Assessment Of Drinking Water Quality (Case study: Abala Town, Afar, Ethiopia)

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This is a thesis prepared by **Mohammed Awol Muusa** entitled: **Assessment of Drinking Water Quality (Case study: Abala Town, Afar, Ethiopia)** and has been approved by the following advisor and examiners in Partial Fulfilment of the Requirements for the Degree of Master of Science in "**Environmental and Sustainable Infrastructure Engineering**.

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Declaration

I declare that the work which is reported in this thesis entitled, assessment of drinking water quality in the Case of Abala town Afar region, Ethiopia, is original work of my own. The work in this thesis has not been submitted in the past for a degree at any other higher education institutions to the best of my knowledge.

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

Advisors name Signature Date

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Abstract

Water is one of the most important of all natural resources known on the earth. The safety of drinking water is important for the health. The safety of drinking water is affected by various contaminants which included physical, chemical and microbiological. Such contaminants cause serious health problems. The objective of this research study is to assess the drinking water quality of Abala town, afar Region, Ethiopia. Temperature, pH, electrical conductivity, total dissolved solids, Total hardness have been determined along various water quality profiles. Water quality is assessing using water quality index by examining first the physical, chemical and biological characteristics of water by taking sample from the case study. The experimental methods and procedures were set for all water quality parameters analyzed. the result of the experiment also comparing with the Ethiopian water quality standard and WHO drinking water standard. The result shows that, except the total hardness, alkalinity, TDS, calcium, sulphate, arsenic, total coliform and E. coli all the parameters fulfill permissible limit for drinking water guidelines. The overall WQI for the water source, reservoir, and tap water was also determined to be 27, 29, and 25.5 points, respectively. Therefore, based on the WQI result, Abala ground water source drinking water quality is good for the source, reservoir, and tap water. The overall WQI for the Subala river water source (upstream, midstream and downstream) determined to be 80.08, 125.3, and 90.15 points, respectively. Therefore, based on the WQI result, Subala river drinking water quality is not recommended to use the water for drinking purpose. The chlorination, simple filtration and boiling treatment methods are recommended to improve the water quality of Abala water supply system.

Keywords: Physico-Chemical Parameters, source of water, Water Quality**,** and water quality index

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Acronym and Abbreviation

No	**Abbreviation**	**Full word**
1	. **WHO**	World health organization
2	**EPA**	Environmental Protection Agency
3	**NTU**	Nephelometric Turbidity Unit
4	**Mg/l**	milligram per liter
5	**FC**	Fecal Coliform
6	**TC**	Total Coliform
7	**UNCIEF**	United Nations Children's Fund
8	**TDS**	Total dissolved solid
9	**Ec**	Electric conductivity
10	**WQI**	Water Quality index
11	**E.C**	Ethiopian Calander

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1. INTRODUCTION

1.1 Background

Water is one of the most essential elements to life on earth. In its purest form it's odorless, colorless and tasteless but due to human and animal activities, it is usually contaminated with solid and human waste, effluents from chemical industries and dissolved gases (Jimoh 2015) and it is most vital liquid for maintaining the life on the earth. About 97% water is exists in oceans that is not suitable for drinking and only 3% is fresh water wherein 2.97% is comprised by glaciers and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use (Holm 2004).

Access to safe drinking water and sanitation is a global concern. However, developing countries, like Ethiopia, have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services. As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells. Since these sources are open, they are highly susceptible to flood and birds, animals and human contamination (Bisrat 2012).

The quality of water is affected by an increase in anthropogenic activities and any pollution either physical or chemical causes changes to the quality of the receiving water body. Chemical contaminants occur in drinking water throughout the world which could possibly threaten human health. In addition, most sources are found near gullies where open field defecation is common and flood-washed wastes affect the quality of water (Bisrat 2012)

One of the most important environment issues today is water contamination and the diversity of contaminants that affect water resources. The natural chemical quality of source water is generally good, but elevated concentrations of a number of constituents can cause problems for water use. Intensive irrigated agricultural discharges into the groundwater can bring about considerable change in the groundwater quality. These anthropogenic activities on the groundwater pose serious threat to the groundwater users. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the sources. It therefore becomes imperative to regularly monitor the quality of groundwater and to devise ways and means to protect it (Bairu GA 2011).

Abala town, afar, Ethiopia is one of the rapidly urbanized towns in afar region. The population rapidly increase from year to year. One of the important basic needs of its growing population is water. While the town is growing, needs of supply water is increasing. But the Abala town residence is not satisfied by the demand of water distributed and the quality of water supplied.

In the present work, attempts have been made to evaluate the water quality of groundwater resources in Abal Town and subala river which has not been reported so far. The various physico-chemical water quality parameters were assessed and the values obtained are compared with the permissible/desirable values prescribed by the Ethiopian and World Health Organization (WHO) guidelines to ensure the quality of water for its use in domestic purpose.

1.2 Problem Statement

Water quality and the risk of water-related diseases are a serious public health problem in many developing countries like Ethiopia. Access to improved water supply and sanitation has been very low and hence majority of the communicable diseases are associated with unsafe and inadequate water supply (UNICEF, 2016). The safety of potable water and the danger of waterborne diseases are major public health issues in Ethiopia. About 60% of health problem is communicable disease associated with unsafe and inadequate water and poor human excreta disposal (Me ride et al., 2016).

Water is an essential component for living things, so its presence with adequate and suitable quality is very vital. There are a lot of projects done on quantity of Abala town but no projects and researches done on quality of drinking except one research did by Gebrihans Haile Gebrewbet, Abadi Gebreyesus Hndeya, 2020 to assess the Bacteriological and Physicochemical Quality of Drinking Water at source. According to their finding most of groundwater sample is polluted and does not meet the water quality standards. This pollution status of Abala is extremely regarding the deterioration of their physicochemical qualities. Though the sources of these deteriorations are often both natural and anthropogenic, the measured water quality parameters during this new study indicate that their elevated levels are mostly polluted because of the human activities present within the areas.

"Those water sources that do not conform to National Standard could end publicly health problems in while exposure. Therefore, the local water authority shall make stronger nearby water exceptional tracking and management systems also as chance evaluation and management mechanisms. The responsible non-governmental and governmental organizations should give decision on the treatment and management of these sources of potable water." However, for the present study area there are no researches were done related to the water quality of Subala river.

Therefore, Due to lack of access to clean water, Peoples in Abala adopted with water related diseases especially kidney infection, kidney failure and gastric. Therefore, it will mandatory to conduct research on second sources of water supply system of the town which can identify the source of water supply which is relatively easy to treat after comparing laboratory result of two resource. So, this study stands to assess quality of river water as alternative water resource and to assess the existing ground water source water quality.

1.3 Objectives

1.3.1 General Objective

The General objective of this research is Assessment of drinking water quality of Abala town ground water and Subala river water used by the Abala people.

1.3.2 Specific Objective

a. To assess the status of water quality situation in Abala town and its health impacts
b. To analyze the physical, chemical and biological water quality parameters
c. To analyze the overall water quality result status performance using water quality index method
d. To recommend drinking water quality improvement possibilities.

1.4 Research Questions

1.what is the water quality status of Subala river and the ground water quality status which are used currently by the people of Abala town?

2.what are the key physical, chemical and biological parameters in most affected the health of Abala people?

3.what is the appropriate method to improve the drinking water quality?

1.5 Significance of the study

In Significance of study is a written statement that explains why your research was needed. It is justification of the importance of your work and impact it has on research field it's to new knowledge and how others benefit from it. In several developing countries, such as like Ethiopia, water safety and the possibility of water related diseases are serious public health issues. This is primarily due to a lack of thorough study and subsequent checking of water quality parameters. Accurate information about drinking water, sanitation and hygiene related issues are invaluable to national leaders, decision-makers and stakeholders when making policy decisions. However, the main focus in this study will assessing the water quality, awareness and giving evidence-based information for the peoples.

1.6 Scope of the study

Is the extent to which a research area will be explored and the parameters that the study will operate under. It provides the reader and writer with insight into the study's goals and what to expect. This study scope limited to assessing the city of abala drinking water quality. The parameters of water quality will determine using laboratory analysis. With the parameters evaluated, a water quality index for drinking water in the study region also calculated.

1.7 Research limitations

Are weakness or flaws in a study's design or methodology that can impact the researcher's conclusion. They are natural part of the research process and should be acknowledged in the research paper. The main limitation encountered during this study Ethiopian internal ware as it affected the duration of the research The main limitation encountered during this study Ethiopian internal ware as it affected the duration of the research

2 LITERATURE REVIEW

2.1 Water Quality

water quality is a term used to express the suitability of water to sustain various uses or processes. Such suitability includes the physical, chemical and biological characteristics of the water. The most popular definition of water quality is “it is the physical, chemical, and biological characteristics of water” (Hassan T,2019). It is a measure of the condition of water relative to the requirements of one or more both species and or to any human need or purpose.

Water quality is continuously under pressure as it is vital to the human body and ecosystem. The growing human population is causing a negative impact on surface waters and watersheds worldwide. Although the process of urbanization is a global phenomenon with far reaching impacts upon natural ecosystems (Grimm et al., 2008). Within urban areas, freshwater ecosystems are exposed to a multitude of risks including increased catchment impermeability (e.g. artificial surfaces) and population density, habitat fragmentation and degradation and poor water quality.

