INSTITUTE OF HEALTH SCIENCES

PUBLIC HEALTH FACULTY

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGY

DRINKING WATER QUALITY ASSESSMENT, THE CASE OF SEKA CHEKORSA WOREDA JIMMA ZONE, SOUTH WEST ETHIOPIA 2021.

RESEARCH THESIS SUBMITTED TO DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGY JIMMA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE (MSC) IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY

BY

Sheleme Beyera

December, 2021

Jimma, Ethiopia

JIMMA UNIVERSITY

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BY

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December, 2021

Jimma, Ethiopia

DECLARATION

I, Sheleme Beyera, declare that all information in this document has been obtained and will be presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and result in this my Thesis title of "Drinking Water Quality Assessment"_ : The Case of Seka Chekorsa Woreda Jimma Zone, South West Ethiopia 2021.

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Acronyms and abbreviations

WHO	World Health Organization
UNICEF,	United Nations Children's Fund
JMP	Joint Monitoring Programme
DO	Dissolved Oxygen
PH	Hydrogen potential
TDS	Total Dissolved Solid,
TSS	Total Suspended Solid
APHA	Analytical hierarchy process
TC	Total coliform
CF	faecal coliform
EC	Electrical conductivity
NTU	Nephelometric turbidity unit
EDTA	ethylenediaminetetraacetic acid; edetic acid
EMB	Eosin Methylene Blue
CV	coefficient of variation %
COR	Crudes odd ratio
AOR	Adjusted odd ratio

Abstract

Background: Quality and safe drinking water is a determinate factor affecting human health and the environment. The quality of drinking water has always been a major health concern, especially in developing countries, where 80 % of the disease cases are attributed to inadequate sanitation and the use of polluted sources of drinking water. This study aimed in assessing drinking water quality in Seka chokorsa woreda.

Methods: A cross - sectional study was conducted in seka town and purposely selected rural kebele of the seka district on assessment of drinking water quality from March to July 2021. The study incorporate 364 households for assessing water handling practice by using a pretested structured questionnaire and 39 water samples were collected from 13 sampling points of protected spring, protected dug well, borehole water sources and tape water including point of reservoir and distribution line. The analyses of various physicochemical and bacteriological parameters were carried out following the standard method (APHA, 1998). The data was entered using Epi-data version 4.604 data entry software and data analysis was carried out by using SPSS version 23. Descriptive statistics, one way ANOVA were also performed.

Result: The prevalence of faecal coliform contamination from water samples taken from drinking water sources and at sampling point of reservoir, distribution line and tap in seka woreda jimma zone was found high 12/13(92.3%) .The analyzed result for physicochemical parameters indicates, most of the parameters were within the level permissible limit set by WHO guideline and ESDWQ standards for drinking water, except for pH, turbidity, and temperature, manganese and iron ion concentration. In multivariable analysis construct latrine floor by wood had 3.56 times higher odds of faecal coliform contamination in drinking water sources (unsafe sources), [AOR: 3.56, 95% CI (1.167- 10.859)] than those construct latrine floor by concrete. Respondents these had latrine nearest to water sources or less than 100m 92% less likely get drinking water from safe water sources, [AOR: 0.08,95% CI (0.021-0.331) than respondents had latrine far from water sources greater than 1000m.

Conclusion: Generally**,** in this study, the prevalence of faecal coliform contamination from water samples taken from drinking water sources and at sampling point of reservoir, distribution line and tap in seka woreda jimma zone was found high 12/13 (92.3%). Physicochemical parameters for pH, turbidity and temperature, manganese and iron for some water sources were beyond the permissible range of WHO and ESDWQ standards. Therefore, the factors associated with drinking water quality problems were the materials from which latrine floor constructed and the distances between latrine to water sources were identified as factors which had significant association with presence of faecal coliform in drinking water sources with p – value less than 0.05($p < 0.05$).

Keywords: Bacteriological parameters, Drinking Water quality Assessment, Fecal Coliform, Physicochemical parameters, sanitary survey inspection and Water Source.

CHAPTER ONE

1. Introduction

1.1 Background

Water is an essential component of human life and it is a universal solvent that can dissolve many substances of organic or inorganic compounds(Alemu *et al*, 2015). Safe and adequate water supply is a vital element to preserve human health, and hence access to clean drinking water is now recognized as a fundamental right of human beings(Abegaz, 2021). Fresh water is already a limiting resource in many parts of the world. Furthermore, in the next century, it will become even more limiting due to increased population, urbanization, and climate change (Meride and Ayenew, 2016). Peoples- in most developing countries obtain their drinking water from surface and underground sources. However both surface and ground water sources could become contaminated by biological and chemical pollutants arising from point and non-point sources(Ali *et al*, 2012). Entry of point and non-point sources into the water can represent the improper discharge of toxic chemicals and pathogenic microorganisms(Vadde *et al*, 2018). In most developing countries of the world, inadequate supplies of drinking water can contribute to the underage death of children in the region (Edokpayi *et al.*, 2018).

Storage of collected water from rivers, springs, community stand-pipes, and boreholes is a common practice in communities that lack potable water supplies piped into their homes. Even when water is piped into the home, it is often not available on a continuous basis, and water storage is still necessary. Water is stored in various containers which include jerry cans, buckets, drums, basins and local pots . It has been reported that when the collection of water from sources of high quality is possible, contamination during transport, handling and storage and poor hygienic practices often results and can cause poor health outcomes (Edokpayi *et al.*, 2018). Two-fifth of Africans lack the improved water supply, 60.2% have access to improved drinking water source, and 36% have access to improved sanitation facilities The lack of safe water creates a remarkable burden of diarrheal disease and other debilitating, life-threatening illnesses for people in the developing world(Sila, 2019).

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 (Meride and Ayenew, 2016).

Consumption of contaminated drinking water is a cause of diarrheal disease, a leading cause of child mortality in developing countries with about 700,000 deaths of children under the age of 5. The health risks associated with the consumption of unsafe drinking water are not only related to infectious diseases but also to other environmental components such as fluoride, arsenic, lead, cadmium, nitrates and mercury. Excessive consumption of these substances from contaminated drinking water can lead to cancer, dental and skeletal fluorosis, acute nausea, memory lapses, renal failure, anaemia, stunted growth, fetal abnormalities and skin rashes (Edokpayi *et al.*, 2018). Around 88% of the global diarrheal burden and 10% of the total disease burden are due to unsafe drinking water, inadequate sanitation, and poor hygienic practices(Duressa, Assefa and Jida, 2019). Waterborne diseases are caused by the ingestion of water contaminated with human or animal faeces or urine containing pathogenic bacteria or viruses including cholera, typhoid, bacillary dysentery, adenoviruses, retroviruses, and other diseases. In addition, water derived from various sources may also contain dissolved inorganic and organic substances which could cause health problems to the community(Duressa, Assefa and Jida, 2019).

Globally, an estimated 785 million people use unimproved water sources; some 144 million people rely on surface water for drinking, and more than 2 billion people use drinking water contaminated with feces(WHO, 2019). The majority of these are in Asia and sub-Saharan Africa. Ethiopia is characterized by lower water supply and sanitation coverage it is estimated that 62.7% of the Ethiopian population relies on unimproved water; diseases in Ethiopia are attributed to poor access to clean water and sanitation. The problem is more serious in the rural area where the majority of the people do not have access to potable water and therefore, depend on well, stream and river water for domestic use(Berhanu and Hailu, 2015).

In Ethiopia over 60% of communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation practices (Berhanu and Hailu, 2015). Only 5 % of the population in rural areas and 37 % in urban areas reported access to safely managed drinking water services. Three-fourth of the health problems of children in the country are communicable diseases arising from the environment, especially water and sanitation. Forty- six percent of less than five years mortality is due to diarrhoea in which water- related diseases occupy a high proportion. The Ministry of Health, Ethiopia estimated 6000 Children die each day from diarrhoea and dehydration (Admassu, Wubshet and Gelaw, 2000).

Therefore, this requires proper protection of water supply from contamination and regular surveillance of water sources to reduce water-related diseases. Continuous examination of water quality analysis based on detection of indicator organisms is among the methods of assessing the hygienic condition of water (Admassu, Wubshet and Gelaw, 2000). Physico-chemical parameters such as turbidity, pH, temperature, nitrate, and others are widely accepted as other critical water quality parameters for drinking water. These parameters are either directly influence microbiological quality or affect disinfection efficiencies and human health(Duressa, Assefa and Jida, 2019).

Several studies carried out in Ethiopia on the physicochemical and bacteriological quality of drinking water from various sources showed that water sources were contaminated with pollution indicators such as faecal and total coliforms(Alemu *et al.*, 2015). These indicate that water-quality problems are rampant in the water-delivery systems of the country. Hence, the aim of this study proposal is to examine the distribution of selected physicochemical and Bacteriological parameters and its health impact by comparing its values with the WHO guidelines and the Ethiopian compulsory Standard for drinking water and to generate information that enables for health regulatory and water authorities to monitor water sources in and around Seka town, Jimma zone, southwest Ethiopia. The water sources included in this study proposal will be tap water, protected wells, protected and unprotected springs and ground water. Although theoretically assumed to be safe, tap water samples were collected from point of disinfection and at household levels.

1.2. Statement of the problem

Drinking water quality is a problem, in developing countries specially sub Saharan countries. In many low-income countries including those in Africa, it may be difficult to deliver tap water to each and every household in rural areas. The development of water infrastructure is very expensive because fewer people are serviced over large distance of piping(Alemayehu *et al*, 2020).

Although developing countries are commonly highlighted for their populations having low coverage for access to safe water, developed countries including the United States continue to have issues as well. For example, Flint, Michigan underwent a water crisis recently due to lead contamination of the water caused by a switch to more corrosive water that was compounded by long water residence times, old age of water distribution piping, and poorest average neighbourhood housing condition that resulted in harmful blood lead levels measured in its inhabitants before the intervention took place(Murduca, 2018)

Globally, 207 million people have no access to improved water sources, and sub-Saharan Africa shared two-thirds of its burden. Accordingly, 29.4 million Ethiopians have no access to improved water sources JMP, 2017 Approximately 785 million people lack even a basic drinking-water service; including 144 million people are dependent on surface water. Globally, at least 2 billion people use a drinking-water source contaminated with faece WHO, (2019).

In many developing countries, water quality is a significant problem even for the most prosperous communities that have access to piped water supplies. A significant proportion of families in developing countries live in this situation and are forced to rely on purchasing bottled water, which they can ill afford. Disproportionately, sub-Saharan Africa contributes to approximately half of this number Duressa, Assefa and Jida, (2019).

In Ethiopia, basic water and sanitation services are very low, resulting in a high prevalence of water-related diseases. Access to safe drinking water only 13 percent of the population was considered to have access to safely managed drinking water in Ethiopia(Azeze *et al.*, 2020). And only 6.3% of households have access to improved sanitation, and over 83 million people live in unhealthy environments. As the result, water-related diseases accounted for 60–80% of all illnesses and diseases in Ethiopia (Sitotaw and Geremew, (2021).

Three-fourth of the health problems of children in Ethiopia are communicable diseases arising from the environment, especially water and sanitation. Forty-six percent of less than five years mortality is due to diarrhoea in which water-related diseases occupy a high proportion. The Ministry of Health, Ethiopia estimated 6000 Children die each day from diarrhoea and dehydration(Admassu, Wubshet and Gelaw, 2000). Ethiopia ranks among the lowest countries in the world in levels of safe water and sanitation coverage. 13% of Ethiopia's access to safely managed drinking water and 79% lack access to basic sanitation. While access to safely managed drinking water services is in general very low, the rate is different for different groups. Approximately 5 % of the population in rural areas and 37 % in urban areas reported access to safely managed drinking water services(Azeze *et al.*, 2020).

Researches were done on the assessment of Drinking water quality by physic-chemical and bacteriological methods in different place water sources including the town water supply system. However, the current study area water quality status of the microbial contamination of drinking water and physic-chemical water quality is unknown.

Therefore, this research determines the level faecal contamination, chemical concentrations and physical acceptability of drinking water quality and its associated risk. So this study will help in the intervention actions to be take by the concerned bodies and will provide decisionline information for other studdies.

The Gaps Which Demand Such Studies, including:

Undertaking this study will have more paramount importance. The study will help for urban water supply and wereda water and energy resources office to evaluate the status of their service, and will be taken appropriate intervention action in Seka Chekorsa wereda/district. Since, methods of drinking water quality control in the study area; i.e. water treatment, storage and distribution not assessed yet, this study will estimate the prevalence and identified risk factors for faecal contamination of drinking water sources and from sources to distribution line supply network and point of usage among residents of Seka Chekorsa wereda/district.

