Step 1 – Protecting your water source
- Step 2 – Sedimentation
- Step 3 – Filtration
- Step 4 – Disinfection
- Step 5 – Safely storing your water after treatment

We can refer to section 1.2.6 of this work on household water treatment methods to have detailed information on the above-mentioned steps.

To ensure the implementation of this procedure, the following can be done in terms of sensitization in order to raise awareness amidst the population.

- Massive sensitization organised by councils to both lecture the population and remind them of water protection and treatment measures.
- Door to door campaigns to evaluate the practices of the population on their HWTS and personal education befitting each household budget in how to improve their water treatment methods and respect of sanitation measures.

Study Limitations

During this study, we faced many limitations of which:

Interview and survey responses could not be independently verified. This is one limitation of studies that use self-reported data. Confirmation bias in this study could have led to interviewees attributing positive or negative consequences of the lack of treatment to specific factors that may or may not have been the main influence. Additionally, social desirability bias could potentially have led to reluctance of interviewees to report on lack of knowledge on HWTS methods in which they were aware of. The study could also have benefited from increased access to under-represented categories of interviewees, particularly children.

Fieldwork was carried out in water sources in homes with similar socio-economic characteristics and the study could have benefited from in-depth analysis if venues with diverse socio-economic characteristics were considered.

Also, the microbial water quality tests could have been improved. The specific parameters were chosen due to performance and low cost. However, performing the test multiple times for each sample would have been advantageous for more accurate concentrations and detections.

Due to the problem of cost, certain parameters such as Zinc (Excess concentration of Zinc in drinking water may cause dehydration, electrolyte imbalance, abdominal pain, nausea and vomiting), Cadmium (Cadmium is poisonous at extremely low concentration and is known to accumulate in human kidney and liver. It causes hypertension, emphysema and renal damage), Lead (Even smaller concentration of lead in human beings is toxic), and Fluoride (Higher concentration of fluoride in groundwater causes fluorosis[9] which becomes a considerable health problem in several regions of the world

The most accurate measurements of water quality are made on-site, because water exists in equilibrium with its surroundings. Measurements usually made on-site and in direct contact with the water source in question include temperature, pH, dissolved oxygen, conductivity, and turbidity and Secchi disk depth. However, in this work, because of restrictions from taking apparatus out of the laboratory, only the temperatures were taken on-site.

[9] Fluorosis is a common dental disorder, characterized by hypo-mineralization of tooth enamel caused by ingestion of excessive fluoride during enamel formation. It appears as a range of visual changes in enamel causing degrees of intrinsic tooth discoloration, and, in some cases, physical damage to the teeth

GENERAL CONCLUSION AND PERSPECTIVES

I. GENERAL CONCLUSION

The national water supplier, CAMWATER, is yet to ensure the distribution of drinking water throughout the national territory. Though huge efforts have been made by the CAMWATER to provide quantitatively to the needs the Yaoundé 6 population, the qualitative aspect of the water supplied is still doubtful and this leaves the population with no other option than to resort to alternative sources of drinking water which unfortunately are even more doubtful quality wise. From this work which was aimed at Assessing the progress of Cameroon in achieving SDG6 precisely target 1 through the evaluation of the potability of the alternative water sources (borehole, spring, wells) provided by stakeholders else than the Government and comparing them with the expected WHO norms in the neighborhood of Melen 5, it was observed that drinking water collected from the most frequented water sources in the neighborhood was unhealthy and not fit for direct consumption by the population. This was evidenced by the presence of high levels of faecal coliform and faecal streptococci which are witnesses of bacteriological pollution. Regardless of this, only 20% of the interviewed population reported some form of household treatment of water with either through filtration or with the use of house bleach agent before consumption though 96% of them were aware of risks of diarrhoea and other waterborne disease. Surprisingly, none reported treatment by boiling and some even declared they perceived the water, from the public borehole in particular, to be already clean hence no need for further treatment.

II. PERSPECTIVES

- The populations should be sensitized on affordable water treatment methods and hygienic ways of conserving water.
- All water sources should be well constructed and protection perimeters as stipulated in the Prime Ministerial Decree respected.
- Physicochemical and bacteriological tests of source waters should be carried out regularly and the necessary precautionary measures taken where need be so as to preserve the health of the population

BIBLIOGRAPHY

Addendum, First, and T. O. Third. *Guidelines for Drinking-Water Quality*.