Water quality is influenced by multiple factors including climate, precipitation, underlying geology, ground water, surface water, anthropogenic activities, pollutants, and other natural and human processes (Ahuja, 2013). As human populations continue to grow and land uses expand, the capacity to negatively impact our surface waters and watersheds throughout the world through contamination and human disturbances likewise increases. This potential for adverse effects on our world's water often results in reduced water quality. It is for this reason that water quality monitoring has become an important aspect of environmental science over the past several decades and is continuing to be an issue of community concern (Ahuja, 2013). Drinking water quality is described as water that is free of disease-causing microbes and potentially harmful chemicals (Tebutt, 1983). According to different studies, even well-protected sources and well-managed systems cannot guarantee that homes receive safe water. Many countries of the globe do not have access to reliable household water, and many of them must still transport water and store it in their houses. Even water gathered from safe sources is likely to become facially polluted during transit, containerization, and storage.

This chapter provides an overview of previous research on knowledge sharing and intranets. It introduces background about water harvesting and its techniques, factors influencing adoption of rainwater harvesting techniques, and climate change impact on water resources, which comprises the focus of the research described in this thesis.

The study focused on the quality of river water for different uses. river water is used for different purposes which include, Irrigation to improve crop production, Livestock watering, domestic water supply and. Water quality requirements and the potential uses are key aspects of any river water application. The quality standards vary depending on the potential uses of water. Therefore, a specific water resource requires a specific level of treatment, depending on the potential use. This makes it important to investigate the initial water quality of each resource, in order to assess the potential uses, level of treatment, appropriate storage and distribution system.

2.2 Water Quality Analysis

Water quality refers to the physical, chemical, and biological characteristics and conditions of water and aquatic environments that affect water's ability to serve the uses for which it was intended. The physical, chemical, microbiological, radiological, and biological properties of water are all considered when determining its consistency.

It is mostly affected by human actions, which can affect/change all of these properties to the point that aquatic and terrestrial species that rely on it are affected (Daba Desissa, 2016).

2.2.1 Physical Drinking Water Quality Parameters

PH

The term pH is used to measure the hydrogen ion concentration (i.e.). pH is the intensity of the alkalinity or acidity in the water it is used to identify the acidity and basicity of solution. If water shows pH greater than 7, it reveals water of that area has enough existence of carbonates concentration. pH value below the 7 produces sour taste and higher values above 8.5 gives alkaline taste based on the permissible limit as prescribed under standard values of WHO.

Electrical Conductivity (EC)

The Electric Conductivity is a degree of water's capability to pass electrical flow and point out the existence of dissolved solid in ionic state. The acceptable standard value of electric conductivity is 1000 µS/cm (Rout 2011). And it is measured in micro-Siemens per centimeter.

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Total Dissolved Solids (TDS).

It usually related to conductivity. Total dissolved solid is due to the being of non-living and natural materials, different solvable salts in drinking water leads to permanent and temporary hardness. Different compounds in water are donors for TDS such as Cl, CO3, Ca, O3 and Mg. In drinking water, corrosion is caused by TDS. Several cardiac diseases, mainly in women 29 during pregnancy toxemia is caused by needless amount of TDS in drinking water (Khan 2015).

Water containing more than 500 mg/l of TDS is not considered desirable for drinking wa-ter supplies suggested by WHO and 1000 mg/L in water is the maximum suitable limit of TDS suggested by Ethiopian environmental agency water quality standards.

Water can be categorized based on the amount of TDS content per litter of water as follows:

Table 1 Types of Water Based On TDS

Water type	TDS (mg/l)
Fresh water	<1500
Brackish water	1500-5000
Saline water	>5000

2.2.2 Chemical Drinking Water Quality Parameters

Total Alkalinity (TA)

Alkalinity is the ability of water to naturalized acid. When there is a occurrence of carbonates, hydroxides and bicarbonates in drinking water, it specifies the higher concentration of alkalinity in water. Alkalinity and acidity have opposite relationship because when alkalinity increases acidity level reduces (WHO 2011)

The alkalinity charge in water provides a precious idea of herbal salts determined inside the water. The cause of alkalinity is the presence of minerals that dissolve in water from the soils. The maximum value of alkalinity limit prescribed by the WHO standard is (200 mg/l CaCO3).

Total Hardness (TH)

Hardness in water reasons due to the presence of highly dissolved minerals which are naturally in water. Mg and Ca show a huge part in donors of hardness. Sulphates, dissolved ions and some other elements are contributed in hardness of water. According to WHO, 200mg/l hardness is acceptable in drinking water

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Color, Odour and Taste

The drinking water quality must have a character of colorless, tasteless and odorless based on WHO standards.

True Color (TCU)

Turbidity (NTU)

Turbidity is caused due to presence of suspended and colloidal solids. The suspended solids may be dead algae or other organisms. It is generally silt, clay rock fragments and metal oxides from soil. turbidity Measures water clarity using Electronic turbid-meter, a device that used for the most accurate way of determining water's turbidity, has a light source and a photoelectric cell that accurately measures the light scattered by suspended particles in a water sample. The results are then reported in units called Nephelo-metric Turbidity Units or NTUs. The prescribed limit of turbidity of groundwater is 5 nephelometer turbidity units (NTU) in WHO Standards.

Total solid (TS)

Total solids include the solids in suspension colloidal and in dissolved form. The quantity of suspended solids is determined by filtering the sample of water through fine filter, drying and weighing. The quantity of dissolved and colloidal solids is determined by evaporating the filtered water obtained from the suspended solid test and weighing the residue.500mg/l is the limit prescribed by the WHO standard.

Cadmium

Cadmium is used in the metallic and plastics industry and is a commonplace factor of batteries. It could additionally enter the water from trace impurities inside the zinc of galvanized pipes and solders and a few metallic fittings. Cadmium can collect inside the kidneys. The values of cadmium measured 0.01 mg/l is the acceptable limit of WHO standards.

Barium

A concentration of barium less than 0.02 is the permissible limit of WHO standards

Zinc

The Zinc content in the groundwater of the study area has a concentration of zero (below detection limit) at sample loca-tion L1and 3 mg/l at sample location L2. Groundwater at sample location L1was below detection limit of zinc. Ground-water at sample location L2was found less than the permissible limit of WHO standards.

Nickel

Nickel could also be a metal utilized within the assembly of stainless steels and alloys and for this reason, can be present in water that comes into touch with nickel or chromium plated taps particularly wherein the water has been stagnant before consumption. Nickel compounds are carcinogenic and steel nickel as likely carcinogenic [15].

The values of Nickel measured at L1and L2water samples are 0.63 mg/l and 0.15 mg/l, which are over the acceptable limit of WHO standards.

Manganese

Manganese is an element plentiful within the Earth's crust and is commonly found in groundwater. In common with iron, the troubles related to stages of manganese above the parametric value are basically aesthetic, as manganese can reason staining problems. High stages of manganese additionally motive objectionable tastes inside the water but there are not any particular toxicological connotations.

The concentrations of manganese estimated are below detection limit of the instrument, at both sample locations.

Chloride

The natural waters near the mines and sea dissolve sodium chloride and also presence of chlorides may be due to mixing of saline water and sewage in the water. Excess of chlorides is dangerous and unfit for use. The chlorides can be reduced by diluting the water. Chloride may demonstrate an adverse physiological effect when present in concentration greater than 250mg/l according to the permissible limit prescribed by WHO standards and with people who are acclimated. However, a local population that is acclimated to the chloride content may not exhibit adverse effect from excessive chloride concentration. Because of high chloride content of urine, chlorides have sometimes been used as an indication of pollution.

Fluoride

Fluoride is toxic to humans and other animals in large quantities, while small concentrations can beneficial. Concentrations of approximately 1.0mg/1 in drinking water help to prevent dental cavities in children. During formation of permanent teeth, fluoride combines chemically with tooth enamel, resulting in harder, stronger teeth that are more resistant to decay. Fluoride is often added to drinking water supplies if quantities for good dental formation are not naturally present.

Sodium

Sodium is Mostly it is dissolved in water from the weathering of igneous rocks. Ground water and lakes have higher concentration of sodium as compared to running water. Sodium is not dangerous for health but is dangerous for those who are suffering from heart diseases, hypertension and kidney diseases.

Potassium

Potassium is less durable in water as compared to other minerals. Therefore, it is less found in drinking water. potassium is necessary for health in adult age and deficiency of potassium leads to the generation of many diseases mainly causes hypokalemia.

Sulphate

Sulphate minerals is the source of scale build up in water pipes like to other minerals and may be related with a unpleasant taste in water that can have a laxative effect on young livestock and humans.

Arsenic

Arsenic is a cumulative poison and its presence indicates pollution. It is used as in agriculture and may contaminate the water supplies.

Chromium

Chromium is normally discovered in the Earth’s crust, although can be present in water from contamination from wooden treatment chemical compounds. The toxicity of chromium depends on the form in which its miles observe.

Mercury

Mercury can be a totally toxic metal that on the whole affects the kidney. It's been utilized in electrical appliances, batteries, plastics and in dental amalgams, although lots of the ones uses are not to any extent further relevant.

The values of mercury measured at both water samples are below detection limit, which indicates that the water samples are below detection limit of the instrument.

Iron

Iron is taken into consideration as an essential micronutrient. Long time intake of consuming water with high attention of iron may result in liver sicknesses.

Ammonium

Ammonium in water substances originates from agricultural and commercial methods. Increase ranges of ammonium may get up from extensive agriculture in the catchment of the water source.