1.3. Significance of the study

The present study conducted to know the level of faecal contamination and magnitude of physicochemical parameters and there associate factors, so that the realistic intervention plan can be made to prevent the community from disease associated with consuming unsafe water. Identifying the magnitude and the level of contamination in water sources and at a point is a key to promote awareness on a condition of associate factors, helping educators, stakeholders and water supply services providers to plan and coordinate to service delivery.

Furthermore, this study will help for water supply and woreda water and energy resource office to evaluate the status of their service, and will be taken appropriate intervention action in Seka Chekorsa Wereda/ district. The findings of this study might also help in influencing the development of appropriate policies, plans and intervention programs for the screening water sources and treatment of drinking water. And the study will also give important clues information for other studdies.

CHAPTER TWO

Literature review

2.1 Drinking water quality

All humans require safe and adequate supply of clean water in order to survive, and a lack of this resource is known to significantly decrease the quality of life (WHO, 2011). According to Jain et al., 2011 the level of access to clean water varies over different populations; however, four criteria can determine whether users have or do not have access to this resource: 1) a sufficient quantity, 2) an acceptable quality, 3) local availability, and 4) affordable price (Murduca, 2018).

A first step to manage water quality is to protect the water sources UNICEF, (2015). According to the JMP: "improved" water sources are piped connections to a dwelling, a plot or a yard, water kiosks (especially in developing countries: Tsegai, Daniel; McBain, Florence; Tischbein, (2013) protected dug wells, boreholes, rainwater collection and standpipes and more generally those that by the nature of their construction, are protected from outside contamination WHO-UNICEF, (2012).

Globally, an estimated 785 million people use unimproved water sources; some 144 million people rely on surface water for drinking WHO, (2019). In 2011, 11% of the world population reported using 'unimproved' drinking water supplies (defined as unprotected springs and dug wells, surface water and water stored in a tank) and 36% had 'unimproved' sanitation (Cumming *et al.*, 2014). 'Improved' and 'unimproved' drinking water and sanitation refer to specific sources and facilities as defined by the WHO/UNICEF 2013 and are often taken as proxy indicators for appropriate and inappropriate water and sanitation Cumming *et al*, (2014). According to the joint WHO/UNICEF, (2015) reports that approximately 663 million peoples were do not used an improved drinking water source. Disproportionately, sub-Saharan Africa contributes to approximately half the population that lacks access to improved drinking water sources UNICEF, (2015).

According to study conducted on bacteriological contamination of drinking water supply from protected water sources to point of use and water handling practices among beneficiary households of Boloso Sore Woreda, Wolaita Zone, Ethiopia, households were using different water sources; 163(29.9%), 123 (22.6%), and 259 (47.5%) of them were benefited from shallow well, protected hand-dug well, and protected spring, respectively.) time required to fetch water was calculated; 447 (82%) fetched water in the distance of <30 minutes.) most commonly preferred type of water collection container was jerry can (540, 99.1%). Only 48 (37.5%) of the respondents cleaned their containers before collection and 462 (84.8%) covered the collection container during transportation Gizachew *et al*, (2020).Another study conducted on bacteriological and physicochemical quality of drinking water in Wegeda Town, Northwest Ethiopia, indicates among the 60 households interviewed and /or inspected, 23 (38.3%) of them had no toilet, and even most of the available toilets were almost nonfunctional. Regarding the behavior of the participants, 21 (35%) of them did not wash their hands after using the toilet. In addition, 34 (56.7%) of the participants were draw water by dipping cups into the storage containers Sitotaw, Melkie and Temesgen, (2021).

According to bacteriological and physicochemical quality of drinking water in Adis Kidame Town, Northwest Ethiopia, the sanitary status 30 households were selected to obtain information on the sociodemographic characteristics and sanitary conditions at the household level. Of the respondents, a significant proportion of them did not wash their hands before drawing water from storage (90%), covered water container inadequately 83.3%), washed their water container with water only (63.3%), retained wastes at home for more than 2 weeks(66.7%), and used buckets as water storages (53.3%) Sitotaw and Geremew, (2021). Another study conducted on bacteriological and physicochemical quality of drinking water in Kobo town, Northern Ethiopia, a total of 17 questions was presented to the364 selected households to obtain preliminary information about the sanitary conditions at the household level. Of the respondents, 88% did not wash their hands before drawing water from the storage, 73% rarely washed drinking water storage containers, 70% had waterborne disease of at least one family member in the last three years, 70% had drinking water collecting container inadequately covered, 68.4% did not wash their hands after using the toilet, and 60.2% had cracked or unclean drinking water storage Nigus, (2021).

In addition, results from sanitary inspection at the source, reservoir, and the distribution system indicated that the source, including the line to the reservoir, had a 61.5% (8/13) risk score while the reservoir, along with the distribution line to the taps, had a 50% (5/10) risk score. Based on the sanitary inspection risk score described in WHO (2012), the source and the distribution line to the reservoir were at the high-risk level. On the other hand, the reservoir and the distribution line to the taps were at the intermediate-risk level Nigus, (2021).

A Result from the 2016 Ethiopia Socioeconomic Survey found that 66 percent of the Ethiopian population uses drinking water from improved sources, with distribution varying by place of residence. In rural areas, 59 percent of the population reported using an improved source, usually protected springs, tube wells, and dug wells. In most countries, contamination of drinking water with faecal matter is the worst water quality problem Bank, (2017)

2.2 Water Quality Parameters

2.2.1 Physico-chemical Parameters

According to Pawari and Gavande,et.al,2015 study focused on the hydrochemistry of groundwater in the Jaipur city to assess the quality of groundwater for determining its suitability for drinking and agricultural purposes indicated that. Groundwater samples were collected from eleven stations of Jaipur city during monsoon season and were analyzed for physico-chemical parameters such as pH, EC, TDS, sodium, potassium, calcium, magnesium, chloride, sulphate, carbonate, bicarbonate, nitrate and fluoride. Comparison of the concentration of the chemical constituents with WHO drinking water standards of 1983, the status of groundwater is better for drinking purposes. The parameters like pH, sodium, potassium, carbonate, bicarbonate, chloride are within permissible limit as per WHO but calcium, magnesium and nitrate values exceeding the limit Pawari and Gavande, (2015).

According to Hemant Pathak et al 2012 Pysico-chemical Analysis was carried out for various water quality parameters were measured by using Standard APHA methods. The ground water samples of Baheria village and Gambhiria villages of Sagar city. It could be concluded from ground water quality of Baheria and Gambhiria village of Sagar city, variables viz. TDS, TH are slightly higher and Alkalinity, Cl are lower in the post monsoon period than in the PreMonsoon.. It was reported that groundwater was contaminated from nitrate fertilizers and manures used in agriculture. Furthermore, nitrate is used by microorganisms as food resources. In addition, high nitrate levels are often accompanied by bacterial and pesticide contamination. Hence, these sample water can be absolutely fit for drinking after disinfectants treatment(Pathak and Limaye, 2012). (Yasin al et, 2015) Had obtained in Serbo town most of the physico-chemical data indicated marginally tolerable quality with respect to pH and TSS but poor quality in relation to turbidity, temperature, conductivity, and BOD and nitrate concentration with values much in excess of the permissible standards. Excessive nitrate concentrations recoded from some water samples are mainly related to pollution (with agriculture as the main source). Similarly, Duressa Gonffa,Assefa Fassil and Jihad Muldisa in Nekemte obtained The TDS values of tap water samples fell below the maximum acceptable standard of 600mg/l Duressa, Assefa and Jida, (2019).

Farther more, All the physico-chemical parameters of all water sources in Digalu-Tijo woreda were found within and below the range of National and International standards except Turbidity, 11.1% of Unprotected spring on spot, 100% of Unprotected Hand dug wells and unprotected Rivers, Temperature (100% of protected spring with distribution system, Unprotected Hand dug well, Unprotected River and Tap water)and pH (7.4% of Unprotected spring on spot) which had above

National and International permissible standards that may result to a cause of serious public health problem over long time exposure Dobo and Bedewi, (2020).

A study conducted by Fitsum Gebreyohannes, Abraha Gebrekidan, Amanual Hadera and others on Water quality assessment by using standard analytical methods (US-EPA, 2004); Sinha and Biswas, 2011) in Tigray Mekele Elala River was based on selective water quality parameters which are relevant to indicate whether or not the water suitable for drinking and agricultural purposes. Present investigation concludes that most of the studied physicochemical parameter concentrations of Elala River water were found to be above the recommended limit of standards for drinking and irrigation waters. 22 different physical and chemical water quality parameters obtained in the study are above the permissible limits of (WHO2008) standards for drinking water but fall within the FAO (Ayers and Westcot, 1994) standard limit for irrigation purposes Gebreyohannes1 *et al*, (2015).

2.2.2 Bacteriological Parameters

According to the survey report water quality, out of the 4,533 tests conducted at water sources, 4,513 results (over 99 percent) could be classified into risk categories (low, moderate, high, or very high risk.). The most common source of low-risk water was piped water on premises (45 percent); most of the very-high-risk water was from unimproved sources (64 percent), particularly unprotected springs (34 percent) and surface water (23 percent). Nearly 95 percent of the populations accessing low-risk water were using improved water supplies Bank, (2017).

Unclean water can have different types and levels of contamination, and most contamination occurs due to anthropological activities Jain, (2012). Typical water quality parameters important for public health include presence of microbiological indicators and pathogens, turbidity and suspended solids, and inorganic and organic pollutants. Although each of these parameters can have associated health risks, many agree that microbial contamination poses the greatest health risk to humans in developing world settings in regards to drinking water contaminants. Exposure to pathogens may be associated with the stomach flu, diarrhea, and vomiting Pathak et al, (2006). Independently, turbidity itself is not a health risk; however, turbidity is associated with the concentration of suspended solids (SS) to which harmful microorganisms or other14 pollutants can be attached Howard, (2002). Turbid and odorous water can also be aesthetically unpleasing resulting in rejection by the user WHO, (2011). Lastly, heavy metal contamination may cause acute or chronic health issues; this contamination can result from leaching from premise plumbing materials like galvanized iron and lead pipes, copper pipes, steel pipes, brass fittings and taps. Many different types of water sources can be contaminated, and drinking water quality can be sacrificed for many different reasons. Although improved drinking water sources theoretically provide safe drinking, limited monitoring, inadequate treatment, poor maintenance, and short-term contamination can result in these improved sources failing to provide users with an adequate supply (Howard et al, 2012). As noted, improved sources can be contaminated after distribution or construction, but supplying agencies hold responsibility for these technologies supplying safe water WHO, (2011).

A study was conducted in condar by cross-sectional method from May to June 2000. A total of 70 water samples were taken for bacteriological analysis. The samples water sources, like unprotected and protected wells and springs in both urban and rural areas. A result shows that, Analysis of protected springs demonstrated that 71.43%, of the samples had all kind of indicator bacteria's. Fifty percent of the positive samples had fecal coliforms, of these 35.7% had E. coli. Fifty percent of protected wells had all kinds of indicator bacteria. Unprotected wells and springs demonstrated that 75% of the samples taken from both sources were contaminated by fecal coliforms, especially E, Coli. Fifty percent of the samples in both cases had a coliform count of 180 and above per 100 ml(Admassu, Wubshet and Gelaw, 2000). Zero faecal cfu/100 ml is considered uncontaminated (WHO, 2006). Therefore all water sources are grossly polluted. The type of coliform exhibited is a fecal type specifically of human originAdmassu, Wubshet and Gelaw, (2000).

According to(Yasin al et, 2015), a study conducted in Jimma Zone Serbo Town , About 66.67 % of tap water samples were found to be negative for FC and E. coli were not detected in all the tap water samples. The entire samples from both unprotected wells and unprotected springs were positive for indicator organisms. Among the 15 protected well water samples analyzed, only 6 (40 %) had bacterial count below 10 CFU/100 ml and four (26.67 %) were negative for fecal coliforms. Sixty percent of protected springs were free from fecal coliforms and 46.67 % of these samples had TC count less than 10 CFU/100 ml. Some studies conducted on bacteriological qualities of drinking water in Akaki-Kalit sub-city of Addis Ababa, Ziway, Bahir Dar and Nazareth (Adama) towns showed contamination of the water samples with indicator bacteria including total coliforms (TC) and faecal coliforms(Yasin al et, 2015).

According to Desalegn Amenu Bacteriological analysis of water samples from the five sources (protected spring, unprotected spring, protected well, unprotected well and tap water) in three sites of Dire Dawa Rural Communities showed that all samples of water sources from each were positive for total coliforms and faecal coliform in two rounds of triplicate sampling(Desalegn Amenu1, 2014).