Ako, Andrew, et al. *Water Resources Management and Integrated Water Resources Management (IWRM) in Cameroon Water Resources Management and Integrated Water Resources Management (IWRM) in Cameroon*. no. March, 2010, p. 19, doi:10.1007/s11269-009-9476-4.

Bartram, J., Brocklehurst, C., Bradley, D. *et al.* Policy review of the means of implementation targets and indicators for the sustainable development goal for water and sanitation. *npj Clean Water* **1,** 3 (2018). https://doi.org/10.1038/s41545-018-0003-0

Communauté Urbaine de Yaoundé (2008). *Plan directeur d'urbanisme 2020*

Figueroa, Maria Elena, and D. Lawrence Kincaid. "Household water treatment and safe storage." *Routledge Handbook of Water and Health*. Routledge, 2015. 239-251

Figueroa, Maria Elena, and D. Lawrence Kincaid. "Household Water Treatment and Safe Storage." *Routledge Handbook of Water and Health*, 2015, pp. 221–33, doi:10.4324/9781315693606.

Finance, Turning. "Water Supply and Sanitation in Cameroon." *Thnnthn*, vol. 5yh5yh5y, 2015.

Garrett, V., et al. "Diarrhoea prevention in a high-risk rural Kenyan population through point-of-use chlorination, safe water storage, sanitation, and rainwater harvesting." *Epidemiology & Infection* 136.11 (2008): 1463-1471

Joint Monitoring Program Website (WHO and UNICEF). Definitions, accessed on 15 October 2019)

Keeble, Brian R. "The Brundtland Report: 'Our Common Future.'" *Medicine and War*, vol. 4, no. 1, 1988, pp. 17–25, doi:10.1080/07488008808408783.

Kuhn, I., Albert, J., Ansaruzzaman, M., Alabi, S.A., Bhuiyanand, N.A., Huys, G., Islam, M.S., Jansen, P. et al. (1997b) Characterization of Aeromonas sp isolated from humans with diarrhoea, from healthy controls, and from in surface water in Bangladesh. Journal of Clinical Microbiology 35, 369–373.

Purposes, Swimming. *Physico-Chemical and Bacteriological Analyses of Water Used for Drinking And*. no. September, 2008, pp. 285–90.

Shepherdson, Nadine. “The Oral Interpretation of Literature.” *Southern Speech Journal*, vol. 1, no. 2, 1936, pp. 18–21, doi:10.1080/10417943609370625.

Solids, Total Dissolved, et al. *Total Dissolved Solids (TDS)*. no. January, 2007.

Tamasang, Christopher F. *The Right to Water in Cameroon: Legal Framework for Sustainable Utilisation*. no. April 2007, 2007.

WHO. “Drinking Water: The Drinking Water Ladder.” *Https://Washdata.Org/Monitoring/Drinking-Water*, 2017, pp. 21–32, https://washdata.org/monitoring/drinking-water.

Wright, Jim, Stephen Gundry, and Ronan Conroy. "Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use." *Tropical medicine & international health* 9.1 (2004): 106-117.

WEB REFERENCES

(https://www.universalis.fr/encyclopedie/yaounde/) accessed on the 9th of May 2021

https://sdgs.un.org/goals, accessed on the 23rd of May 2021

https://en.climate-data.org, 2019, accessed on the 10th of May 2021

www.cdc.gov/safewater/manual/sws_manual.pdf, accessed on the 17th of June 2021

https://www.primalsurvivor.net/purify-water-bleach/ accessed on the 17th of June 2021

https://en.climate-data.org/africa/cameroon-142/ accessed on the 10th of May 2021

(https://www.britannica.com/place/Cameroon/Climate), accessed on the 13th of May 2021

(https://www.primalsurvivor.net/purify-water-bleach/), accessed on the 5th of August 2021

(https://www.who.int/water_sanitation_health/hygiene/om/linkingchap6.pdf?ua=1) accessed on the 11th of August 2021

http://www.xinhuanet.com/english/africa/2021-03/22/c_139827689_2.htm accessed on the 20th of July 2021

www.weather-atlas.com accessed on the 17th of May 2021

ANNEXES

I. LABORATORY RESULTS

UNIVERSITE DE YAOUNDE I
UNIVERSITY OF YAOUNDE I

FACULTE DES SCIENCES
FACULTY OF SCIENCE

WASTEWATER RESEARCH UNIT

Analyse des Eaux Résiduaires Industrielles & Domestiques, Expertise Environnementale