Calcium

Over 95% of total frame calcium is discovered in bones and enamel, in which it features as a key structural element. Where it functions as a key structural element. Insufficient intakes of calcium were related to increased risks of osteoporosis, kidney stones, colorectal cancer, hypertension and stroke, coronary artery ailment, insulin resistance, and weight problems. (Karunanidhi 2020)

Magnesium

Magnesium is plentiful and a major nutritional requirement for humans (0.3-0.5 g/day). It is the second major component of hardness and it generally comprises 15-20 per cent of the total hardness expressed as $CaCO_3$ (Enviromental Protection Agency 2001). Human body contains about 25g of magnesium (60% in bones and 40% in muscles and tissues). According to the WHO standards, the allowable range of magnesium in water should be 150 mg/l.

Phosphate.

Phosphate is a made of phosphorus. Water bodies can be infected from the courses of washing with phosphorus-containing detergents in it. This can get to the water table through leaching, infiltration, and seepage from water bodies. Phosphorus is a constituent of DNA or RNA. Via the infiltration of detergents down the water desk, other organic and inorganic chemical components can get to infect the water (Das 2010).

2.2.3 Biological Drinking Water Quality Parameters

Total coliform and E. coli

For drinking water analysis, in order to recognize the disease spreading organisms the *E. coli and total coliform* has been chosen as the prime signal of bacteria. It is a prime symbol of suitability of water for use. In the water samples, if huge number of colonies of total coliform and *E. coli* are originated, then there is a massive possibility of the occurrence of pathogenic bacteria or other organisms present in drinking water (Ojo 2007).

Coliform count and E. coli are the counts of viable microbial colony units in both water samples. The total coliform count in both the water sample location is zero (free).

Table 2 Bacteriological Count per 100ml

number	Bacteriological count per 100ml	Risk to health
1	0	None
2	1-10	Low risk
3	11-100	Intermediate risk
4	101-1000	High risk
5	>1000	Very high risk

(Source: Michael et al. 2006)

2.3 Water quality index

Water Quality Index (WQI) is a unique and effective rating technique for assessing the quality of water. Nevertheless, most of the indices are not applicable to all water types as these are dependent on core physico-chemical water parameters that can make them biased and sensitive towards specific attributes including: time, location and frequency for data sampling; (ii) number, variety and weights allocation of parameters. The important water quality indices used worldwide include: the Weighted Arithmetic WQI Method (WAWQI) (Brown 1972).

Water Quality Index (WQI) is a mathematical tool that represents the water quality class by categorizing different water parameters into a standard numerical value that lies between 0 and 100. WQI classifies water quality typically in five classes or categories ranging from excellent to worst and summarizes the complex water quality data for the general public (House 1989).

This classification has helped many studies to determine the quality of water (Kumar 2002) ; it may also help to analyze the trend of water quality over a period of time and can identify how environmental impact and anthropogenic activities have affected the water quality for drinking or other water consumption.

2.4 Drinking Water Quality Standards

The WHO Guidelines for Drinking Water describe reasonable minimum safe practice criteria to protect consumers' health and establish numerical "guideline values" for water constituents or indicators of water quality. WHO, on the other hand, recognizes that local or national environmental, social, economic, and cultural situations may impose additional mandatory restrictions, resulting in national, local, or regional norms? As a result, there is a wide range of drinking water standards because there is no universally applicable method to drinking water standards. (WHO, 2011). Unfortunately, WHO does not support the adoption of international drinking-water quality standards because the conditions that force the adoption of other standards may mandate even lower quality. Thus, Ethiopia has its own standard, compulsory Ethiopian Standard (CES), which is utilized together with established worldwide and regional standards that apply to various test and analysis specifications in the drinking water sector.

The Compulsory Ethiopian Standard for Drinking Water Specification (CES 58) provides the physical, chemical, and bacteriological standards for water for drinking and household purposes in order to assure access to clean drinking water. It establishes quality and safety standards that meet all toxic, bacteriological, and organoleptic requirements, and is aligned with the new SDG aims (MOWIE,2017).

3 MATERIAL AND METHODOLOGY

3.1 Description of study area

3.1.1 Geographical location of the study area

Abala (afar: abqaala) is a town in northern abala. the administrative center of kilbati rasu, afar region, this town has a latitude and longitude of 13022’ 39045’ with an elevation of 1465 matters. The location of the study area, Abala district is one district under afar regional state, zone within the regional state and Ethiopia (Balehegn et.,2015)

Abala is one of the woredas in the afar region of Ethiopia, part of administrative zone two, is located at the base of eastern escarpment the of Ethiopian highlands, and bordered on the south by megale, on the west by Tigray region, , and on north by Berahale, on the northeast by Afdera,and on the east Erebti .The major town is abala .Abala (afar : abqaala) is a town in north-eastern, it is administrative zone of kilbati rasu.

Abala woreda in afar region of Ethiopia is a region with a predominantly afar population, a significant portion of whom are pastoralist. The area is characterized by a mix of urban and pastoralist communities, with the afar people being the majority ethnic group. While many afar pastoralists practice transhumance, moving to the Tigray highlands during drought, some have transitioned to mixed farming, establishing permanent croplands. The region is also home to a smaller Tigrayan Christian in the village of hidmo.

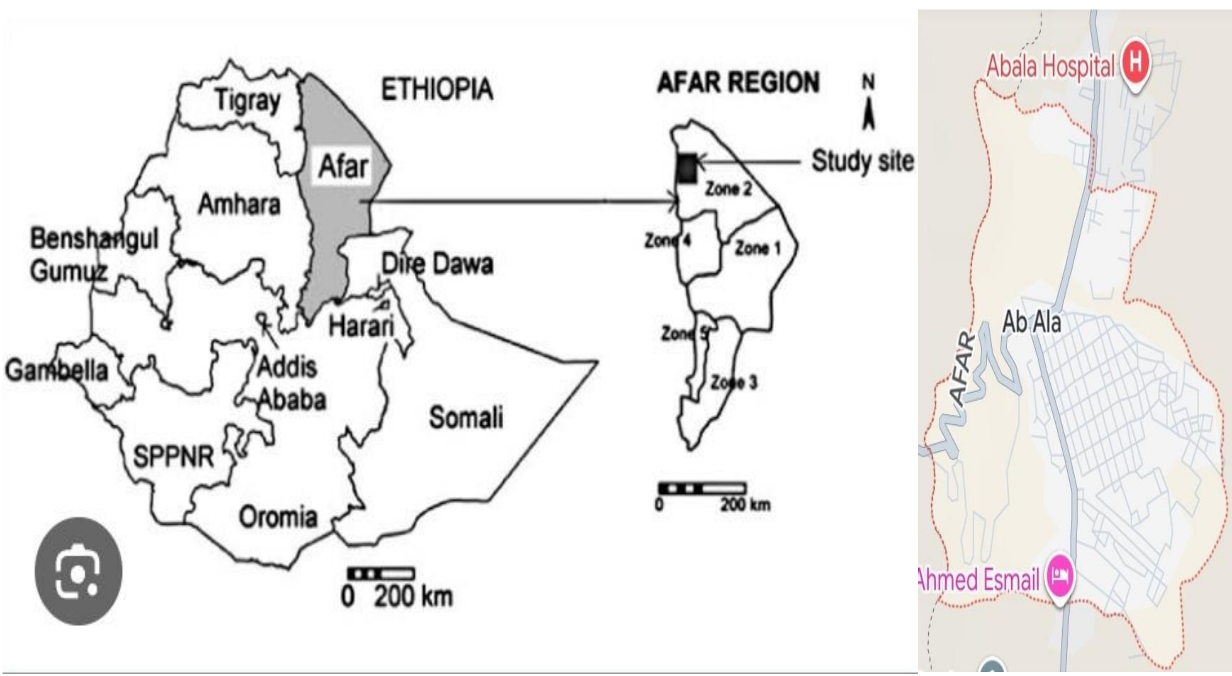

Figure 1 : Location of the study area, Abala town (source, Ethiopian map agency and google map)

3.1.2 Climate

Abala, in the afar region of Ethiopia, experiences a hot, arid climate characterized by high temperature and low rainfall. The regions' location in the Danakil depression, which includes areas below sea level, contributes to its extreme heat. while abala is at higher elevation than the lowest part of the afar region, it falls within the lower elevations experiencing topical savanna or desert condition.

The area is arid and semi-arid climate with low and erratic rainfall characterize the district. There are two rainy seasons in the area (karma: July to September; Sugum: short-season April/May) and the mean annual rainfall is 200mm.The Water supply in the city is from two types of sources: ground water and untreated river water. All the sources are located out of the city (an average of 15 km). abala town obtains largest water supply sources from ground water length of 3 kms.

3.1.3 Population

Based on the 2007 census conducted by the central statistical agency of Ethiopia (CSA), this woreda has a total population of 37963. Know the population of abala town in afar is 56245

3.2 Existing situation of water supply system

Abala town fetches its water from ground water sources located at east of town with 5 bore holes and 1 is dried and 4 Borehole are functional with total capacity of 27.5 liter/ second and the second source is the subala river directly they fetch water without any treatment mechanism around 10625 liter daily and this river is located to the south direction of the town.

3.3 Data collection and material used

3.3.1 Data collection

The purpose of this chapter is to bring all the available data and select relevant information for the analysis. The data collection system in this research is mostly from primary collection method. Secondary data's is collected through recorded data, historical data, Literature studies, and document analysis.