2.3 Conceptual Framework

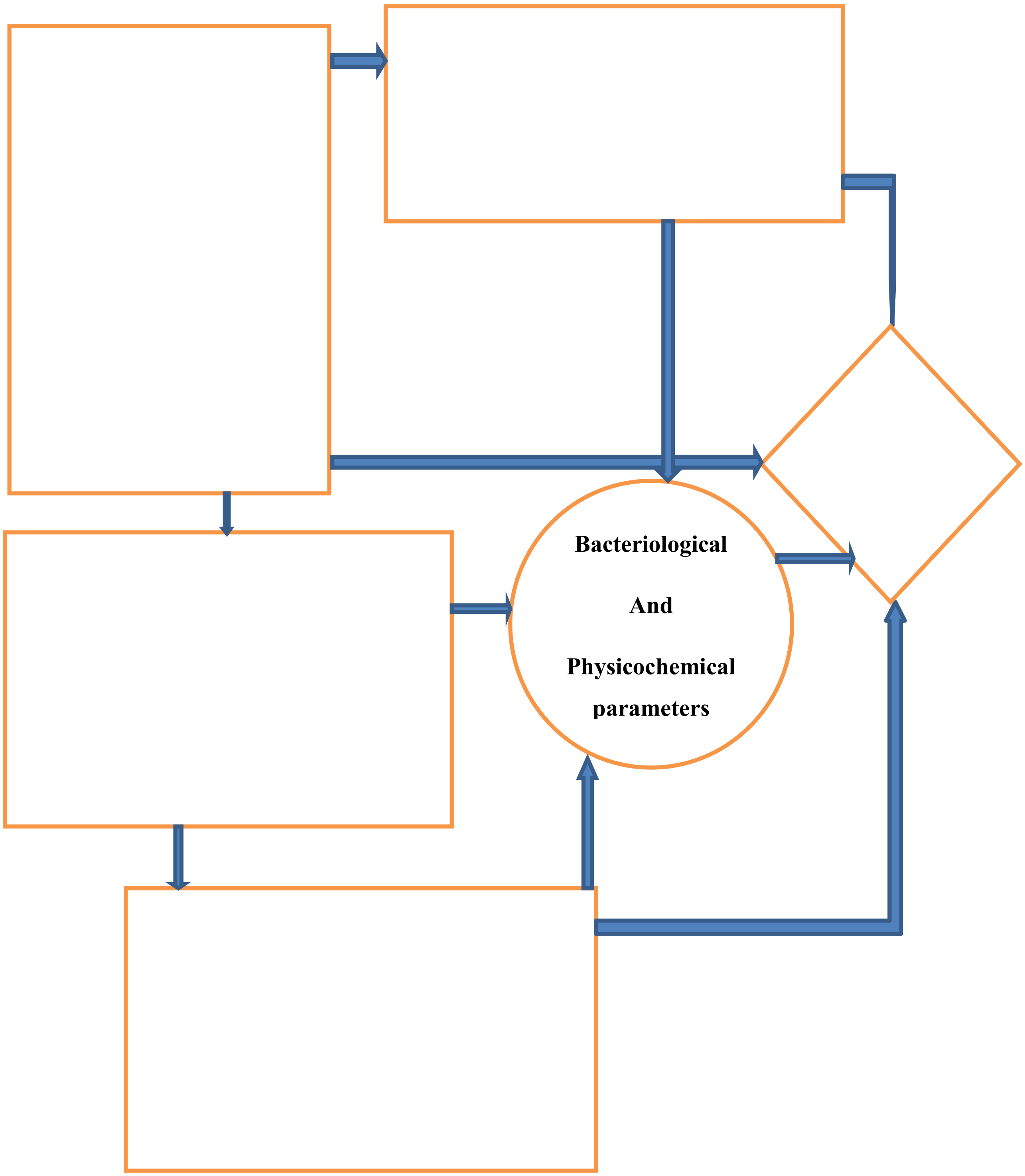


Figure 1:Conceptual framework for assessment of drinking water studies.

CHAPTER THREE

OBJECTIVES

3.1 General Objective

To assess physicochemical and bacteriological quality of drinking water supplies among residents of Seka chekorsa Woreda, Jimma zone, Southwest Ethiopia 2021.

2.2 Specific Objective

Specifically the study is geared to:

- To identify the level of physicochemical parameters such as pH, DO turbidity, TDS, TSS EC, Temperature, Hardness, nitrate, Iron and phosphate in the drinking water sources.
- To identify the extent of bacteriological contamination of drinking water sources.
- To determine possible risk factors for faecal contamination of drinking water sources

3.3 Research Question

The research will be aimed to answer the following research questions?

- How the following physicochemical parameters such as pH, temperature, EC, DO, TDS, TSS, Turbidity, iron and manganese can affect drinking water quality
- What is the level of bacteriological contamination and water quality looks like in drinking water sources
- What are the factors that contribute to the faecal contamination of drinking water sources

3.4. Hypotheses

Drinking water Quality either at sources of water or in water supply network, reservoir, distribution line and tap point will not get contaminates by faecal coliform and physicochemical parameters.

CHAPTER FOUR

METHODS AND MATERIALS

4.1. Description of the Study Area

The study was conductted in Seka Chekorsa Woreda/ district, which is located at a distance of 373 Km from Addis Ababa; the woreda has an altitude of 1500 to 2881 m above sea level with latitude and longitude of 7°32′00″N and 36°46′00″E respectively. Moreover, it has an average temperature and annual rainfall of 19.76°C and 1988mm, respectively. Covering a total area of 85825KM2, the woreda is inhabited by a population size of 316,818 residing in a total of 61758 households. The Woreda is supplied with piped and ground (sources improved spring and dug well) water Sources (Seka-chorsa wereda Administration office)

Sources of drinking water supplies in the study area are including (tap, improved springs, improved dug wells and ground water).

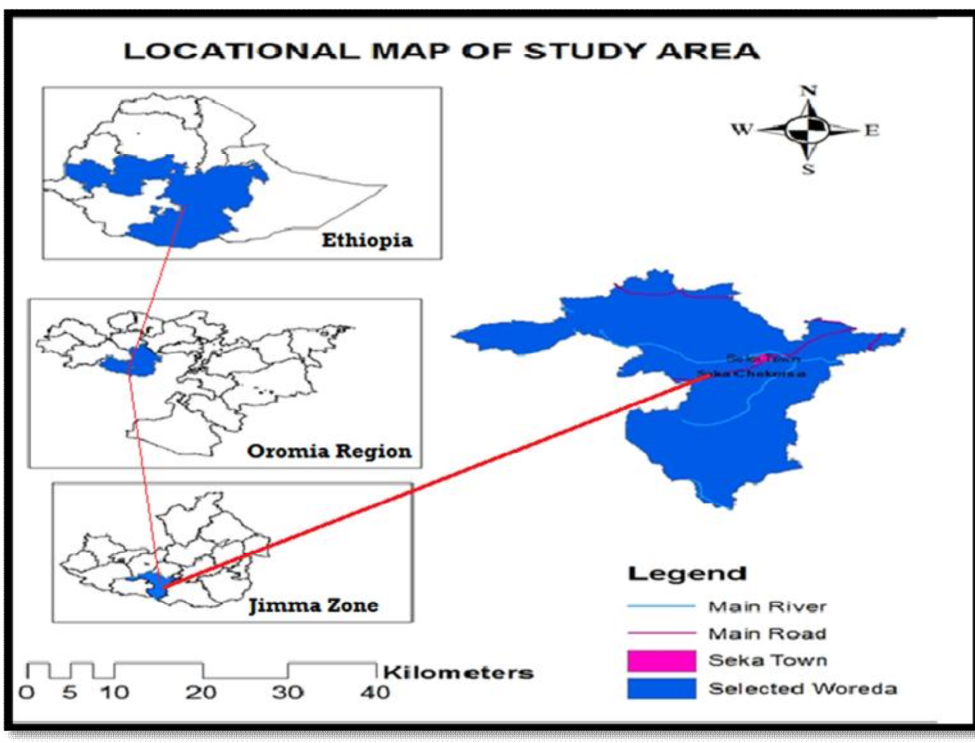


Figure 2:Location Map of Study Area

4.2. Study Design and period

Cross sectional study was conducted from March to July 2021 which is geared towards assessment of physicochemical and bacteriological quality of drinking water supplies in Seka chekorsa Woreda/district, Southwest Ethiopia

4.3 Variables

a) Dependent variables (outcome variable)

- Water quality
- Faecal coliforms and total coliform.
- pH, turbidity, temperature, totals dissolved solid, dissolved oxygen, electric conductivity, nitrate, and phosphate**.**

b) Independent variables

- Scio-demographic and economic factors: Age and family size, Ethnicity, education level, occupation, marital status and income level
- **Water related factors**: source of drinking water, accessibility of drinking water, water collection container type, hand washing practice,
- **Sanitation and hygiene:** Availability of a toilet facility, type of the toilet, latrine functionality, solid waste storage, storage type and disposal facility.

4.4 Sample size

From 6,443 households in the study area, 364 households were selected at random. For each household, after obtaining written informed consent, trained interviewers administered a structured questionnaire to the household head, Mother or adult daughter. All selected households who were approached by the data collectors' team have participated in the study and none refused. Using simple random sampling technique, which was determined by using the following statistical formula (Kothari, 1990)?

$n(\text{i}) = NZ^2 * p * (1-p) / N\text{e}^2 + Z^2 * p\ 1 - p$ Eq. 1

where

n(i) = is the sample size,

N = is the total number of households,

Z = is the confidence level at 95% of Z = 1.96,

P = is the estimated population proportion of 0.5 which maximize the sample size and

e = is the error limit of 5% which is equal to 0.05.

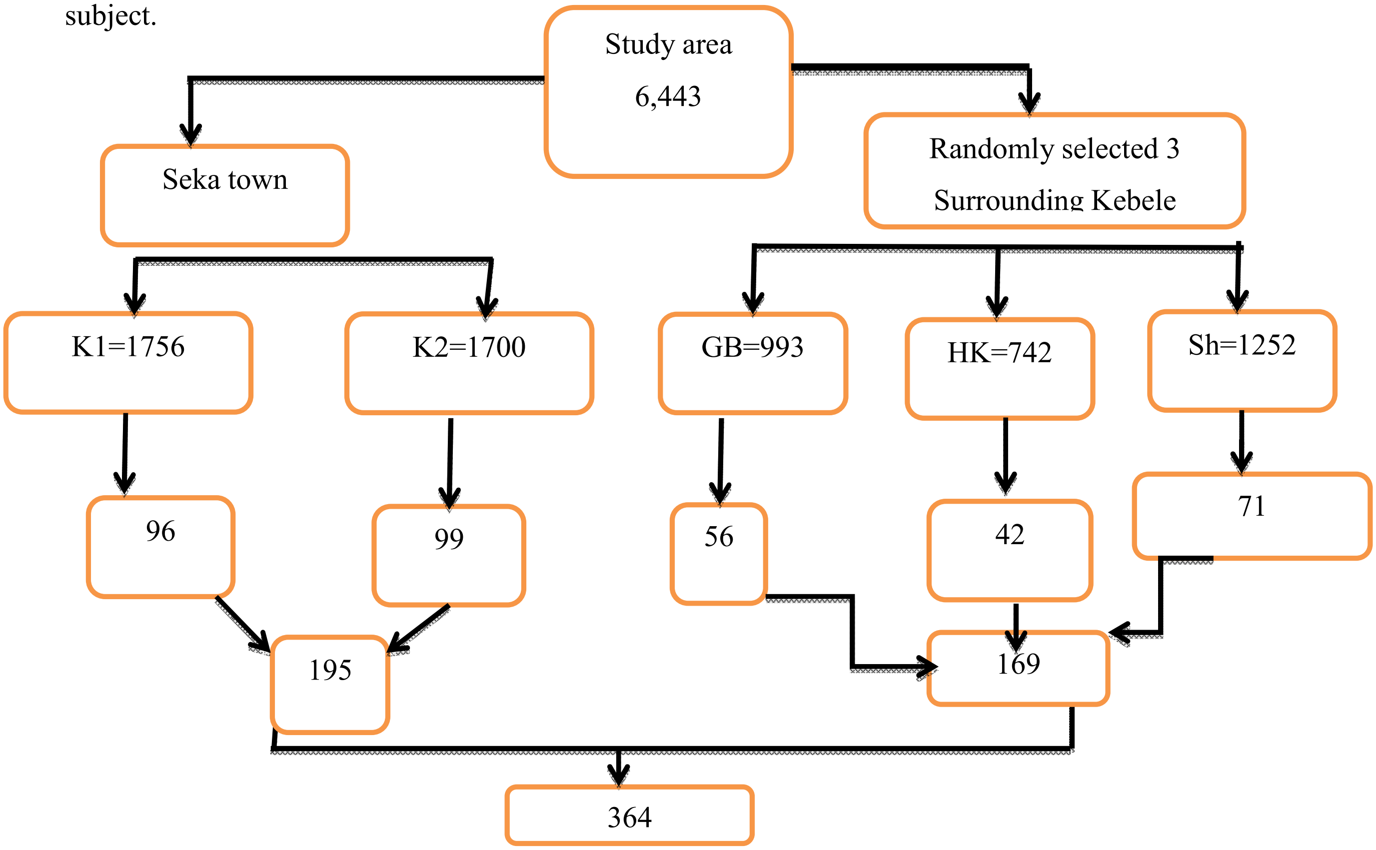
$n(\mathrm{i}) = NZ^2 * p * (1 - p) / Ne^2 + Z^2 * p\ 1 - p$

$N(\mathrm{i}) = (6,443) * (1.96)^2 * 0.5(1-0.5) / (0.05)2 * (6,443-1) + (1.96)2 * 0.5(1-0.5)$

= 364 house holds

4.4 Sampling procedures and Sampling Techniques

A stratified household sampling technique was used for the selection of sampling units. It was assumed that the population of Seka town and the surrounding Kebeles are a homogeneous population. Hence, it was stratified as an urban and rural stratum. A Household was located at an immediate distance from the water source selected for this study. After having a list of households and with proportional allocation methods household heads or Mother and Adult daughter were taken as a study subject.