BP. 8250 Yaoundé, Cameroun
Tel: (237) 674 37 29 37/6 95 70 62 72
Email: jnoutadie@yahoo.com

Yaoundé le 11/06/2021

Demandeur: Mme FIMZOLE Joannie Carene
Titre: Analyse physico-chimique de quatre (04) échantillons d'eaux préléves dans la zone de gendamerie nationale

Echantillons / Paramètres	Unités	Forage	Puits 1	Puits 2	Source
Temperature	°C	28	26,9	27,8	27,4
Potentiel d'hydrogène (pH)	/	7,50	7,63	4,91	7,89
Conductivité (Cnd)	µS/cm	579	1702	2340	2670
Solide Totaux Dissous (TDS)	mg/l	281	851	1185	1361
Matières En Suspension (MES)	mg/l	0	1	3	0
Couleur	Ptco	1	23	24	0
Nitrates (NO_3^-)	mg/l	2,2	7	4,5	5,5
Ammonium (NH_4^+)	mg/l	0,30	0,36	3,58	0,37
Coliformes Fécaux (CF)	UFC/100 ml	0	15	25	20
Streptocoques Fécaux (SF)	UFC/100ml	0	5	7	13

Po

Le responsible des analyses

Dr Djoumpa Wafo Guy V.
Water & Sanitation Specialist
Lab Assistant

II. ANOR WATER STANDARDS

NC 207 : 2003 – 02 Imprimé par l'ANOR le 12 novembre 2012 pour le Docteur AKO Andrew

3.2 – Les critères de qualité de l'eau destinée à la consommation humaine

Les eaux destinées à la consommation humaine doivent satisfaire aux exigences de qualité définies dans le **tableau 3.**

Tableau 3 : Les critères de qualité des eaux destinées à la consommation humaine

N°	PARAMETRES	UNITES	VALEURS
Paramètres organoleptiques			
1	Coloration (après filtration simple)	mg/l échelle Pt	≤ 15
2	Odeur, saveur	Absence	
3	Turbidité	Unités Jackson	≤ 2
Paramètres en relation avec la structure naturelle des eaux			
4	PH		6,5 - 9
5	Température	°C	≤ 25
7	Conductivité	µS/cm^{-1} à 20°C	1000
8	Sulfates	mg/l SO_4	≤ 250
9	Chlorures	mg/l Cl	≤ 200
10	Magnésium	mg/ l Mg	≤ 50
11	Sodium	mg/ l Na	≤ 150
12	Potassium	mg/ l K	≤ 12
13	Aluminium total	mg/ l Al	≤ 0,2
14	La quantité des résidus secs après dessiccation à 180 °C	mg/ l	≤ 1 500 mg/l
Paramètres concernant les substances indésirables			
15	Nitrates	mg/l NO_3	≤ 50
16	Nitrites	mg/l NO_2	≤ 0,1
17	Fluorures	mg/l F	≤ 0,7/1
18	Argent	mg/l Ag	≤ 0,01
19	Fer	mg/l Fe	≤ 0,2
20	Manganèse	mg/l Mn	≤ 0,05
21	Cuivre	mg/l Cu	≤ 1
22	Zinc	mg/l Zn	≤ 5
23	Agents de surface (réagissant au bleu de méthylène)	mg/l (lauryl-sulfate)	≤ 0,2
24	Phénols (Indice phénols) para-nitraniline, 4-aminoantipyrine.	mg/l C_4H_3OH	≤ 0,0005
25	Hydrocarbures dissous ou émulsionnés (après extraction par éther de pétrole ou CCl_4)	mg/l	≤ 0,01
26	L'oxydabilité au permanganate de potassium ($KMnO_4$) mesurée après 10 minutes en milieu acide, à chaud,	mg/l O_2	≤ 5
27	Azote Kjeldahl (NO_3 excepté)	mg/l N	≤ 1
28	Phosphore	mg/l P_2O_3	≤ 5
29	Sulfure d'hydrogène	mg/l H_2S	Absence
30	Ammonium	mg/l NH_4	≤ 0,5