Primary data

those data or other information which will be gathered from the proposed study area by observation, sample collection by identifying critical points, interviewing users (customers), asking the professionals, preparing questions to users and laboratory results.

Those data are:

- ✓ Water quality sample collection site identification and procedure
- ✓ Population served and per capita demand required by the community
- ✓ Current Water quality status of the water supply system in the town
- ✓ Number of patients related to water quality problem and types of the water related disease
- ✓ Key Water quality parameter available and where is the location of the problem at the source, distribution or taps
- ✓ Mechanism Treatment of water quality usually they used to treat the water

observation

observation is first step in data assembling it helped to understanding of the study area. It is personal judgment for good researcher have capability to judge area problem but did not totally depend on the outcome of this they will transfer the analysis for data collection.

Questionnaire

The prime data on drinking water were collected through specific design of questionnaire, open hand and closed hand Questionnaire was taking from the health practitioners, general communities and water quality experts. These questionnaires were randomly filled from the general community, health practitioners and water supply professionals.

Interviews

Interviews were conduct with health practitioners, general communities and environmental experts. From the help of interview, we identify about the drinking water quality and its health impact, in the study area. Health practitioners were interview for health condition, water borne diseases and the great effecting group of community from these waters borne diseases.

Secondary data

The main secondary data are collecting the data's recorded for the existing water supply system available in Abala town water supply service, Number of patient due to water born disease in Abala town hospitals.

3.3.2 Data analysis

Samples and Sampling Techniques

The sampling technique will focus on prioritizing the availability of required data and the criteria that will consider for selection river water samples. the sampling collection method includes when is sampling take date and time, where is the possible location of sample take and what methods used to collect the sample.

The water quality parameters are measure on site at the monitoring point (on spot) at the source water and in the laboratory by taking sample using plastic container to water quality laboratory. Water quality parameters such as PH, water temperature, TDS, salinity, electric conductivity, turbidity, color, odor, teste, total coliform, e coli, alkalinity, bod, hardness, acidity, minerals and others physio-chemical and biological parameters will be examined in mekelle university water quality laboratory.

The data and materials that will be required for field work, laboratory experiments are; PH meter, electric conductivity meter, titration method, flame photometer, turbidimeter and spectrophotometer and other water quality laboratory equipment, reagents and procedures used.

Table 3: Description for Samples, Data and Material Used:

s.no	Data and materials	descriptions and used for;
1	Sample taken date	February 2,2025
1	Sample taken location	From Subala river (upstream, midstream and downstream source location and ground water source from borehole, distribution and tap locations
2	Number of samples collected	From Six sites
3	Water bottles	Used For sample collection
4	On spot instruments used	For measuring Physical parameters
5	Laboratory instrument used	Spectrometer, titration, turbidimeter, AAS and soon
6	Research transportation date	More than 10 days
7	water quality test place	on spot, mekelle university water quality
8	laboratory apparatus	For testing the water quality

six months water born disease data due to the unsafe water quality use are the secondary data's collected from the Abala town hospital are listed below.

Table 4 : Water born disease recorded in Abala hospital from September to February 2017 E.C

Number	Name	Male	Female	sum
1	Diarrhea	38	36	74
2	Typhoid	154	162	316
3	Amebiasis	247	176	423
4	gastroenteritis	3	2	5
5	giardiasis	240	228	468
6	campylobacteria's	106	115	221
7	scabies	57	52	109
8	Urinary tract infection	263	337	600

3.4 Methodology

In order to achieve the stated objective of the desired area, we have used stratification sampling technique analyzing of data as well as stating the methodology used step by step for this research study.

3.4.1 Research frame work

The diagram in figure below indicates the procedural flow chart to be applied for the accomplishment of the objectives.

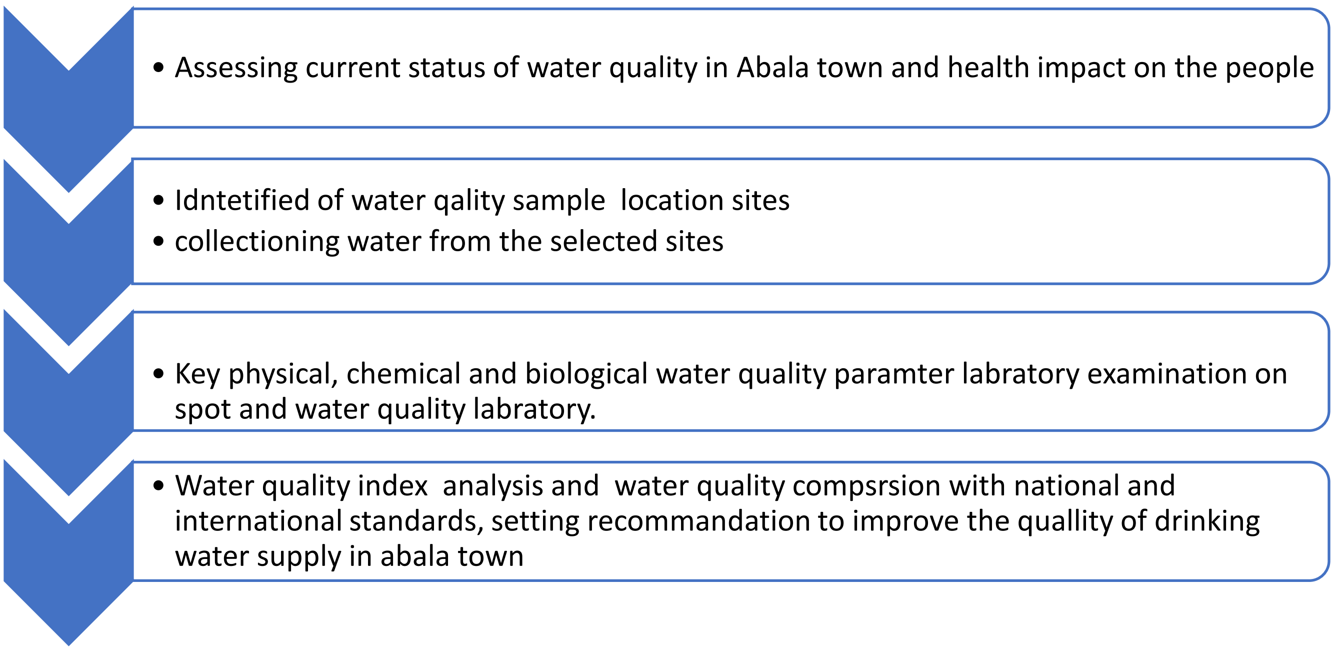

Figure 2: Research Design Diagram

3.4.2 Site Identification

To choose representative sample location of the overall water quality in a specific area. The sites for sampling points were selected in Subala river and the ground water supply source because the Abala town people use those sources for drinking water supply purpose.

3.4.3 Samples collection

Collect representative water from various part of the water source and the samples were collected in bottles. For samples the bottles were washed with hot water, after this bottle were filled and tightly capped and properly labelled.

3.4.4 Number of samples

It is recommended that the water sample taken is more than two due to the complexity of the water system and the desired level of precision. Six (6) water samples were collected from different locations of Subala river and the ground water source used by the people of Abala town.

3.4.5 Sampling points

strategically selected locations where water samples are collected to assess the waters quality. The points should be representative and reflective the overall water quality. the following location of water sample collection listed below on the table are selected as a representative point.

Table 5: Sample collection site location

Source	Location of sample taken		
Subala river	upstream	midstream	downstream
Ground water	borehole	Distribution Reservoir	Selected water taps

3.4.6 Lab work / Analysis sites

The samples collected from different sources were transferred to the water quality laboratory in mekelle university environmental engineering and geology labs but some parameters are measure in the site. Then the samples are analyzed using equipment's and techniques to determine the concentration of each physical, chemical and biological parameters.
The details of parameters and methods used for water quality analysis of physical, chemical and biological parameters are given below.

3.4.6.1 Methods for physical Parameters

Sensitive water quality parameters such as temperature, pH, EC, and TDS were determined using on-site measurements. The methods and procedures used for physical water quality analysis is below in the table.

Table 6 The following methods were used to analyze the physical water quality parameters

Parameter	Instruments used	Reagents used	Procedure
Temperature	thermometer	No need of reagent	Directly measure by the instrument on spot
PH	PH meter	No need of reagent	Directly measure by the instrument on spot
Electric conductivity	Portable digital conductivity meter	No need of reagent	Directly measure by the instrument on spot
Total dissolved solid	Portable digital conductivity meter	No need of reagent	Directly measure by the instrument on spot
Turbidity	Turbidometry	reagent	Directly measure by the instrument on spot

3.4.6.2 Methods for chemical Parameters

water quality parameters such as alkalinity, hardness, Mg, Ca, Fe, K, Na, zinc, arsenic, mercury, cadmium, barium and soon determined using laboratory measurements. The methods and procedures used for physical water quality analysis is below in the table.