K1 =01 kebele, K2 = 02 kebele Where Sh= shashemene

GB= Gibe Bosso HK=Hushane Koche

Figure 3:Diagrammatic Representation of sampling techniques

4.5 Inclusion and exclusion Criteria

- Household head or mother and adult daughters' age above 18 years, who is able to Speak.
- Living in Seka town/ werada in the last 6 months.

4.5.1 Exclusion criteria

- Households those no permanent resident.

4.6 Water Sample Collection and preservation techniques

All water sampling and preservation procedures were performed according to the standard methods, American Public Health Association (APHA 1998) for the Examination of Water and WHO guidelines for drinking water(WHO, 1997). Water samples had been taken from locations that were representative of the water source, storage facilities, distribution network, and points at which water was delivered to the consumer, and points of use. Water sample selected purposely. Water samples for bacteriological analysis were aseptically collected in sterilized (250 ml) glass bottles and labeled, and then the samples were kept in an ice-box and transported for testing immediately to the department of Environmental laboratory by ice cold containers within 6 hour of collection. All samples were analyzed for faecal and total coliform count using the membrane filter technique.After sterilizing all the necessary materials for faecal and total coliform enumeration 100ml water sample was filtered through the membrane filter techniques in 0.45µm of filter paper. Then, the filtrate put on absorbent pad that was dispensed with m-lauryl sulfate broth and sterilized in a petri dish. Membrane lauryl sulfate broth medium was used for bacterial growth. Finally, the samples labeled and incubated at temperature 44.5□ for faecal coliform (FC) and 37□ for total coliform (TC) in oven. The pink and yellow color CFU/100ml was counted as coliforms under magnifying lance.

Water samples for Physicochemical were collected in pre-cleaned and rinsed polythene bottles of one litre capacity with necessary precautions and prior to filling; Water samples were collected after sterilizing the taps with ignited cotton wool soaked in alcohol (Ethanol) aseptically. Then, the bottles were rinsed two to three times with the water to be collected. Temperature,Turbidity, pH, EC, DO and TDS were measured at the sites of collection with portable equipment following standard protocols. Samples were transported to the laboratory in iceboxes and analyzed immediately.

4.6.1 Types of water samples and frequency of sampling

Purposively, 13 water sampling points were selected for this study from different water sources (dug well 3, spring 3 and borehole 1) including Reservoir point 1, and distribution line point 1and at the tap water point 4. The sampling was followed triplicate sampling style. As a result the sampling frequency is 13*3.

Triplicated grab water samples, in a week time interval, were collected from 13 points representing source, storage (reservoir), distribution line and tap sampling point within the water supply system framework.

4.7 Data collectors

Data collectors were trained and oriented on how to use and administer the questionnaire; the ethical principles of confidentiality and data management; how to identify participants and referral process that would have been followed in the case of adverse events occurring during the data collection process prior to their involvement with data collection. The investigator was also selected two BSc. Experts from water engineer and technician for data collection.

4.8 Operational definition

Functional latrine - latrine with sub and superstructures and that provided services at the time of data collection even if the latrine required maintenance Andualem Anteneh, (2010).

Satisfactory Latrine utilization – households with functional latrines and the family disposed the faeces of under-five children in a latrine, no observable faeces in the compound Andualem Anteneh, (2010)

Borehole – generally used to refer to a small diameter water point constructed by drilling. Most boreholes are between 90 m and 250 m deep, but in some areas reach over 400 m deep Wash, (2020).

Improved water sources- are drinking water sources that are protected from the outside environment by concrete covers (WHO/UNICEF, 2017).

4.9 Data collection

Structured questionnaires were used to gather pertinent information on socio-demographic characteristics of the study population and water supply source, Latrine type and On site solid waste handling characteristics were used for household head, mothers and daughters above 18 years in the town and 3 selected kebele of the study area. The questionnaire were prepared originally in English and translated into Amharic and Afan Oromo language and back to English. Almost all of the study community can understand and communicate with both language. In addition, visual sanitary inspection (Source inspections) were carried out on the water source, reservoir, distribution line and tape by using

WHO drinking water survey check list by transect walking and observing around the water source area(WHO, 2011).

4.10 Water Sample collection technique for bacteriological analysis:

Samples collection for Bacteriological water samples were according to the standard procedure of WHO guideline of membrane filtration methods. A total of 13 water samples were collected from four different water sources including tap water (n = 4), protected shallow wells and Dug well (n = 3), protected springs (n = 3) and Borehole at source 1,Reservior 1 and Distribution Line 1 (n=3). Water samples were aseptically collected from each sampling site within 250ml of sterilsized glass bottles and transported to laboratory in ice box and analyzed within 6 h of sample collection.

4.11 Physicochemical analysis:

Cross sectional study were done to examine the related physico-chemical quality of drinking water at different sources.The analyses of various physicochemical parameters were carried out following the standard method (APHA,1998). The potential of hydrogen (pH) , electrical conductivity(EC), total dissolved solid (TDS) and Turbidity were measured using HI 98290 multi parameter with a HI 7639829/10 probe (HANNA Instrument, Woonsocket, RI USA) at the time of sample collection respectively.While, dissolved oxygen (DO) and Temperature were measured on site using the instrument HQ 40D portable multi parameter probe.

4.11.1 Gravimetric method of Analysis

It related with mass measurement, so that total suspended solid (TSS) was determined by gravimetric method. For TSS analysis empty filter paper was dried in the oven for one hour at a temperature 103℃ and the filter paper was cooled in desiccator and then, the initial weight of filter paper was recorded. A 150ml water sample measured and filtered using filtration apparatus and then, again putted filtered paper with TSS in the oven for one hour at 103℃ and cooled in desiccator and the final weight of filter paper with TSS was weighed and the result was calculated.

TSS mg/L = (A-B)*100/150ml, where

A = weight of filter paper with TSS

B= weight of empty filter paper

4.11.2. Volumetric/Titrimetric Methods of Analysis

It related with measurement of volume of titrant for this total hardness, calcium, magnesium and alkalinity of water samples were measured. Titrimetric method were used to measure the concentration of total water hardness and the concentrations of Calcium (Ca^{2+}) in the water samples: Total water hardness were determined by using Automatic zero biuret with 0.02N of EDTA titrant and10 drops of buffer solution was added to adjust pH of samples and small amount of EBT (Erecrom black Tablet) indicator was added to 50ml water samples and titrated until end point light blue color developed. Then, the result calculated as Total Hardness as $CaCO_3$ in mg/l = (A-B)*N*50,000/ml sample. Also calcium was determined by EDTA titrant but, 2ml of NaOH was added to adjust pH and 1N of calico (NaOH) indicator was used. Calcium (Ca^{2+}) as $CaCO_3$ in mg/l = (A-B)*N*50,000/ml sample.

Magnesium (Mg^{2+}) concentration were determined by difference between the analysis of Total Hardness and Calcium ($Ca^{2+)}$. Alkalinity of water samples were determined by acid titrimetric method, with 0.02N of H_2SO_4 titrant and by adding 4 drops of phenolphthalein and mixed bromo cresol green indicator to 50ml samples.

4.11.3 Colorimetric (Spectrophotometric) method of Analysis

It related with color or Absorbance; Iron (Fe), Manganese (Mn) , Nitrate as NO_3-N and Phosphate as Ortho-phosphate were determined/ measured by spectrophotometric method of model number DR 5000 (HACH LANGE) with Quartz cuvette (QS 1.000).

Water samples were analyzed for presence of Iron and Manganese using with color or Absorbance by spectrophotometric method . Accordingly, 50 ml of the water samples were mixed with 2ml concentrated HCl in flask and 1ml hydroxylamine hydrochloride solution was added and mixed. Also, for controlling pumping a few glass beads were added and the solution boiled until the volume reduced 15-20ml then cooled and transferred to 100ml measuring cylinder and adjusted to 100 ml with de-ionized water. Finally, to the sample 10ml acetate buffer solution was added and mixed thoroughly and after 15 minute read the concentration and orange red color already developed for analysis of iron. For Manganese to 50ml sample 5ml special reagent solution added and mixed, then boiled until the volume reduced to 45ml. 1gm ammonium per sulfate added and transferred to 50ml measuring cylinder and diluted to 50ml mark pink to purple color developed. For nitrate analysis 20ml sample was obtained filtered by filter paper and ignited with prey weighed and labeled crucible until the crucible gets empty. Then the crucible cooled and 2ml phenol di sulfonic acid was added and then the residual rubbed using glass road. For neutralizing 20ml distilled water was added and then, 7ml of concentrated NH_4OH ammonia solution was added. Finally the content was transferred into 50ml measuring cylinder and diluted to 50ml mark. As a result, the concentration of Iron, Manganese and Nitrate as NO3-N in each sample were measured using spectrophotometric method of model number DR 5000 (HACH LANGE) with Quartz cuvette (QS 1.000).

Table 1:Standard methods of sample analysis

Parameter	Method	APHA(1998) number
pH, EC, TDS and Turbidity	HI 98290 multi parameter	Digital pH-meter, Digital Conductivity-meter
Dissolved solid (DO)	HQ 40D portable multi parameter probe	Winkler method (DO meter)
Temperature	HQ 40D portable multi parameter probe	Thermometer
Total Alkalinity	Volumetric method	Titrimetric method (With HCl)
Total Hardness	Volumetric method	EDTA titrimetric method
Ca^{+2}	Volumetric method	EDTA titrimetric method
Mg^{+2}	Volumetric method	EDTA titrimetric method
Mn	Persulfate method	Colorimetric Method
Fe	Phenanthroline method	Colorimetric Method
Nitrate (NO_3^-N)	Phenol di-sulfonic Acid method	Spectrophotometric method
Total Suspended Solids	Gravimetric method dried at 103-105ºC	method 2540 D
Phosphate	Gravimetric method	Mass measurement

4.12 Bacteriological Analysis

The samples were analyzed for total coliform(TC) and faecal coliform(FC) using the membrane filter technique. After all the necessary materials were sterilized 10ml of water sample from each sampling site were diluted to 90ml sterilized distilled water mixed thoroughly to made 100ml and placed on the surface of a sterile and gridded membrane filter with pore size 0.45µm and 47mm diameter placed on funnel unit of the membrane filter support assembly. The filtration was facilitated by applying a vacuum pump and the assembly was rinsed with hot plate water.Then, the membranes were placed in a small Petri dish containing an absorbent pad soaked in 2ml sterilized M-Lauryl Sulfate Broth. Finally, the cultures were labeled and Petri dishes were incubated at temperature desired, (at 44.5 for fecal coliform within 24 to 48hrs and at 37 for total coliform within 18 to 24hours). The number of colonies formed on the media with expected color change were reported as colony forming units (CFU) per

100ml of samples. Finally, the total and fecal coliform qualities of water were reported based on the WHO and ESDWQ standards. Furthermore,Confirmatory test on EMB Agar, presence of Escherichia coli was confirmed by streaking loopful of broth culture onto Eosine Methylene Blue (EMB) agar and evaluating for the formation of metallic sheen color, a positive test for presence of E. Coli.The lactose Broth with in dole red were mixed up for complete test and a colonies were randomly picked from countable plates of PCA and Mac Conkey agar and inoculated into 5 ml nutrient broth drum tubes followed by incubation at 37 for 24hour a color change from reddish to yellow indicates that the presence of e-coli in the water sample followed by kovac's reagent test. Formation of red ring shows that kovacs positive test for presence of E-coli.