Paramètres concernant les substances toxiques			
31	Arsenic	mg/l As	≤ 0,05
32	Cadmium	mg/l Cd	≤ 0,005
33	Chrome total	mg/l Cr	≤ 0,05
34	Plomb	mg/l Pb	≤ 0,05
35	Sélénium	mg/l Se	≤ 0,01
36	Mercure	mg/l Hg	≤ 0,001
37	Cyanure	mg/l Cn	≤ 0,05
38	Nikel	mg/l Ni	≤ 0,05
	Baryum	mg/l Ba	≤ 0,1
39	Antimoine de Sabatier	mg/l Sb	≤ 0,01
40	• Hydrocarbures aromatiques polycyclique (Fluoranthène, Benzo (3,4) fluoranthène, Benzo (11,12) fluoranthène, Benzo (1,12) pérylène, Indéno (1,2,3-cd) pyrène • Benzo (3,4) pyrène	mg/l mg/ l	≤ 0,0002 ≤ 0,00001
41	Radioactivité alpha globale	pCi/l	≤ 3
42	Radioactivité bêta globale	pCi/l	≤ 30
Paramètres concernant les pesticides et produits apparentés (insecticides organochlorés persistants, organophosphorés et carbamates, les herbicides, les fongicides, les P.C.B et P.C.T)			
43	Par substance individualisée	µg/l	≤ 0,1
44	Aldrine et dieldrine	µg/l	≤ 0,03
45	Heptachlore et époxyde d'heptachlore	µg/l	≤ 0,03
46	Total des substances mesurées	µg/l	≤ 0,5
Paramètres biologiques et microbiologiques			
47	Demande chimique en oxygène (DCO)	mg/l O_2	30
48	Demande Biochimique en oxygène (DBO_2) à 20 °C sans nitrification	mg/l O_2	50 % de la teneur initiale en O_2 dissous
49	Substances extractibles au chloroforme	mg/l SEC	Absence
50	Carbone organique résiduel après floculation et filtration sur membrane (5 µ) TOC	mg/l C	
51	Coliformes totaux 37 °C	/100 ml	Absence
52	Coliformes fécaux	/100 ml	Absence
53	Streptocoques fécaux	/100 ml	Absence
54	Salmonelles.	/5 l	Absence
55	Staphylocoques pathogène	/100 ml	Absence
56	Bactériophages fécaux	/50 ml	Absence

57	Entérovirus	/10 l	Absence
58	Spores de bactéries anaérobies sulfito-réductrices	/20 ml	Absence
59	Bactéries aérobies revivifiables à 37 °C après 24 h Bactéries aérobies revivifiables à 22 °C après 72 h	/ml (dans l'eau conditionnée) /ml (dans l'eau conditionnée)	20 100
60	Pseudomonas aeruginosa	/100 ml (dans l'eau conditionnée)	Absence
61	Protozoaires		Absence totale
62	Animalcules		Absence

3.3 – Les critères de qualité de l'eau adoucie livrée à la consommation humaine

Les eaux adoucies livrées à la consommation humaine doivent satisfaire, en outre aux exigences suivantes :

- la dureté totale ne doit pas être inférieure à 15 degrés français ;
- l'alcalinité ne doit pas être inférieure à 2,5 degrés français.

IV – HYGIENE

Il est recommandé que les eaux destinées à la consommation humaine soient préparées et manipulées selon les dispositions de la norme camerounaise des Principes généraux d'hygiène alimentaire.

Dans toute la mesure où le permettent de bonnes pratiques de fabrication, les eaux destinées à la consommation humaine doivent être exempts de substances inadmissibles.

Quand elles sont analysés selon des méthodes appropriées d'échantillonnage et d'examen, les eaux destinées à la consommation humaine :

- ☞ doivent être exemptes de microorganismes capables de se développer dans des conditions normales d'entreposage,
- ☞ ne doivent contenir aucune substance provenant de microorganismes en quantités pouvant présenter un risque pour la santé.

V – ETIQUETAGE

Outre les spécifications de la norme NC 04 : 2000 – 20 d'Etiquetage des denrées Alimentaires Préemballées au Cameroun, les dispositions spécifiques ci-après sont applicables à l'eau distribuée sous la forme conditionnée, à l'exception de l'eau minérale:

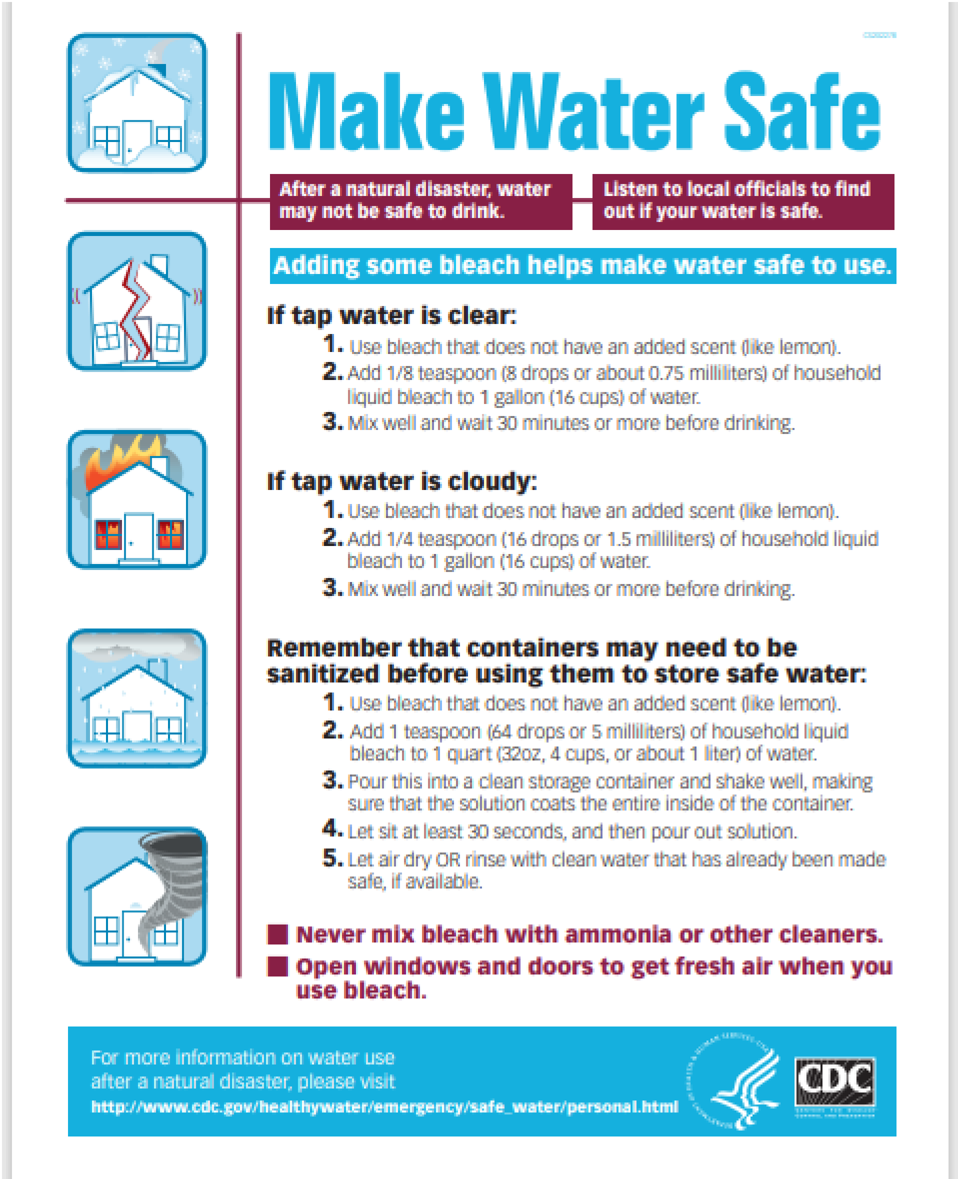
5.1 – Le nom du produit

Le nom du produit doit être « ***Eau de consommation courante*** » ou « ***Glace alimentaire*** » selon le cas.

5.2 – Récipients non destinés à la vente au détail

Les renseignements concernant les récipients non destinés à la vente au détail devront figurer soit sur le

III. CDC recommendations for treating water with bleach



Make Water Safe

After a natural disaster, water may not be safe to drink.

Listen to local officials to find out if your water is safe.

Adding some bleach helps make water safe to use.

If tap water is clear:

1. Use bleach that does not have an added scent (like lemon).
2. Add 1/8 teaspoon (8 drops or about 0.75 milliliters) of household liquid bleach to 1 gallon (16 cups) of water.
3. Mix well and wait 30 minutes or more before drinking.

If tap water is cloudy:

1. Use bleach that does not have an added scent (like lemon).
2. Add 1/4 teaspoon (16 drops or 1.5 milliliters) of household liquid bleach to 1 gallon (16 cups) of water.
3. Mix well and wait 30 minutes or more before drinking.