Table 7 The following methods were used to analyze the chemical water quality parameters;

Parameter	Instruments/method used	Reagents used	Procedures
alkalinity	Titration method	Sulfuric acid solution	Adding sample, adding titrant solution, wait until the color change, Analyze and Read the result
Total hardness	Titration method	Standard solution of EDTA	Adding sample, adding titrant solution, wait until the color change, Analyze and Read the result
Calcium	Titration method	Standard solution of EDTA	Adding sample, adding titrant solution, wait until the color change, Analyze and Read the result
magnesium	Titration method	Standard solution of EDTA	Adding sample, adding titrant solution, wait until the color change, Analyze and Read the result
sodium	AAS flame photometer	Standard solution sodium	Sample preparation, Solution preparation, Analyze and Reading
potassium	AAS flame photometer	Standard solution potassium	Sample preparation, Solution preparation, Analyze and Reading
Chloride	Titration method	silver nitrate solution	Adding sample, adding titrant solution, wait until the color change, Analyze and Read the result
sulphate	Uv-spectrometer	Barium sulphate solution	Sample preparation, Solution preparation, Analyze and Reading
Iron	AAS flame photometer	Iron buffer solution	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample
arsenic	AAS flame photometer	Agar flour, sodium chloride and water	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample
Copper	AAS flame photometer	Neutral buffered solution containing copper	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample

zinc	AAS flame photometer	Agar flour, sodium chloride and water	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample
Cadmium	AAS flame photometer	Cadmium chloride or cadmium sulfate	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample
Barium	AAS flame photometer	Barium salt	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample
nickel	AAS flame photometer	Agar flour, sodium chloride and water	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample
Mercury	AAS flame photometer	Agar flour, sodium chloride and water	Connect gas hole with AAS and allow it to burn Stabilize the flame, prepare sample and solution, Analyze sample

3.4.6.3 Methods for biological Parameters

water quality parameters such as E. coli and fecal coliform were determined using biological examinations. The methods and procedures used for biological water quality analysis is below in the table

Table 8 The following methods were used to analyze the biological water quality parameters

Parameter	Instruments used	Reagents used	Procedure
Total coliform	Membrane filtration	Bacterial food	Water is filter through a membrane in the filter media
E. coli	Membrane filtration	Bacterial food	Water is filter through a membrane in the filter media

3.4.7 Water quality index

Water Quality Index (WQI) is considered as the most effective method of measuring water quality. A number of water quality parameters are included in a mathematical equation to rate water quality, determining the suitability of water for drinking (Brown 1972).

The water quality index (WQI) model simplifies the presentation of results of an investigation related to a water body as its summaries in one value or concept a series of parameters analyses. A single WQI value makes information more easily and rapidly understood than a long list of numerical values for a large variety of parameters. More so, WQI also facilitates comparison between different sampling sites and events. The following steps were used for determining the WQI.

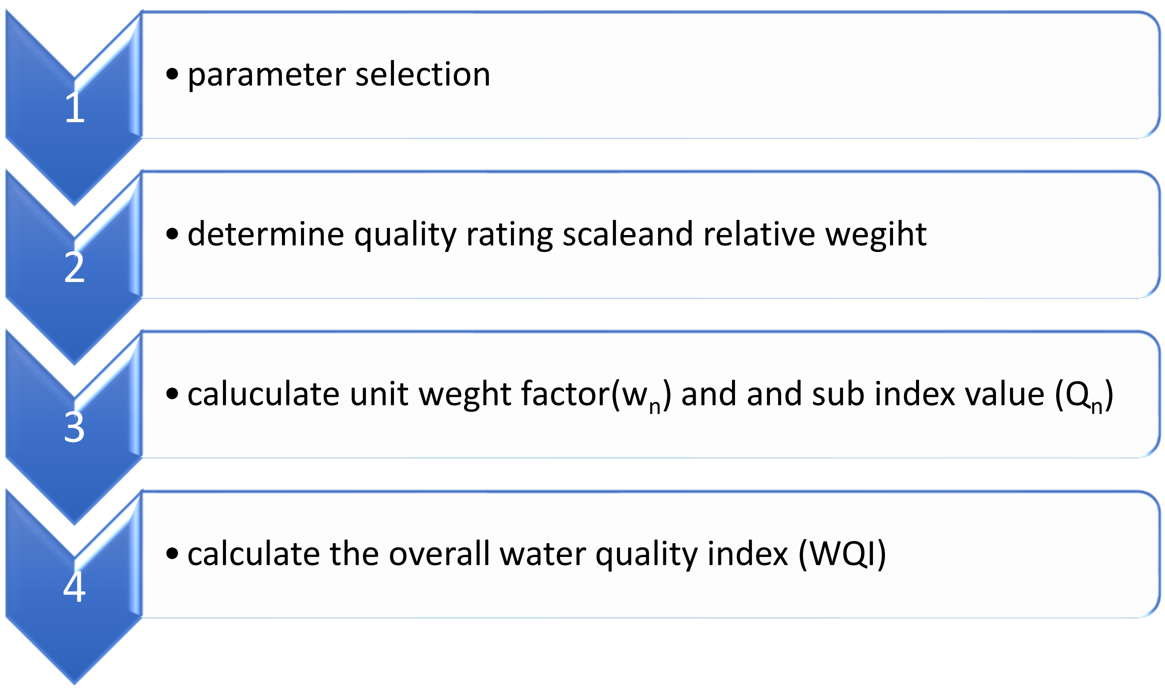

Figure 3: steps for water quality index calculation (Kumar 2002)

Parmeter selection: when selecting parameters for a water quality index for drinking water focus on those that are essential for assessing the water suitability for human consumptions, including physical, chemical and biological parameters.

Weighted arithmetic Water Quality Index (WQI) method: The weighted arithmetic WQI method [Tyagi, 2014] was applied to assess water suitability for drinking purposes. In this method, water quality rating scale, relative weight, and overall WQI were calculated by the following formulae:

$$q_i = \left({}^{c_i}/_{s_i}\right) * 100$$

where qi, Ci, and Si indicated quality rating scale, concentration of c_i parameter, and standard value of s_i parameter, respectively.

Calculate the unit weight (w_n) factors for each for each parameter by using the formula

$\boldsymbol{W_n}=k/_{sn}$ where $k = \frac{1}{\frac{1}{s1}+\frac{1}{s2}+\frac{1}{s3}+\frac{1}{s4}-----\frac{1}{sn}}$ s_n is standard value of each parameter

Finally, overall **WQI** was calculated according to the following expression (Brown 1972)

$$WQI = \sum q_i w_i / \sum w_i$$

4 Result and discussion

4.1 Physical Parameters results

The various physical parameters when analyzed showed the following results.

Physical water quality Results of Source, Reservoir, and Tap Water Samples

The physical parameters such as total dissolved solids (TDS), turbidity, electrical conductivity (EC), temperature, and pH, at source, reservoir and last tap sample locations are shown in Table below.

Table 9: laboratory physical parameters water quality results for ground water at borehole, reservoir and last taps

No	parameters	borehole	Reservoir	Last tap	WHO standard	Ethiopian standard(mg/L)
1	Ph	7.717	7.777	8	6.5-8.5	6.5-8.5
2	Temperature	31.5	28.27	28.27		
3	TDS	1198.74	1277.18	1282	500	1000
4	turbidity	3.36	3.637	3.637	1.5	<5
5	Conductivity	168.7	178	182	1000	

The total dissolved solid result obtained is above the water quality standard of WHO and national standards which is exceeded by 198 mg/l at bore location, 277.18 mg/l at reservoir site and 282mg/l at tap location. the others physical parameters are below the standards of national and international standards.

Physical water quality Results of upstream, midstream and downstream Water Samples

The physical parameters such as total dissolved solids (TDS), turbidity, electrical conductivity (EC), temperature, and pH, at upstream, midstream and downstream of Subala sample locations are shown in Table below.

Table 10: laboratory physical parameters water quality results for Subala river water at upstream, midstream and downstream

No	parameters	Upstream	Midstream	Downstream	WHO	ES	detected
1	PH	8.09	8.33	8.35	6.5-8.5	6.5-8.5	Negative
2	Temp (° c)	25.93	23.4	25.73			Negative
3	TDS (mg/l)	1725.73	1682.94	1675.81	500	1000	Positive
4	Turbidity (NTU)	1.68	3.163	1.24	1.5	<5	Negative
5	Conductivity	251.664	414	413	1000		Negative

The total dissolved solid result obtained is above the water quality standard of WHO and national standards which is exceeded by 725.73 mg/l at upstream location, 682.94 mg/l at midstream location and 675.81 mg/l at downstream location. the others physical parameters are below the standards of national and international standards.in all sample location of Subala river the result of water quality the TDS parameter is positive detected and the other physical parameters like PH, turbidity, temperature, conductivity are negative results which are below the national and international standards. The representation of negative detection means the parameter water quality result is below the water quality standard and positive detection represents the result of water quality parameter is above the water quality standard.

4.2 Chemical parameters laboratory results

Chemical l water quality Results of Source, Reservoir, and Tap Water Samples

The physical parameters such as total hardness alkalinity, magnesium, calcium , zinc, arsenic, chloride and soon , at source, reservoir and last tap sample locations are shown in Table below.