4.13. Data Analysis

The data was entered using Epi-data version 4.604 data entry software. Data analysis were carried out by SPSS version 23. Descriptive statistics, one way ANOVA and Correlation analyses were also performed between some selected water physico-chemical parameters and bacterial content of the water samples. logistic regressions will performe to estimate some of important variables .Water samples were compared with the set standards (WHO guide lines for drinking water quality) and interprete as acceptable or unacceptable. The significances of differences within samples were determined based on calculated coefficient of variation (% CV). Mean separation between samples categories were computed using one-way ANOVA. The parameters were correlated against each other to determine their relationship using Pearson's correlation. All variables at P-value of ≤0.25 in the bivariate analysis were included in the multivariable logistic regression model. Finally, all variables with P-value of ≤0.05 were considered statistically significant as predictor factors.

4.14 Ethical consideration

Ethical clearance was obtained from the college of public health of Jimma University ethical committee. After thoroughly discussing the ultimate purpose and method of the study, a written informed consent was obtained from the study participants during data collection. The privacy and confidentiality were maintained during the interview. Participation in the study was based on willingness and the participants had the full right not to participate.

4.15 Analytical quality assurance and quality control

Standard methods for drinking-water analysis was tested under local condition for accuracy and precision, agreed at national level, and applied universally by both water-supply and regulatory agencies. Analytical quality assurance comprises all the steps taken by a laboratory to assure those who receive the data that the laboratory is producing valid results.

All chemicals used had a high purity and analytical grade. Fresh reagents were used and great care was taken to avoid chemical contamination.

4.16 Limitation of the study

Due to various reasons, the following limitations were observed. Drinking water quality assessment and analysis usually cover the sources, the reservoir (disinfection point), tap (point of use), and the storage container. In this study, even though assessment was performed at sources, reservoir, distribution line and tap water point, since the water sample was not obtained from household storage container, which should had been used to identifying statistically significant relation between household water handling practices and behavioral factors which used to evaluate and find out the possible source of contamination at household level was limited. In addition, since there was no chlorination, residual chlorine was not checked. Moreover, self-administered questionnaires usually bias the results.

CHAPTER FIVE

RESULT AND DISCUTION

5. RESULT

5.1 Socio-demographic characteristics of the study participant

From the total 364 participant's households, 195(53.6%) were urban residents and 169(46.4%) were rural residents. The majority 206(56.6%) of respondents' age group were between 31 and 50 years. The mean family size of the respondent household was 5.13 with SD ± 2.116. Most of the respondents 332(91.21%) were married and majority of participants 198(54.4%) were Muslims. About 309(84.89%) of participates were belongs to Oromo ethnicity and 276(74.2%) of the participants were passed in different form of educations whereas, 88(24.8%) of the participants were illiterate. In addition, about 129(35.4%) participants were farmers and majority 265 (72.8%) participants were got less than 10,000 annual income.

Table 2: Socio-demographic characteristics of study participant in seka chekorsa Jimma zone south west Ethiopia 2021.

Variables	Frequency(n=364)	Percentage (%)
Residence		
Urban	195	53.60
Rural	169	46.40
Age		
18-30	87	23.9
31-50	206	56.6
>50	71	19.5
Martials status		
married	332	91.21
single	7	1.92
Divorced	7	1.92
widowed	18	4.95
Religion		
Muslim	198	54.4
Orthodox	124	34.1
Protestant	42	11.5
Ethnicity		
Gurage	13	3.6
Amahara	10	2.7
Oromo	309	84.9
Dawuro	13	3.6
Kefa	11	3.0
Other	8	2.2
Educational level		
illiterate	88	24.2
Only read and write	43	11.8
Grade 1 to grade 4	48	13.2
Grade 5 to grade 8	64	17.6
Grade 9 to grade 10	31	8.5
Grade11 and grade12	18	4.9
>Grade 12+	72	19.8
Occupation		
Government employee	77	21.2
merchant	97	26.6
student	10	2.7
Farmer	129	35.4
Day labored	42	11.5
other	9	2.5
Annual Income		
< 10,000	255	70
In 101,000-20,000	96	26.4
>20,000	13	3.6

5.1.1 Water source condition of respondents

From the total 364 respondents, households were using different water sources; the majorities 322(88.5 %) have been using from borehole/ drilled well and spring water sources, while the rest was relying on Dug wells sources 42(11.5 %). In addition 195 (53.6 %) of urban/town populations was used tap water for domestic's purposes. As a result, 312(85.4%) of them were travelled less than or equal to1km distance to get water and 52(14.6%) were travelled greater than 1km.So that, 314(86.5%) of them were travelled less or equal to 30 minute to fetch water and 50(13.5%) were travelled greater than 30 minutes. Almost all of the respondents were used plastics containers for water collection and those store water in the home were also used plastics storage. More than half, 199(54.67%) of the respondents were collected water once round time per day. From the respondents about 225(61.81%) clean water storage container, of which 165 (73.3%) were cleaning water collection materials with water and detergents and (26.7%) were cleaned with water only. Furthermore, 305(83.8%) were used the water containers which had cover and 362(99.5%) were got water from containers by pouring and the rest were got by dipper with handle. Only 40(10.99 %) of the respondents were treat water to drinking in household level by filtration and boiling method, while the majority 324(89.01%) were drink water without treatment.

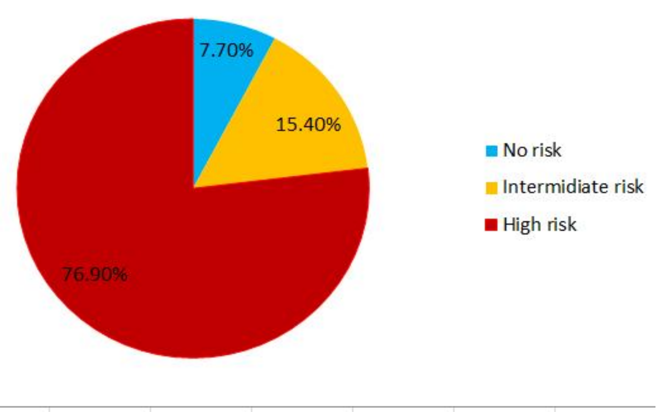
Table 3: Sources of Water Supply for study participant in seka chekorsa Jimma zone south west Ethiopia 2021.

Variables	Frequency (n=364)	Percentage (%)
Type of water source		
Dug Well	42	11.5
Tap/ Deep well	195	53.6
Spring	127	34.89
Time taken to fetch water		
≤ 30 min	315	86.54
≥30 min	49	13.46
Volume of water fetched per day		
< 25L	134	36.8
25-45L	194	53.3
>45L	36	9.9
Round trips to fetch water		
Once	199	54.67
Twice	138	37.91
Three times	27	7.42
Length of water storage		
D ly	311	85.43
Twice a week	35	9.6
Three times a week	17	4.67
Other	1	0.3

Type of water collection container		
Plastic	364	100
Clean collection container		
Yes	364	100
No	0	0
Method of water cleaning		
With water only:	50	13.74
With water and detergent	314	86.26
Frequency Daily	77	21.15
Twice a week	134	36.81
Three times a week	140	38.47
Others	13	3.57
Type of storage container		
Plastics	363	99.7
Metal	1	0.3
Clean storage container		
No	139	38.19
yes	225	61.81
Methods of cleaning storage		
water only	60	26.67
water and detergent	165	73.33
Frequency of storage cleaning		
Daily	57	25.33
Twice a week	121	53.78
Three times a week	43	19.11
Others	4	1.78
Container have cover		
No	59	16.2
yes	305	83.8
Get water from the container		
Pour from container	362	99.45
Dipper with handle	2	0.55
Water treatment		
No	324	89.01
Yes	40	10.99
Method of treatment		
Filtering	36	90
Boiling	4	10

The level of faecal contamination at sources of drinking water was determined as no risk of contamination 1/13(7.7%0, intermediate risk level 2/13(15.4%) and high risk level was 10/13 (76.9%)

Faecal contamination risk level of sampling sites



5.1.2 Excreta Management practices of the participants

Excreta management of the respondents indicates that 248(68.1%) were had a latrine, and of which 128(51.6%) have been used traditional pit latrine and 113(45.6%) was used ventilated improved pit latrine while the reset 7(2.8%) have been used pour flush latrine. In addition, 207 (83.5%) of the household latrine were functional with no need of maintenance and the reset 41(16.5%) were functional but, need maintenance. However, only 116 (31.9%) of respondents were reported as there was fly and odor problem and majority 248(68.1%) were not reported. Therefore, majority of the respondents 248(68.1%) were cleaned latrine and only 116 (31.9%) were not cleaned the latrine. From, these clean latrine 133 (45.6%) respondents were clean latrine twice a week. Furthermore, from all respondents cleaned latrine were practicing hand washing after cleaned the latrine with water and using detergent. About, 193(53%) respondents travelled less than 6 meter between living unit and latrine. The distance between latrine and drinking water sources for 193(53%) respondents were between 100m-1000m far apart.

Table 4: Excreta Management practice of study participant in seka chekorsa Jimma zone south west Ethiopia 2021

Variables	Frequency (n=364)	Percentage (%)
Availability of a latrine		
No	116	31.9
yes	248	68.1
Types of latrine	128	51.6
Traditional pit latrine	113	45.6
Ventilated Improved Pit L	7	2.8
Pour flush latrine		
The status of latrine		
Functional, no need maintenance	207	83.5
Functional but need maintenance	41	16.5
Fly and odour problems of facility		
No	228	68.1
yes	116	31.9
Clean the latrine		
No	116	31.9
yes	248	68.1
Frequency cleans a latrine		
Daily	42	17.3
Twice a week	133	45.6
three times a week	84	33.9
other	62	25
Use water and detergent to clean the latrine		
No	116	31.9
yes	248	68.1
Wash hands by water and detergent after cleaning	116	31.9
No	248	68.1
yes		
Distance between latrine and water sources		
< 100m	157	43.2
100-1000m	193	53.0
> 1000m	14	3.8
Distance between latrine and living unit		
< 6m	193	53.0
6-20m	162	44.5
> 20m	9	2.5

5.1.3 Onsite handling and storage of domestic solid waste

From the total 364 respondents the majority 235 (64.56%) were used solid waste storage container and most of the participants 220(93.62%) were used sacks for solid waste storage and only 24(10.21%) can clean solid waste storage containers. Also, 25(6.87%) of the participants were used solid waste recovery as fertilizer and energy sources and out of which 20(80%) were decomposable. From the respondents 165(45.33%) were practicing open dumping solid waste disposal facility.

Table 5: Onsite handling and storage of domestic solid waste of study participant in seka chekorsa Jimma zone south west Ethiopia 2021

Variables	Frequency(n=364)	Percentage (%)
Solid waste storage container		
No	129	35.44
Yes	235	64.56
Solid waste container type		
Tin	3	1.28
plastic bag	12	5.11
Sack	220	93.62
Clean solid waste storage container		
No	211	89.79
Yes	24	10.21
Cleaning solid waste storage container		
Once in a week	11	45.83
Twice in a week	12	50
Every two weeks	1	4.17
Ways of storage container cleaning		
water only	13	54.17
water & detergent	11	45.83
Condition of solid waste storage area		
No splash of solid waste	207	88.09
there is splash of solid waste	23	9.79
not overfilled	4	1.7
Other	1	0.43
Responsible to collect and disposal		
Municipal	195	33.19
rural health extension	169	64.68
Frequent is solid waste collected		
Once in a week	78	33.19
Twice in a week	152	64.68
Other	5	2.13
Recovery or reuse as solid waste		
No	339	93.13
Yes	25	6.87
solid waste part recovered or reused		
decomposable	20	80
Dry	2	8
Food remains	3	12
The purpose of solid waste recovery/ reuse		
Fertilizer	17	68
for energy	5	20
Animals food	3	12
Methods of solid waste disposal facility		
Composting	20	5.49
Refuse pit	68	18.68
Open dumping	165	45.33
Backyard	76	20.88
Other	35	9.62
Distance disposal facility from living unit		
< 100m	210	57.7
100-1000m	144	39.6
> 1000m	10	2.7
Distance disposal facility from water supply source		
< 100m	41	11.3
100-1000m	299	82.1
> 1000m	24	6.6

5.2 Determination the level of Bacteriological quality of Drinking Water Sources

5.2.1 Presence of Total Coliform in water samples

The total coliform indicators bacteria loading water quality value of samples from different sources of the study area was calculated as log (CFU/100ml). The total coliform value of each sampling point and similar water sources were recorded. Based on the output of the analysis results, the mean and standard deviation of spring, dug well and borehole sources including tap point, reservoir and distribution line point was 3.126± 0.0889, 2.38 ± 0.2940, 3.798± 0.0166 and 3.7393 ± .00902, 4.340± .020 and 3.340± .040 respectively. As a result, the maximum value was observed at the reservoir sampling point (4.340± .020 log CFU/100ml) and the minimum value was recorded in an improved dug well (2.38 ± 0.2940, in log CFU/100ml) relatively to the others site. There was no significant variation between water samples sites obtained from different water sources, that was %CV< 10, but there was statically significant variation within borehole sources and all tap sampling points with the %CV was > 90 and among spring and dug well sources with %CV >90.