Remember that containers may need to be sanitized before using them to store safe water:

1. Use bleach that does not have an added scent (like lemon).
2. Add 1 teaspoon (64 drops or 5 milliliters) of household liquid bleach to 1 quart (32oz, 4 cups, or about 1 liter) of water.
3. Pour this into a clean storage container and shake well, making sure that the solution coats the entire inside of the container.
4. Let sit at least 30 seconds, and then pour out solution.
5. Let air dry OR rinse with clean water that has already been made safe, if available.

- **Never mix bleach with ammonia or other cleaners.**
- **Open windows and doors to get fresh air when you use bleach.**

For more information on water use after a natural disaster, please visit
http://www.cdc.gov/healthywater/emergency/safe_water/personal.html

CDC

IV. QUESTIONNAIRE

In view of obtaining a Master's Degree in Environmental Engineering, please spare me 04 minutes of your time to respond to these questions which is based on the research titled **'Access to potable water and sanitation in Cameroon within the context of sustainable development**' //Dans le cadre d'obtention d'un Masters en Ingénierie, option Génie de l'environnement, S'il vous plait accordez moi 04 minutes de votre temps en m'aidant a répondre à ces questions basée sur le thème de recherche '**Access a l'eau potable et assainissement au Cameroun dans le cadre du développement durable'**

1-What is the name of your quarter? Vous êtes de quel quartier? ………………………………………………………………………………………

2- For how long have you been in this zone? // Depuis combien de temps habitez-vous la zone?

Less than 1year // Moins de 1 an

b) From 1 year to 5 years // De 1 an à 5 ans

c) From 5years to 15 years // De 5 ans à 15 ans

d) More than 15years // plus de 15ans

3- Do you have access to potable water coneection in your home? // Êtes-vous raccorder à domicile a de l'eau potable ?

a) Yes // Oui b) No// Non

4- Do you use any alternative potable water sources ? // Avez-vous accès a des sources alternatives d'eau potable ?

YES // OUI b) NO // NON

5-If yes which ? // Si oui lesquelles ?

a) Bottle water // Eau embouteille b) Ground water(borehole, well)//Eau souterraine(forage, puit)

c) Spring // Source d) if other (specify)…………….. // Autre(precisez)…………….

6- Do you treat your water before consumption? // Traitez-vous votre eau avant consommation?

Yes //Oui b) No //Non

7-If yes what treatment method do you use // Si oui quelle méthode de traitement utilisez-vous

Boiling // L'ébullition

Filtering // Filtrer

Allowing it to settle// Laisser décanter

If other(specify)……………………………. // Autre(precisez)…………………………………..

8- If No, what is your reason ?// Si non quelle est votre raison

water is already clean // l'eau est déjà propre

too expensive // très cher

time consuming// Prend du temps

not effective // inefficace

9- How much time does it take you to fetch the water (to and fro)// Combien de temps prenez-vous (aller et retour) pour aller puiser de l'eau?

less than 15mins// moins de 15mins

16-30mins

31-45mins

More than 45mins// plus de 45mins

10- How will you rate the cleanliness of the water source and its environment on 10?// Comment évaluez-vous la propreté de la source d'eau et de son environnement sur 10 ?

Clean and protected 8-10 // Propre et protégée 8-10

Clean but not protected 6-8 // Propre mais pas protégée 6-8

Dirty and not protected, less than 5 // Sale et non protégée, moins de 5

11- What container is used for carrying and storing water? // Quel récipient est utilisé pour transporter et stocker l'eau?

A covered bucket // Un seau couvert

Opened buckets // Un seau ouvert

Bottles // bouteilles

Other// autre ……………………..

12- How many people are in your house? // combien de personnes vivent chez vous ?

…………………………………………………………….

13- How much water does your household consume on average in litters// Combien d'eau votre ménage consomme-t-il en moyenne en litres ?

……………………………………..

14-Is the water enough for cooking and drinking ? L'eau est-elle suffisante pour cuisiner et boire ?

Yes // oui

N0 // non

15- If you could get more water, will your household increase its water use?

Yes // oui

Non // non

16-Are you aware of right to water? Connaissez-vous vos doits a l'eau?

Yes // oui

No // Non

Never heard of

17- Indicate diseases caused by drinking contaminated water you know. Connaissez-vous les maladies causées par la consommation d'eau contaminée ?

Diarrhea

Dysentery

Typhoid

Cholera

Other …………………………………

18- Do any of them affect members of your household often? Certains d'entre eux affectent-ils souvent les membres de votre foyer ?

Yes // Oui

No // Non