Table 11: laboratory chemical parameters water quality results for ground water at borehole, reservoir and last taps

No	parameters	borehole	reservoir	Last tap	WHO standard	Ethiopian standard(mg/L)
1	Alkalinity	315	480	285	200	
2	Salinity	0.38	0.39	0.25		
3	Calcium	341.9	521.4	533.9	200	200
4	Magnesium	75	79.7	81.6	100	
5	Total hardness	1167.25	1634.33	1674.75	200	300
6	Sodium	18.41	25.94	9.69	50	200
7	Potassium	8.91	8.07	8.64	12	1.5
8	Sulphate	296.5	283.4	302.6	200	250
9	Phosphate	0.52	0.49	0.12	0.1	0.02
10	Zinc	0.247	0.042	0.012	15	300
11	Chloride	35.7	32.4	18.6	250	250
12	Copper	0.052	0.49	0.12	2	1.5
13	Iron	0.057	0.074	0.076	0.3	0.3
14	Barium	0.21	0.08	0.04	0.7	0.7
15	Cadmium	0.069	0.063	0.01	0.003	0.003
16	Nickel	0.004	0.003	0.002	0.07	0.02
17	Arsenic	0.03	0.02	0.009	0.01	0.01
18	Mercury	0.001	0.0	0.053	0.006	0.001

The alkalinity, total hardness, calcium, sulphate and arsenic result at all sample location obtained is above the water quality standard of WHO and national standards. the others chemical parameters are below the standards of national and international standards.

Chemical l water quality Results of upstream, midstream and downstream Water Samples

The physical parameters such as total hardness alkalinity, magnesium, calcium , zinc, arsenic, chloride and soon , at upstream, midstream and downstream sample locations are shown in Table below.

Table 12: laboratory chemical parameters water quality results for Subala river upstream, midstream and downstream

No	parameters	Upstream	Midstream	Downstream	WHO standard	Ethiopian standard(mg/L)
1	Alkalinity	485	300	375	200	
2	Salinity	0.26	0.31	0.27		
3	Calcium	578.5	557.9	615.3	200	200
4	Magnesium	95.5	90.6	91.5	100	
5	Total hardness	1844.16	1772.25	1919.5	200	300
6	Sodium	24.32	23.68	24.00	50	200
7	Potassium	15.87	16.16	15.49	12	1.5
8	Sulphate	346.7	286.9	304.8	200	250
9	Phosphate	0.16	0.21	0.41	0.1	0.02
10	Zinc	0.138	0.109	0.098	15	300
11	Chloride	32.5	33.4	29.6	250	250
12	Copper	0.146	0.140	0.0	2	1.5
13	Iron	0.114	0.536	0.389	0.3	0.3
14	Barium	0.15	0.04	0.08	0.7	0.7
15	Cadmium	0.0	0.03	0.028	0.003	0.003
16	Nickel	0.001	0.002	0.001	0.07	0.02
17	Arsenic	0.08	0.07	0.005	0.01	0.01
18	Mercury	0.001	0.002	0.003	0.006	0.001

The alkalinity, total hardness, calcium, sulphate and arsenic result obtained is above the water quality standard of WHO and national standards. the others chemical parameters are below the standards of national and international standards.

4.3 Biological parameters results

biological l water quality Results of Source, Reservoir, and Tap Water Samples

The biological parameters such as total coliform and E.coli at source, reservoir and last tap sample locations are shown in Table below.

Table 13: laboratory biological parameters water quality results for ground water at borehole, reservoir and last taps

No	parameter	borehole	Reservoir	Last tap	WHO standard	Ethiopian standard(mg/L)
1	E. coli	2.00	1.00	0.00	Absent	0
2	Total coliform	4.00	3.00	0.00	absent	0

The total coliform and E. coli result in the Borehole and Reservoir location obtained is above the water quality standard of WHO and national standards. The total coliform and E. coli result at last tap location are below the standards of national and international standards because chlorination process is applied to kill the microorganisms.

Biological water quality Results of upstream, midstream and downstream Water Samples

The biological parameters such as total coliform and E.coli at upstream, midstream and downstream sample locations are shown in Table below.

Table 14: laboratory biological parameters water quality results for Subala river upstream, midstream and downstream

No	parameters	Upstream	Midstream	Downstream	WHO standard	Ethiopian standard
1	E. coli	Positive	Positive	positive	Absent	0
2	Total coliform	positive	positive	Positive	Absent	0

The Subala river water used directly by the people of Abala which is detected to total coliform and E. coli this indicates that potential contamination and an increase risk of water born illness. this water source needs boiling or proper treatment before use for drinking purpose.

4.4 Water quality index result

The water quality result for Abala ground water and Subala river is listed in the table below

Table 15 Water quality index result at the last tap location

No	parameters	Last tap	Ethiopian standard(mg/L)	Wi=k/sn	(vn/sn)*100=Qn	WnQn
1	PH	8	7	0.0278	114.2857	3.180021
2	TDS	1182	1000	0.0002	118.2	0.023023
3	turbidity	3.637	5	0.0390	72.74	2.833605
4	EC	1.182	1000	0.0002	0.1182	2.3E-05
5	Alkalinity	285	200	0.0010	142.5	0.138778
6	Calcium	533.9	200	0.0010	266.95	0.259978
7	Magnesium	81.6	100	0.0019	81.6	0.158937
8	T. hardness	1674.75	300	0.0006	558.25	0.362446
9	Chloride	18.6	25	0.0078	74.4	0.579654
10	Iron	0.076	0.3	0.6493	25.33333	16.44778
11	Barium	0.04	0.7	0.2783	5.714286	1.59001
			$\sum W_n$	**1**	$\sum W_n Q_n$	**25.57**
					Over all WQI	**25.57**

The water quality index result showed that the laboratory analysis result at last tap very good Drinking' water quality status.

Table 16 Water quality index result at the source location

No	parameters	borehole	Ethiopian standard(mg/L)	Wi=k/sn	(vn/sn)*100=Qn	WnQn
1	PH	7.717	7	0.0278	110.2429	3.067528
2	TDS	1667	1000	0.0002	166.7	0.032469
3	turbidity	3.36	5	0.0390	67.2	2.617793
4	EC	1687	1000	0.0002	168.7	0.032859
5	Alkalinity	315	200	0.0010	157.5	0.153386
6	Calcium	341.9	200	0.0010	170.95	0.166485
7	Magnesium	75	100	0.0019	75	0.146082
8	T. hardness	1167.25	300	0.0006	389.0833	0.252614
9	Chloride	35.7	25	0.0078	142.8	1.112562
10	Iron	0.057	0.3	0.6493	19	12.33583
11	Barium	0.24	0.7	0.2783	34.28571	9.540063
		$\sum W_n$		1	$\sum W_n Q_n$	**29.46**
					Over all WQI	**29.46**

The water quality index result showed that the laboratory analysis result at good   Drinking water quality status.

Table 17 Water quality index result at the reservoir location

No	parameters	Reservoir	Ethiopian standard(mg/L)	$W_i=k/s_n$	(vn/sn)*100=Qn	WnQn
1	PH	7.777	7	0.0278	111.1	3.091378
2	TDS	1.78	1000	0.0002	0.178	3.47E-05
3	turbidity	3.637	5	0.0390	72.74	2.833605
4	EC	1.78	1000	0.0002	0.178	3.47E-05
5	Alkalinity	480	200	0.0010	240	0.233732
6	Calcium	521.4	200	0.0010	260.7	0.253891
7	Magnesium	79.7	100	0.0019	79.7	0.155237
8	T. hardness	1634.33	300	0.0006	544.7767	0.353699
9	Chloride	32.4	25	0.0078	129.6	1.00972
10	Iron	0.074	0.3	0.6493	24.66667	16.01494
11	Barium	0.08	0.7	0.2783	11.42857	3.180021
$\sum W_n$				1	$\sum W_n Q_n$	**27.13**
					Over all WQI	27.13

The water quality index result showed that the laboratory analysis result at borehole has good Drinking water quality status.

Table 18 Water quality index result at the upstream location

No	parameters	upstream	Ethiopian standard(mg/L)	Wi=k/sn	(vn/sn)*100=Qn	WnQn
1	PH	8.09	7	0.0278252	2.7825184	3.215796
2	TDS	1725.73	1000	0.0001948	0.0194776	0.033613
3	turbidity	1.68	5	0.0389553	3.8955257	1.308897
4	EC	2.56	1000	0.0001948	0.0194776	4.99E-05
5	Alkalinity	485	200	0.0009739	0.0973881	0.236166
6	Calcium	578.5	200	0.0009739	0.0973881	0.281695
7	Magnesium	95.5	100	0.0019478	0.1947763	0.186011
8	T. hardness	1844.16	300	0.0006493	0.0649254	0.39911
9	Chloride	32.5	25	0.0077911	0.7791051	1.012837
10	Iron	0.314	0.3	0.6492543	64.925429	67.95528
11	Barium	0.15	0.7	0.2782518	27.825184	5.962539
	$\sum W_n$			1	$\sum W_n Q_n$	**80.59**
					Over all WQI	**80.59**

The water quality index result showed that the laboratory analysis result at upstream has very Poor Drinking' water quality status

Table 19 Water quality index result at the midstream location

No	parameters	Midstream	Ethiopian standard(mg/L)	Wi=k/sn	(vn/sn)*100=Qn	WnQn
1	PH	8.33	7	0.027631	119	3.288141
2	TDS	1682.94	1000	0.000193	168.294	0.032551
3	turbidity	3.16	5	0.038684	63.2	2.444829
4	EC	4.014	1000	0.000193	0.4014	7.76E-05
5	Alkalinity	300	200	0.000967	150	0.145065
6	Calcium	557.9	200	0.000967	278.95	0.269773
7	Magnesium	90.6	100	0.001934	90.6	0.175239
8	T. hardness	1772.25	300	0.000645	590.75	0.380876
9	Chloride	33.4	25	0.007737	133.6	1.033637

10	Iron	0.536	0.3	0.644733	178.6667	115.1924
11	Barium	0.07	0.7	0.276314	10	2.763143
		$\sum W_n$		**1**	$\sum W_n Q_n$	**125.73**
					Over all WQI	**125.73**