Multiple Comparisons

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Total Coliform	Tukey HSD	Borehole		-.600000*	.056870	.000	-.80667	-.39333
			Reservoir	1.066667*	.056870	.000	.86000	1.27334
			Spring o3	.556667*	.056870	.000	.35000	.76334
			Spring 04	.906667*	.056870	.000	.70000	1.11334
			Dug Well05	.220000*	.056870	.029	.01333	.42667
			Spring 06	.400000*	.056870	.000	.19333	.60667
			Dug well 07	2.290000*	.056870	.000	2.08333	2.49667
			Dug well 08	-.080000	.056870	.964	-.28667	.12667
			Tap 09	0.000000	.056870	1.000	-.20667	.20667
			Tap 10	-.079667	.056870	.965	-.28634	.12700
			Tap 11	.400000*	.056870	.000	.19333	.60667
			DL 12	-.073000	.056870	.982	-.27967	.13367
			Tap 13	-0.073	0.05687	0.982	-0.27967	0.13367

*. The mean difference is significant at the 0.05 level.

Where, DL, was distribution line point

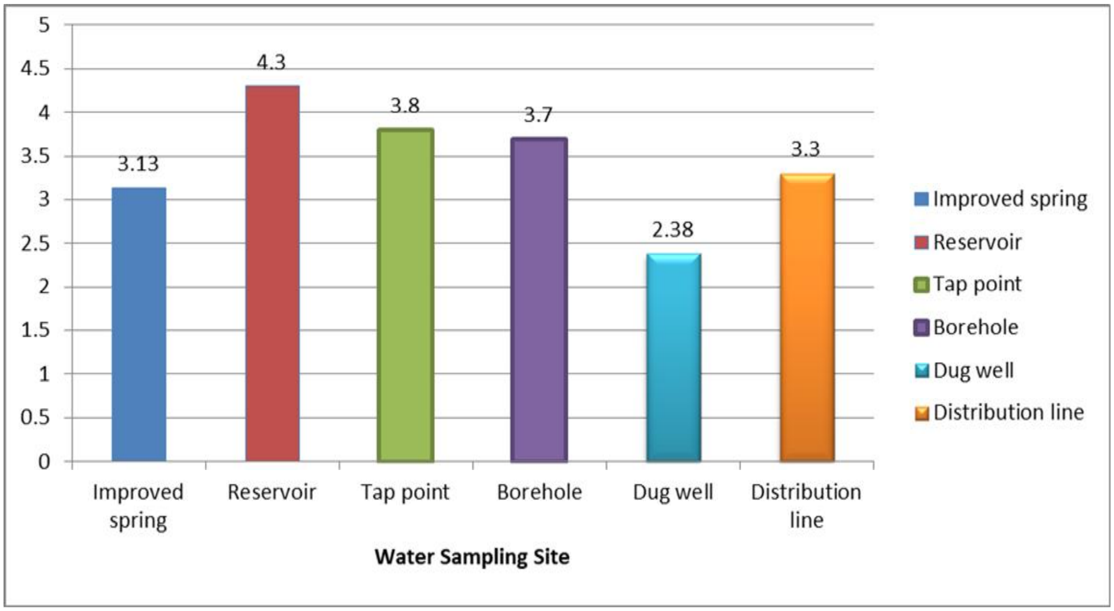


Figure:-1 Bacteriological/ total coliform Analysis of water sampling site.

5.2.2 Level of faecal contamination of drinking water sources

Faecal coliforms were thermo tolerant coliform organisms that incubated at 44.5 and observed coliform with pink color and count by using glass. So that, the analysis result of mean and standard deviation of water samples sources and sampling point of faecal coliform bacterial count for borehole, spring, dug well water sources and tap point, reservoir and distribution line sampling point were recorded. Based on the value, the maximum faecal coliform contamination result was recorded at the reservoir sampling point (4.25 ± 0.0025) as log CFU/100ml). The intermediate level of contamination by faecal coliform values was recorded at one Dug well and two spring water sources, distribution line and two tap water sampling point (1.67 ± .05716, 1.59 ± .10967, 1.36 ± .10392,1.3 ± 0.3 and 1.48 ± .43475, 1.286 ± 1.12355 as log CFU/100ml) respectively. The level of faecal contamination was zero / minimum at one dug well (08) sampling point. There was no statistically significant mean variation among different water sources obtained from different sampling point with %CV < 10, but except within sampling point of borehole and reservoir as well as borehole and one dug well(07), which had statically significant mean variation with %CV > 90 and %CV > 10 respectively .

Multiple Comparisons

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Faecal Coliform	Tukey HSD	Borehole	Reservoir	-.506333	.383088	.977	-1.89849	.88582
			Spring o3	2.379333*	.383088	.000	.98718	3.77149
			Spring 04	2.146333*	.383088	.000	.75418	3.53849
			Dug Well05	2.073333*	.383088	.001	.68118	3.46549
			Spring 06	1.712667*	.383088	.007	.32051	3.10482
			Dug well 07	1.276667	.383088	.095	-.11549	2.66882
			Dug well 08	2.972667*	.383088	.000	1.58051	4.36482
			Tap 09	2.972667*	.383088	.000	1.58051	4.36482
			Tap 10	2.453667*	.383088	.000	1.06151	3.84582
			Tap 11	1.976000*	.383088	.001	.58384	3.36816
			DL 12	2.439333*	.383088	.000	1.04718	3.83149
			Tap 13	2.257667*	.383088	.000	.86551	3.64982

*. The mean difference is significant at the 0.05 level.

Where, was DL distribution line.

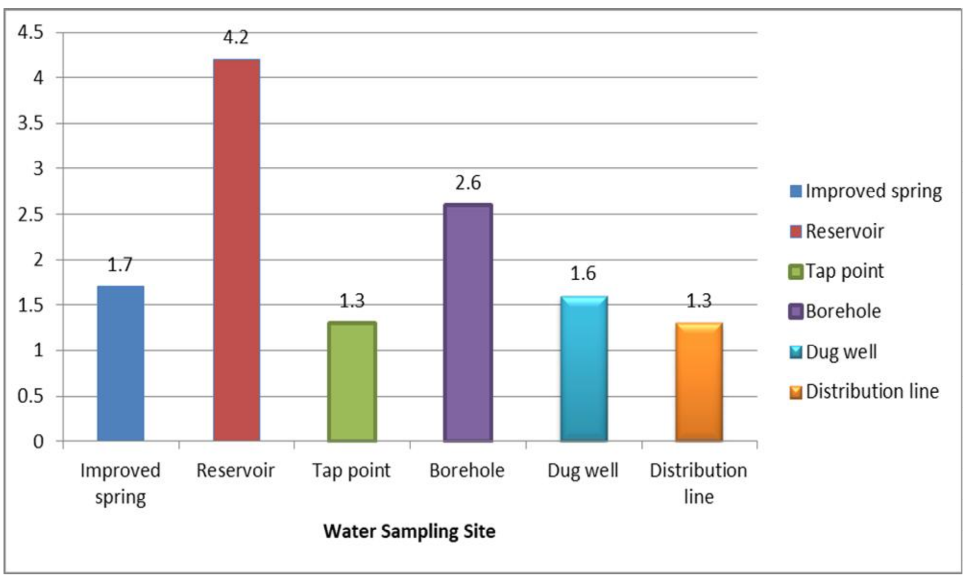


Figure: - 2 Bacteriological/ faecal coliform Analysis of water sampling site.

5.3 Physicochemical Analysis of drinking water quality parameters

The analysis result of physicochemical parameters of water sample chemical concentration from different sources was recorded as mean and standard deviation (Mean ± SD) of the current study and WHO recommended value was presented in table (6).

5.3.1 Temperature

The recorded value temperature of water samples from improved springs, improved dug well and Borehole sources including at tap point, reservoir and distribution line sampling point were 22.6± 0.100, 22.33±.252 and 22.73±0.96. The value temperature of different water sources almost similar, but the highest/ maximum temperature value recorded at the reservoir sampling point (24.7□) and the lowest temperature value were recorded at tap sampling point TW11 and TW13 (21.9□) and the range was 21.9□-24.7□.There was no statistically significant variations were observed among the different water samples collected from borehole and all spring sources and dug well sampling points. Temperature had no correlation with all parameters except manganese ion.

5.3.2 Turbidity

The value of turbidity for water samples from different sources and sampling points of improved spring, improved dug well and tap point with its source, reservoir and distribution line as 2.93±2.54 NTU, 4.83±2.65NTU and 15.21±4.46NTU were recorded respectively. Depend on observed value tap sampling point had the maximum value was recorded (19.8 NTU). The lowest value was recorded in improved spring at one sampling point PS 03 zero value or minimum result was recorded. There was statistically significant variations were observed among the water samples sites collected from different sampling points ($p < 0.05$), but there was no significant variations within the similar sources. Turbidity had correlation with all parameters except temperature and manganese ions.

5.3.3 PH

The pH value of water samples for spring, dug well and Borehole sources with tap point, reservoir and distribution line sampling point were (6.2± 0.100, 6.06± 0.061 and 6.69±0.333) respectively. So that the analyzed water samples value from tap point with source, reservoir and distribution line were recorded highest and the maximum result observed at sampling point of reservoir (7.07) this indicates tap sampling point (46.2%) of overall samples pH were in the range of WHO and national standard which is (6.5-8.5).Whereas the mean value in dug wells were lowest and the minimum value observed at sampling point DW 08(6.01) and the overall range of pH was (6.01-7.07). Statistically significant variations were observed among the water samples sites collected from twelve different sampling points ($p < 0.05$), but at one sampling point reservoir there was no significant differences ($p > 0.05$) and %CV< 10,and between different sources. The pH of water samples had correlation with all parameters except dissolved oxygen and Iron ions concentration.

5.3.4 Electrical Conductivity (EC)

The value of electrical conductivity (μS/cm) for tap point, dug well and spring were (367.86± 6.414, 167± 82.82 and 123.33±34.020) respectively. In this study the maximum value were recorded at the sampling point of borehole source /BH01 (380 μS/cm). In addition, the lowest value were recorded in spring sources at the sampling point of spring (PS04) (90 μS/cm) and 100% water sample were met the acceptable level of WHO standard which is 1000 μS/cm. There was a statistically significant difference ($P < 0.05$) among value of electric conductivities of different water sampling point, but not significant within sampling point of tap point and dug well (07) with spring (04) ($p>0.05$). The EC of water samples had correlation with all parameters except temperature and Iron ions concentration. In general, electrical conductivity was decreasing from source to reservoir, distribution line and tap sampling points.

5.3.5 Total Dissolved Solid (TDS)

The highest/ maximum value of total dissolved solid (TDS mg/L) was also recorded in borehole source sampling point (191±1mg/L). The lowest/ minimum value was recorded in improved spring 04 (45±2mg/L) which is in the range of the minimum allowable limit (300 mg/L) or in the range of acceptable levels as recommended by (WHO, 2006). All the samples 100% were less than 500mg/L TDS value in drinking water which indicates that the pot ability of water samples and it's good for the consumers. There was a statistically significant difference ($P < 0.05$) among the value of TDS in different water sampling point, but not significant within sampling point borehole and reservoir, within tap water and distribution line. The TDS of water samples had correlation with all parameters except temperature and Iron ions concentration. In general, TDS was decreasing from source to reservoir, distribution line and tap sampling points.

5.3.6 Dissolved Oxygen (DO)

The maximum value of DO (mg/L) concentration was recorded in tap sampling point (5.21±0.01,). Whereas, the minimum value of DO, was recorded in an improved spring water source sampling point (1.71±0.01). There was a statistically significant difference ($P < 0.05$) among value of DO in different water sampling point, except borehole and spring (03) and dug well(08) and tap water(TW2).The DO was statistically significant within the same sampling points ($P < 0.05$). The DO of water samples had correlation with EC, TDS, turbidity and TSS. In general, DO was increasing from source to reservoir, distribution line and tap sampling points within water supply network.