The water quality index result showed that the laboratory analysis result at midstream has unfit for consumption Drinking' water quality status

Table 20 : Water quality index result at the downstream location

No	parameters	down stream	Ethiopian standard(mg/L)	Wi=k/sn	(vn/sn)*100=Qn	WnQn
1	PH	8.35	7	0.027825	119.2857143	3.319147
2	TDS	1627	1000	0.000195	162.7	0.03169
3	turbidity	1.24	5	0.038955	24.8	0.96609
4	EC	4.137	1000	0.000195	0.4137	8.06E-05
5	Alkalinity	375	200	0.000974	187.5	0.182603
6	Calcium	0.27	200	0.000974	0.135	0.000131
7	Magnesium	65.3	100	0.001948	65.3	0.127189
8	T. hardness	1919	300	0.000649	639.6666667	0.415306
9	Chloride	29	25	0.007791	116	0.903762
10	Iron	0.389	0.3	0.649254	129.6666667	84.18664
11	Barium	0.001	0.7	0.278252	0.142857143	0.03975
			$\sum W_n$	1	$\sum W_n Q_n$	**90.17**
					Over all WQI	**90.17**

The water quality index result showed that the laboratory analysis result at downstream has very Poor Drinking' water quality status

A general statistical study and analysis on the bio-physio and chemical parameters using water quality index method comparison of their difference percentage between the observed and the simulation categorized as <25 vary good which is suitable for consumption it is possible usage for drinking irrigation and industrial purpose, 26-50 good which is good for domestic industrial and irrigation usages , 51-75 fair it is possible for irrigation and industrial usages, 76-100 very poor only it is possible to use for irrigation and gardening and >100 unfit for consumption and restricted use for irrigation and proper treatment required before use according to Ethiopian standard 261:2013, international guidelines WHO standard that use water quality index principle limits and clean water act in the US(via 305(b)reports) water quality regulations.

Table 21 Water quality index regulation (source: ES 261:2013 & US clean water act via 305(b) report)

water quality index (%)	**water quality status**
0-25	Very good
26-50	Good
51-75	Poor
76-100	very poor
>100	unfit for consumption

(Brown 1972)

Table 22 : location Over all water quality index results for ground water

location	**Over all water quality index results**	**water quality status**
Borehole	27	Good
reservoir	29	Good
tap	25.57	Excellent

It can be seen that the WQI result of ground water used by Abala people calculated for the reservoir, last tap, borehole shows that the water quality mostly lies in 'good' class water quality status .and the result of water tap is 25.57 which is possible to use for drinking ,industrial and irrigation purpose and the result of bore hole and reservoir 27 &29 is also good to use especially for irrigation ,washing clothes ,for showering and industrial purposes.

Table 23 Over all water quality index results of Subala river

location	**Over all water quality index result**	**water quality status**
upstream	80	very poor
Midstream	125	unfit for consumption
Down stream	90	very poor

It can be seen that the overall WQI status of Subala river used by the people of Abala calculated for the upstream, midstream, downstream shows that the water quality mostly lies in 'very poor water quality status.it is difficult to use for drinking purpose even for industrial and irrigation purposes this source of water its WQI result rating shows the water needs proper treatment options before use for different water supply purpose.

WQI describes a greater number of variables using a single value that indicates the overall quality of water in a certain area. It is concluded that the water quality in Abala town ground water supply is good for drinking purpose and the Subala river water source was found unsuitable for drinking purpose.

4.5 Questionaries result

Table 24: Questionaries response result filled by the community of Abal town

Questionaries	**total respondent**	**response**			
		frequency		**percentage**	
		yes	**no**	**yes**	**no**
Q1	10	Both ground water and Subala river			
Q2	10	2	8	20%	80%
Q3	10	1	9	10%	90%
Q4	10	3	7	30%	70%
Q5	10	Ground water source is not enough			
Q6	10	Dharia, typhoid, kidney problems			

From the questionaries result the respondent answer shows the water quality is not safe and there is a water born disease cases due to the quality**.**

Table 25 : Questionaries response result filled by the hospital of Abal town

Questionaries	**total respondent**	**response**			
		frequency		**percentage**	
		yes	**no**	**yes**	**no**
Q1	3	3	0	100%	0%
Q2	3	Dharia, typhoid, kidney problems			
Q3	3	2	1	10%	90%
Q4	3	average 30 patients per month			
Q5	3	Used unprotected and not treated water			

From the questionaries result the respondent answer shows the water quality is not safe and there is a water born disease cases due to the quality.

Table 26 : Questionaries response result from the community, hospital and the water supply office of Abal town

Questionaries	total respondent	response			
		frequency		percentage	
		yes	no	yes	no
Q1	3	3	0	100%	0%
Q2	3	1	2	33%	67%
Q3	3	0	3	0%	100%
Q4	3			30%	70%
Q5	3	we didn't take any measurement actions			

From the questionaries result the respondent answer shows the water quality is not safe and there is a water born disease cases due to the quality.

4.6 Recommendation on water quality improvement

Improving drinking water can be achieved through various methods by protecting the source by selecting affective treatment methods like filtration and by maintaining the reservoir the whole water distribution system of water.

In order to protect drinking water quality local governments, organizations and communities are designing and adopting source protection plans. A source protection plan is a management strategy designed to minimize the impacts that human activities and natural events have on water sources. Such a plan should take a comprehensive ecosystem approach to water management, recognizing the need for clean drinking water, sustainable services for other human uses, and protecting the integrity of ecosystems also the non-structural best management practice to be apply in such a case.

In general, the prevention of water contamination is always preferable to attempting to remove contamination at a source level. A large proportion of drinking-water quality problems can be prevented through: adequate source protection and good water resource management; good design, operation and management of water supplies; and regular and thorough surveillance activities.

Finally, to improve the water quality of Abala town to make acceptable by the people and to protect the health of the Popole use the treatment methods like chlorination, boiling, filtration and aeration options.

5 Conclusion

The present research was conducted to assess the drinking water quality in the Abala town and their impacts on health. The result obtained during study was compared with Ethiopian standards using water quality index. The final findings of physical, chemical and biological parameters analysis and the questions asked in questionnaire were to a certain serious impact on the health of the people. the physical, chemical and biological parameters were in accordance with the permissible values recommended by WHO and EPA except total hardness, alkalinity, TDS, calcium, sulphate, arsenic, total coliform and E. coli in both sources. Therefore, drinking water quality of Ground water source of Abala town is good for drinking purpose and the overall WQI for the water source, reservoir, and tap water was also determined to be 27, 29, and 25.5 points, respectively. but the Subala river water source is very poor to use for drinking water supply purpose and the overall WQI for the Subala river water source (upstream, midstream and downstream) determined 80.08, 125.3, and 90.15 points, respectively. So, there is illness impacts to the Abala people due to consuming of water from Subala river.

6 Recommendation

The following recommendations are proposed based on the outcome of the research study

- ✓ Few periods of water quality data were used in this study due to highly cost and requires long time to survey. But daily, weekly, and annually Water quality recorded data were required to assess the quality of drinking water., so, it will be recommended to record the daily, weekly, monthly and annually water quality data of Subala river and the ground water source of Abala town to get a better result.
- ✓ Effective treatment, management, protection and maintenance of drinking water sources should be properly carried out.
- ✓ Proper implementation and sufficient disinfection of water with chlorine should be done actively.
- ✓ Continuous follow up on the water quality status give a better chance to safe the drinking water supply system. Check list is one way of collecting data used to know the quality status of the drinking water.
- ✓ Proper documentation system about existing water quality status is helpful to know the current status of drinking water quality.

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APPENDIX

Table 27 Standard of Drinking Water Quality Guide Fulfillment Criteria

Parameter		Unit	Maximum permissible limit	
			WHO	NDWQS limits
Physical	Color		Un objectional	15
	Test and odor		Un objectional	Unobjectionable
	Turbidity	NTU	**5**	**7**
	Electric conductivity	µS/cm	1000	1500
Chemical	Temperature	^{o}C	15	**-**
	TDS		1000	1000
	Total alkalinity (Caco3) (mg/l)	Mg/l	6.5–8.5	6.5 to 8.5
	Calcium (mg/l)	Mg/l	75	75
	Magnesium	Mg/l	150 mg/l	50
	Fluoride	Mg/l	1.5	3
	Hardness	Mg/l	300	300
	Sodium	Mg/l		200
	Iron	Mg/l	0.3	0.3
	Nitrate (NO3)	Mg/l	50	50
Biological	Total Coliform	CFU	0/100	0/100 ml
	Bacteria		0/100	0/100

Figure 4 Representative photos which shows the Abala town community fetch from Subala river daily

Figure 5: sample of water collected from study area to water quality laboratory work

Figure 6: laboratory instrument used for water quality examination in the laboratory