5.3.7 Total Hardness

The value of total hardness recorded in borehole with tap point, reservoir and distribution line, improved dug well and improved spring were analyzed. The highest/ maximum value recorded improved dug well (05) sampling point (98±1.0mg/L) and the lowest/ minimum value was in improved spring (24±1mg/L). Therefore, the analysis result of all water sample 100% within the range of permissible limit of WHO and ES standard for total hardness 300mg/L. There was a statistically significant difference ($P < 0.05$) among the value of total Hardness in different water sources. In general, total hardness was decreasing from source to reservoir, distribution line and tap sampling points within water supply network.

5.3.8 Calcium and Magnesium ions

The value calcium ions in borehole source with tap point, reservoir and distribution line, improved dug well and improved spring were recorded as mg/L. The maximum value of calcium ion concentration was recorded in improved dug well (05) (62±1.0) and the minimum value were recorded at improved spring (04) (15±3.0). Magnesium the maximum value was recorded at reservoir sampling point (44±0.00) and the minimum value was at, improved spring 04, (9±2.0). Based on the analyzed result, for calcium and magnesium all (100%) of water sample were within the permissible limit of WHO and ES national standard. There was a statistically significant difference ($P < 0.05$) among the value of Ca^{+2} and Mg^{+2}ions in different water sources except at one dug well for Mg^{+2} ions. In general, calcium ions were slight decreasing from source to reservoir, distribution line and tap sampling points within water supply network.

5.3.9 Alkalinity

The value for alkalinity of water samples were recorded borehole with tap point, reservoir and distribution line, improved dug well and improved spring were recorded as mg/L CaCO3. The highest/ maximum value was recorded in reservoir and tap point11, (148±2.0mg/L). The minimum value of alkalinity was recorded in improved spring (04) and improved dug well 08, (4.00± 2mg/L). There was a statistically significant difference ($P < 0.05$) among the value of alkalinity in different water sources. In general, alkalinity was variability from source to reservoir, distribution line and tap sampling points within water supply network.

5.3.10 Total Suspended Solid (TSS)

The value of TSS (mg/L) concentration of borehole, spring and dug well water sources were recorded. The highest/ maximum value was observed at tap water (53.335±10.67) and the minimum value was recorded in improved spring sources (12.67±6.665). There was a statistically significant difference ($P < 0.05$) among value of TSS different water sources, but not statistically significant within similar sampling points. The TSS of water samples had correlation with all parameters except temperature and Iron ions concentration.

5.3.11 Phosphate and Nitrate

Phosphate ion analysis result value of water sample sources and sampling point for tap point with source, reservoir and distribution line, improved dug well and improved spring were recorded The maximum value was recorded at improved spring 03, (2.98±0.0125) and the minimum value was recorded at improved dug well 05, (0.25± 0.01). The analyzed result indicates about (92.3%) water samples within the acceptable limit as recommended by WHO and ES national standard for drinking water 2mg/L, but, at one improved spring 03 water sampling point was above the limit. Similarly, Nitrate as (NO3-N) the concentration value recorded in improved spring, improved dug well and borehole sources, reservoir and distribution line and tap point. The value analyzed for nitrate concentration of all water sampling point was very low and met the acceptable limit of WHO and ES national standard 45 and 50 respectively. There was a statistically significant difference ($P < 0.05$) among the value of nitrate in different water sources, except for dug well, and phosphate had a statistically significant difference ($P < 0.05$) among the value of different water sources, but had no within significant at one sampling point.

Table 2: The analysis of physicochemical and Bacteriological parameters of different water sources and sampling point of Seka woreda 2021

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Standards for Comparison	
							WHO	ESD
Total coliform	39	3.060	1.300	4.360	3.35482	.709351	0CFU/100ml	0CFU/100ml
Fecal coliform	39	4.248	0.000	4.248	1.82236	1.090455	0CFU	0CFU
pH	39	1.08	6.00	7.08	6.4331	.37112	6.5-8.5	6.5-8.5
EC(µS/cm)	39	292.00	89.00	381.00	265.0769	119.00031	750	1500
TDS in (mg/L)	39	149.00	43.00	192.00	132.7692	59.68534	500	1000
Turbidity(NTU)	39	19.90	0.00	19.90	9.3154	6.24465	5	5
DO in (mg/L)	39	3.52	1.70	5.22	2.7585	.87104	5-7	-
Temprature(□)	39	3.20	21.60	24.80	22.6077	.70240	25	-
TotalHardnessas $CaCO_3$in (mg/L)	39	77.00	23.00	100.00	66.77	24.20685	300	300
Ca^{+2}(mg/L)	39	51.00	12.00	63.00	35.23	13.41143	100	70
Mg^{+2}(mg/L)	39	39.00	7.00	46.00	31.54	12.10436	50	50
Alkalinity mg/L)$CaCO_3$	39	148.00	2.00	150.00	93.5385	61.35052	120	200
TSS in mg/L	39	58.00	6.00	64.00	27.9236	13.32005	-	-
NO3-N in mg /L	39	2.760	.240	3.000	.86710	.775208	45	50
Phosphate	39	.361	.069	.430	.04709	.104273	2	2
Iron	39	1.570	.200	1.770	.22462	.447985	0.3	0.3
Manganese	39	.170	.030	.200	.73192	.043218	0.05-0.1	0. 5
N	39							

Table 3 Significant variation between and within samples sites categories of physicochemical Analysis of water sample of different samples sites in Seka Chekorsa wereda/district in (2021)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	5.203	12	.434	373.315	.000
	Within Groups	.030	26	.001		
	Total	5.234	38			
EC	Between Groups	538070.769	12	44839.231	23316.400	.000
	Within Groups	50.000	26	1.923		
	Total	538120.769	38			
TDS	Between Groups	135318.923	12	11276.577	5863.820	.000
	Within Groups	50.000	26	1.923		
	Total	135368.923	38			
Turbidity in(NTU)	Between Groups	1479.891	12	123.324	1648.550	.000
	Within Groups	1.945	26	.075		
	Total	1481.836	38			
DO	Between Groups	28.828	12	2.402	17112.219	.000
	Within Groups	.004	26	.000		
	Total	28.831	38			
Temperature	Between Groups	18.028	12	1.502	54.250	.000
	Within Groups	.720	26	.028		
	Total	18.748	38			
Total Hardness as CaCO3	Between Groups	22194.923	12	1849.577	728.621	.000
	Within Groups	66.000	26	2.538		
	Total	22260.923	38			
Calcium ion	Between Groups	6768.923	12	564.077	222.212	.000
	Within Groups	66.000	26	2.538		
	Total	6834.923	38			
Magnesium ion	Between Groups	5421.692	12	451.808	94.734	.000
	Within Groups	124.000	26	4.769		
	Total	5545.692	38			
Alkalinity as CaCO3	Between Groups	142923.692	12	11910.308	2977.577	.000
	Within Groups	104.000	26	4.000		
	Total	143027.692	38			
TSS mg/L	Between Groups	6138.833	12	511.569	22.048	.000
	Within Groups	603.267	26	23.203		
	Total	6742.100	38			
NO3–N	Between Groups	22.828	12	1.902	5909.650	.000
	Within Groups	.008	26	.000		
	Total	22.836	38			
Phosphate	Between Groups	.013	12	.001	950.388	.000
	Within Groups	.000	26	.000		
	Total	.013	38			
Iron concentration	Between Groups	.410	12	.034	296.036	.000
	Within Groups	.003	26	.000		
	Total	.413	38			
Manganese concentration	Between Groups	7.624	12	.635	8471.423	.000
	Within Groups	.002	26	.000		
	Total	7.626	38			

5.3.12 Iron and Manganese

The value of analysis for iron test in water samples from different sources were recorded in spring, dug well and borehole source with tap point its, reservoir and distribution line. As a result, the maximum value was recorded in improved dug well 08, (1.76±0.01mg/L) 1.76mg/L and the second largest value was observed in tap sampling point of TW 09 was 1.42mg/L. The minimum value iron ion for this study was recorded in improved dug well (05) source (0.205±0.005 mg/L). There was a statistically significant difference ($P < 0.05$) among mean Iron ions of different water sources and sampling point. The iron ions of water samples had no correlation with all parameters except turbidity.

The analysis value for manganese ion concentration were recorded in borehole, tap point with, reservoir and distribution line, improved dug well and improved spring. From the analyzed values maximum result was recorded in reservoir sampling point, (0.19±0.01 mg/L), whereas the minimum value was recorded in improved spring06, (0.05±0.02 mg/L). The analyzed result indicates about (69.23%) water samples were above the acceptable limit as recommended by WHO standard for drinking water (0.05- 0.1) mg/L and 30.77% of water samples were within the WHO standard acceptable limit.

Table 6: Correlations between physicochemical Water quality parameter

Correlations

	pH	EC	TDS	Turbidity	DO	Temprature	TH	Ca+2	Mg+2	Alkalinity	TSS	Nitrate	PO3−	Fe	Mn
pH	1														
EC	.742**	1													
TDS	.743**	1.000**	1												
Turbidity	.482**	.723**	.723**	1											
DO	-.125	.378*	.376*	.403*	1										
Temprature	.523**	.147	.147	-.120	-.157	1									
Total Hardness	.597**	.908**	.909**	.522**	.332*	.069	1								
Ca2+	.459**	.778**	.779**	.406*	.278	-.043	.955**	1							
Mg2+	.687**	.956**	.956**	.596**	.358*	.185	.944**	.802**	1						
Alkalinity	.714**	.972**	.972**	.681**	.333*	.127	.940**	.846**	.944**	1					
TSS	.363*	.553**	.554**	.622**	.591**	.128	.532**	.460**	.555**	.539**	1				
NO3-NH4	-.454**	-.672**	-.673**	-.573**	.029	-.059	-.687**	-.638**	-.667**	-.688**	-.389*	1			
PO43−	.727**	.832**	.833**	.830**	.190	.087	.759**	.689**	.755**	.800**	.670**	-.732**	1		
Fe	-.159	.134	.133	.355*	.300	-.246	-.015	-.142	.128	.002	.170	-.200	.117	1	
Mn	.621**	.519**	.521**	.198	-.289	.356*	.576**	.573**	.518**	.545**	.047	-.602**	.519**	-.302	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5.4 Association between physicochemical and bacteriological Water quality parameter

The correlation analysis result of the current study indicates that total coliform was positively correlated with pH, electrical conductivity, TDS, turbidity and temperature with value of (r=0.643, r=0.589, r=0.588, r=0.505 and r=0.362 respectively). But, total coliform did not had a correlation with DO and TSS (r= 0.094 and 0.302 respectively) since p > 0.05. Faecal coliform also had a positive correlation with pH and temperature with r value of (0.611and 0.719 respectively) and also had negative correlation with DO with value of -0.321). So that, in both cases faecal coliform were had p-value (p < 0.05). But faecal coliform did not had a correlation with EC, TDS, turbidity and TSS since p- value (p >0.05).

Table 4: Correlation between physicochemical and bacteriological parameters of drinking water sampling point in Seka woreda/ district 2021

Correlations

	TC	FC	pH	EC	TDS	Turbidity	DO	Temprature	Alkalinity	TSS	Nitrate	PO_{43}-
TC	1											
FC	.593**	1										
pH	.643**	.635**	1									
EC	.589**	.226	.742**	1								
TDS	.588**	.227	.743**	1.000**	1							
Turbidity	.505**	.080	.482**	.723**	.723**	1						
DO	.094	-.292	-.125	.378*	.376*	.403*	1					
Temprature	.362*	.702**	.523**	.147	.147	-.120	-.157	1				
Alkalinity	.684**	.287	.714**	.972**	.972**	.681**	.333*	.127	1			
TSS	.302	.211	.363*	.553**	.554**	.622**	.591**	.128	.539**	1		
NO_3-N	-.335*	-.157	-.454**	-.672**	-.673**	-.573**	.029	-.059	-.688**	-.389*	1	
PO_4^{3-}	.456**	.336*	.727**	.832**	.833**	.830**	.190	.087	.800**	.670**	-.732**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5.5 Sanitary risk factor Assessment at source, Reservoir, Distribution line and Tap point

The result from sanitary inspection at the borehole dug well and spring water sources and at point of tap water, reservoir and distribution line were recorded. Therefore, the inspection assessment result indicates 63.6% (7/11), 54.5 %(6/11) and 27.3 %(3/11) for dug well sources and for springs were 30% (3/10), 60% (6/10) and 50% (5/10). Based on the sanitary inspection risk score described by WHO (2012) most dug wells in a high risk level, which is (6-8) and Borehole 33.33 %(3/9), reservoir 8.3% (1/12) distribution line 20% (2/10) and tap water 15% (1/10, 2/10, 2/10 and 1/10). In addition, borehole and springs sources were in intermediate risk level, which is (3-5). Generally, tap water, at reservoir point and distribution line was at low risk level which is 0-2. During water sources sanitary assessment by checklist, the identified factors were area around and uphill of the source was eroded, there was human activity in the vicinity, in some sources there was insanity (open defecation), fence missing for the source, flood collection around the area, diversion above water sources absent, there was solid waste disposal near the sources and masonry faulty for some spring sources, cement floor cracks, pump loose and drainage channel cracks for dug well sources. For tape water nearest latrine, nearest sewer and main pipe exposed were the identified factory by sources survey assessment checklist.