Figure 7: field visit and on spot water quality parameter examination

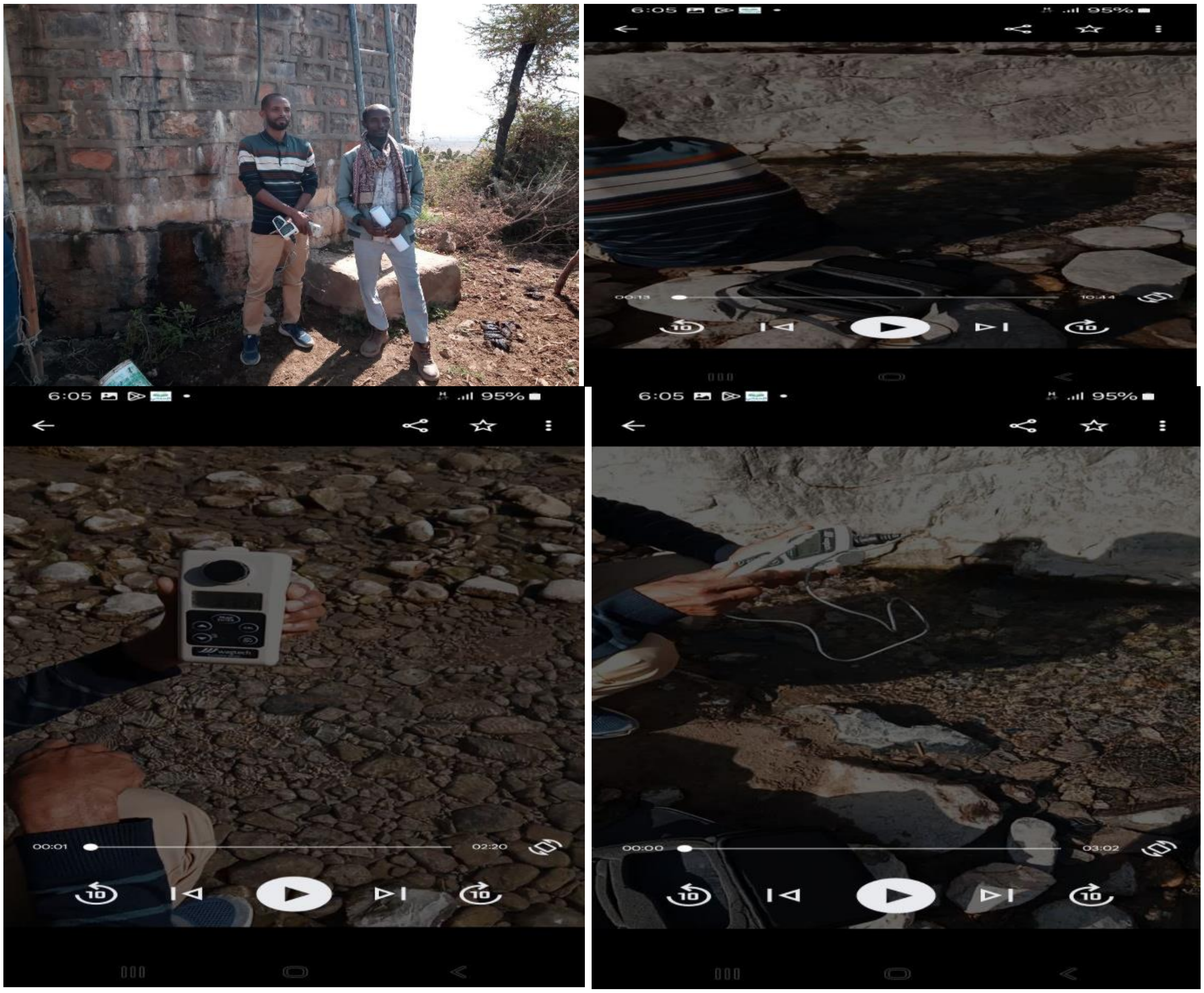

Table 28 Statical analysis result for Abala ground water quality

No	parameters	Source	reservoir	Last tap	standards		Mean	std dev
					WHO	Ethiopia		
1	Ph	7.717	7.777	8	6.5-8.5	6.5-8.5	7.83	0.15
2	Temperature	31.5	28.27	28.27			29.35	1.86
3	TDS	1198.74	1277	1270	500	1000	1248.58	43.30
4	turbidity	3.36	3.637	3.637	1.5	<5	3.54	0.16
5	Conductivity	1.687	1.78	1.82	1000		1.76	0.07
6	Alkalinity	315	480	285	200		360.00	105.00
7	Salinity	0.38	0.39	0.25			0.34	0.08
8	Calcium	341.9	521.4	533.9	200	200	465.73	107.42
9	Magnesium	75	79.7	81.6	100		78.77	3.40
10	Total hardness	1167.25	1634.33	1674.75	200	300	1492.11	282.06
11	Sodium	18.41	25.94	9.69	50	200	18.01	8.13
12	Potassium	8.91	8.07	8.64	12	1.5	8.54	0.43
13	Sulphate	296.5	283.4	302.6	200	250	294.17	9.81
14	Phosphate	0.52	0.49	0.12	0.1	0.02	0.38	0.22
15	Zinc	0.247	0.042	0.012	15	300	0.10	0.13
16	Chloride	35.7	32.4	18.6	250	250	28.90	9.07
17	Copper	0.052	0.49	0.12	2	1.5	0.22	0.24
18	Iron	0.057	0.074	0.076	0.3	0.3	0.07	0.01
19	Barium	0.21	0.08	0.04	0.7	0.7	0.11	0.09
20	Cadmium	0.069	0.063	0.01	0.003	0.003	0.05	0.03
21	Nickel	0.004	0.003	0.002	0.07	0.02	0.00	0.00
22	Arsenic	0.03	0.02	0.009	0.01	0.01	0.02	0.01
23	Mercury	0.001	0	0.053	0.006	0.001	0.02	0.03
24	E. coli	0	1	2	Absent	0	1.00	1.00
25	Total coliform	0	3	4	absent	0	2.33	2.08

Table 29 Statical analysis result for Subala river water quality

No	**parameters**	**Up stream**	**Mid stream**	**Down stream**	**standards**		**mean**	**std dev**
					WHO	**Ethiopia**		
1	Ph	8.09	8.33	8.35	6.5-8.5	6.5-8.5	8.26	0.14
2	Temperature	25.93	23.4	25.73			25.02	1.41
3	TDS	1725.73	1682.94	1682.94	500	1000	1697.20	24.70
4	turbidity	1.68	3.163	1.24	1.5	<5	2.03	1.01
5	Conductivity	251.664	414	413.7	1000		359.79	93.64
6	Alkalinity	485	300	375	200		386.67	93.05
7	Salinity	0.26	0.31	0.27			0.28	0.03
8	Calcium	578.5	557.9	615.3	200	200	583.90	29.08
9	Magnesium	95.5	90.6	91.5	100		92.53	2.61
10	Total hardness	1844.16	1772.25	1919.5	200	300	1845.30	73.63
11	Sodium	24.32	23.68	24	50	200	24.00	0.32
12	Potassium	15.87	16.16	15.49	12	1.5	15.84	0.34
13	Sulphate	346.7	286.9	304.8	200	250	312.80	30.69
14	Phosphate	0.16	0.21	0.41	0.1	0.02	0.26	0.13
15	Zinc	0.138	0.109	0.098	15	300	0.12	0.02
16	Chloride	32.5	33.4	29.6	250	250	31.83	1.99
17	Copper	0.146	0.14	0	2	1.5	0.10	0.08
18	Iron	0.114	0.536	0.389	0.3	0.3	0.35	0.21
19	Barium	0.15	0.04	0.08	0.7	0.7	0.09	0.06
20	Cadmium	0	0.03	0.028	0.003	0.003	0.02	0.02
21	Nickel	0.001	0.002	0.001	0.07	0.02	0.00	0.00
22	Arsenic	0.08	0.07	0.005	0.01	0.01	0.05	0.04
23	Mercury	0.001	0.002	0.003	0.006	0.001	0.00	0.00
24	E. coli	1	0	0	Absent	0	0.33	0.58
25	Total coliform	2	0	0	absent	0	0.67	1.15

Water quality related Questioners to be filled by abala town community

Background information

1. Name ___________________________
2. Sex: - Male [ ] Female [ ]
3. age --------------------------------------
4. your job -------------------------------

5. address-------------------------------

Question

1. **What kind of water do you use as the main source of your drinking water?**

2. **Are you satisfied with your drinking water quality**
   A. Yes B. no
3. **Do you believe your water is safe for consumption**
   A. Yes B. No
4. **Have you noticed any health problems that you think may be related to you water**
   A, Yes B. No

5. **Why did you use subala river for water consumption?**

6. **If your response for question No 4 is "yes" what are health problems related to water born disease)? ____**

Water quality related Questioners to be filled water/ environmental expert in abala town water supply service office

Background information

1. Name ________________________
2. Sex: - Male [ ] Female [ ]
3. age --------------------------------------
4. your job -------------------------------
5. address-------------------------------

Question

1. Do you have any water treatment system used in the water supply system of abala town
2. If your response is yes what are the treatment methods apply to clean the water
3. Do you trust the safety of drinking water of abala town
4. Have you had your water tested for quality
5. If Q4 is yes , what were the result
6. What measure did you take at the time the quality of water is not safe

Water quality related Questionaries to be filled by abala referral hospital

Background information

1. Name ________________________
2. Sex: - Male [ ] Female [ ]
3. age -------------------------------------
4. your job -------------------------------

5. address------------------------------

Question

1. **Are there any water borne diseases experienced in your hospital?**
   a. **Yes** B. **No**
2. **If your response for question No 1 is "yes" what are health problems related to water born disease)? ____**

3. **Are there any water borne diseases occurred day to day in your hospital?**
   A.Yes B. **No**

4. **How many patients do you care per month due to water born disease**

5. **What ate the most effective way to prevent water born disease**