5.6 Factors Associated with presence of faecal coliform in drinking Water sources.

From the result of bivariate binary logistic regression analysis, religion, type of water source, cleaning storage container, Presence of latrine facility, Latrine floor made off, non-functionality reason, cleaning latrine, hand washing after cleaning, distance latrine to water source, presence of solid waste container, container type, distance living unit to storage container, disposal facility, distance of place disposal were identified with p – value less than 0.2 and then, further analyzed by multivariable binary logistic regression to get the most confounding factor. Finally, the materials from which latrine floor made off and the distances between latrine to water sources were identified factors which had significant association with presence of faecal coliform in drinking water sources with p – value less than 0.05($p < 0.05$).

Respondents those made latrine floor by wood had 3.56 times higher odds of faecal coliform contamination in drinking water sources (unsafe sources), [AOR: 3.56, 95% CI (1.167- 10.859)] than those made latrine floor by concrete. Respondents those had latrine nearest to water sources or less than 100m 92% less likely get drinking water from safe sources, [AOR: 0.08,95% CI (0.021-0.331) than respondents had latrine far from water sources, greater than 1000m.

Table 5 Bivariate and multivariable analysis of factors affecting the presence of faecal in drinking water sources in Seka District jimma zone south west Ethiopia ,2021.

Variables	**Presence of faecal contamination in water sources**		**Crude OR (95% CI)**	**Adjusted OR (95% CI)**
	Yes	**No**		
Latrine floor made of				
Wood	109	17	4.875(1.764- 13.472)	**3.56 (1.167- 10.859**)
Concrete	117	5	3.65(1.302- 10.23)	1:00
Distance Latrine to water source				
< 100m	149	8	0.072(0.02- 0.256)	0.084(0.021-0.331)
100-1000m	165	28	0.226(0.073- 0.702)	0.196(0.06- 0.645)
>1000m	8	6	1:00	1:00

5. DISCUSSION

In this study, the prevalence12/13 (92.3%) of faecal coliform contamination from water samples taken from drinking water sources and at sampling point of reservoir, distribution line and tap in seka woreda jimma zone was found as high and the analysis of total coliform bacterial count in the current 13 water samples, the prevalence is 100% positive of total coliform bacteria. This high prevalence of faecal coliform contamination was in contrast to WHO guideline for drinking water sources, which is zero (0) CFU/100ml water sample(WHO, 2006) and national standards. However, the prevalence of faecal and total coliform contamination in, this finding was in line with studies done in Wegeda town Northwest Ethiopia, indicated that 82.2% contaminated by faecal coliform and 94.16% of the drinking water samples were tested positive for total coliforms TC Sitotaw, Melkie and Temesgen, (2021), and Kobo town Northern Ethiopia, which indicates that 74% faecal and 95.8% total coliform contamination of drinking water sources Nigus, (2021). Also, in line with study done in Addis Kidame town Northwest Ethiopia reported as 77% and 89% of water samples were positive for faecal coliform and total coliform contamination Sitotaw and Geremew, (2021).

Another related study conducted on the quality and safety in Guto Gida district, Oromia, Ethiopia prevailed that 100% TC and 87.5% FC water sample with high rate of contamination Duressa, Assefa and Jida, (2019). This was due to absence/ discontinuity of treatment in sources of water or disinfection by chlorine at reservoir point and choke-chlorination at collection chamber as identified in this study and admitted by most respondents in the study area.

Accordingly, most water sources (92.3%) analyzed in this study is positive for fecal coliform. Therefore, the analyzed values were greater than WHO and ESDWQ acceptable limit which is nil or zero for total and fecal coliform (0 CFU/100ml) of water sample. As a result, from the total of 13 water sample sources, 10/13 (76.9%) water samples were classified under high risk of the faecal coliform contamination. However, other water samples 2/13 (15.4%) were under medium risk that is (11-50 CFU/100 ml) and only, one site water sample 1/13(7.7 %) were classified under no risk (0 CFU/100 ml). As a result, the maximum value of faecal coliform was observed at the reservoir sampling point (4.25 ± 0.0025log CFU/100ml) and the minimum value was recorded in an improved dug well was zero (0) in log CFU/100ml) relatively to the others site. There was no statistically significant variation of faecal coliform among different water sources obtained from different sampling point with $\%CV < 10$, but except within sampling point of borehole and reservoir as well as borehole and one dug well(07), which had statically significant variation with $\%CV > 90$ and $\%CV > 10$ respectively. Faecal coliform had a positive correlation with pH and temperature and also had negative correlation with DO. Furthermore, the maximum value of total coliform was observed at the reservoir sampling point (4.340± .020 log CFU/100ml) and the minimum value was recorded in an improved dug well (2.38 ± 0.2940, in log CFU/100ml) relatively to the others site. There was no significant variation in total coliform between water samples obtained from different water sources, that was %CV< 10, but there was statically significant variation within borehole sources and all tap sampling points with the %CV was > 90 and among spring and dug well sources with %CV >90. The correlation analysis result of the current study indicates that total coliform was positively correlated with pH, electrical conductivity, TDS, turbidity and temperature with p-value ($p < 0.05$).

The materials from which latrine floor made off and the distances between latrine to water sources were the identified factors of this study which had significant association with presence of faecal coliform in drinking water sources with p – value less than 0.05($p < 0.05$). Respondents whose made off latrine floor by wood had 3.56 times higher odds of faecal coliform contamination in drinking water sources (unsafe sources), [AOR: 3.56, 95% CI (1.167- 10.859)] than those made off latrine floor by concrete. Respondents these had latrine nearest to water sources or less than 100m 92% less likely get drinking water from safe sources, [AOR: 0.08,95% CI (0.021-0.331) than respondents had latrine far from water sources greater than 1000m. Almost all of the households were at risk of waterborne diseases likely due to improper excreta management practice at household level.

Moreover, the finding of this study the prevalence of households owned latrine was 68.1%. Most of the households were constructed and utilizing latrine with their family members. This finding is in line with a study conducted in Maichew Woreda, Aksum, and Tigray, Ethiopia which was over all 71.2% latrine utilization by model family Gebremedhin *et al*, (2018). In contrast to this finding, the latrine utilization of Mehal Meda Town in North Shewa Zone, Amhara Region, Ethiopia 91.2%. was higher Zone *et al*, (2020). Similarly, another study on Latrine Ownership and its Determinants in Tigray, Northern Ethiopia prevailed 34.7% was much lower Ajemu *et al*, (2020).

In this study the temperature range was 21.9℃-24.7℃. All the analyzed temperature values of current study area water samples (100%) were above the permissible level as recommended by WHO and ES national standards, for drinking water which was <15℃. Temperature can be considered as an important factor in natural drinking water sources as temperature can affect mostly all physicochemical processes. In addition, temperature controls rate of reactions, metabolic activities and growth of living organisms in water Singh, Tarun and Neha, (2020). A similar study conducted in Serbo town Jimma zone, Southwest Ethiopia shows almost all the recorded water temperatures was ranges from 20.67℃-25.73℃, which were above the WHO recommended level, Yasin al et, (2015). Another related study conducted in Asgede Tsimbila District, Tigray, Ethiopia temperature was recorded in range of 21.6 °C-24.7 °C groundwater sample to surface water sample and thus, temperature of Asigde Tsimbla Woreda is likely suitable for drinking purpose Haftu and Sathishkumar, (2020).

The overall range of pH in this study was 6.01-7.07. pH values for improved dug wells and improved springs (53.8%) were below the range of WHO and national standard limit and slightly acidic. A similar study conducted on physicochemical and bacteriological quality of drinking water of different sources, Serbo town Jimma zone, Southwest Ethiopia indicated that the range of pH value between (5.72 and 8.14), only about half (52.3 %) of the pH of water samples fall within WHO permissible limit was form tape water sources Yasin et al, (2015). According to, a case study of Kenya, Africa on Physicochemical and bacteriological quality of water sources in rural settings determined that water pH in the study sites ranged between 6.0 and 8.3.As a result, both the spring and Manual dug well water sources recorded pH levels that were below the acceptable lower limits of WHO standard Sila, (2019). The mean electrical conductivity range from 90 µS/cm-380 µS/cm and overall mean was 265±119 µS/cm, which indicates electrical conductivity is in range of WHO and ES national standard permissible limit for drinking water. Low value of electrical conductivity also indicates the presence of fewer ions in the water samples in the study area and water is suitable for drinking purpose. A related study conducted in a hilly village of Uttarakhand, India, on assessment of pot ability of spring water and its health implication determined that conductivity of the water samples ranged between 132 and 145 µS/ cm with an average of 138.6 µS/cm (Singh, Tarun and Neha, 2020).

In the current study, about 69.23 %(9/13) water samples were had turbidity greater than 5NTU as recommended by WHO and ESDWQ standard. All tape water including borehole source, reservoir and distribution line sampling point and two improved dug well were had turbidity above 5NTU as recommended by WHO and ESDWQ standard. In contrast to this, the result of all the improved spring and one protected dug well (30.87%) of the samples analyzed were met the acceptable level of WHO and national standard limit of drinking water turbidity, which is (< 5 NTU) and one zero(0NTU) result at sampling point improved spring (PS1 03). Therefore, the recorded high turbidity value in this study may be from high level of microorganisms and suspended organic matter in the water sources. A similar study conducted Jimma zone, Southwest Ethiopia determined that about 60 % of water samples had turbidity level above 5 NTU. High turbidity is often associated with higher levels of suspended organic matter and microorganisms including bacteria and other parasites. The consumption of highly turbid water may constitute a health risk as excessive turbidity can protect pathogenic microorganisms from the effect of disinfectants, and also stimulate the growth of bacteria (Yasin al et, 2015).

The value of TDS and DO of water sample were in the range of 45mg/L-191mg/L and 1.71mg/L- 5.21mg/L in water samples respectively. The overall DO content of water samples value was 2.76mg/L. As a result, DO value in this study 92.3% of water sample were below the permissible range of limit and only one water sample was within range of standard, which is 4.5-7.5 (WHO,1996). According to International Organization for Standardization, the palatability of drinking water has been rated to its TDS level as follows: excellent, less than 300 mg/liter; good, between 300 and 600 mg/liter; fair, between 600 and 900 mg/liter; poor, between 900 and 1200 mg/liter; and unacceptable, greater than1200 mg/liter (Beyene, 2015). Based on this, the result of TDS concentration of water samples in this study all (100%) were in range of excellent permissible limit of pot ability for drinking water.

The overall TSS mean value of this study was 27.92mg/L and the range of TSS water samples were from 12.67mg/L to 53.335mg/L. All the analyzed water samples were met the acceptable low level as recommended by WHO, which is 1000mg/L for potable drinking water. The TSS values of water samples indicate the quality of non-filterable suspended particles contained in it. A related study conducted in Rafin Zurfi, Bauchi State, Nigeria on hand dug wells obtained TSS value range 100 to 400mg/L, with mean value of 146.667mg/L, it poses no health risk to human and this implies that the sampled hand-dug well water is suitable for drinking Jagaba *et al*, (2020).

Total Alkalinity overall mean value in this study was recorded (93.54 ± 61.35) as $CaCO_3$mg/L with the range of 4mg/L to 148 mg/L and the maximum range result was above the maximum permissible limit by WHO which is 120mg/L, but it’s in the range of national standard ESDWQ, which is 200mg/L. Alkalinity is a measure of the ability of water to neutralize acids and it mainly occurs due to the presence of carbonates and bicarbonates in the water. According to study conducted in western Niger, the presence of HCO_3^- in more than half of the analyzed water samples shows a strong capacity of the water to neutralize acids, but it is not available for drinking in the daily life due to its high alkalinity Adamou *et al*, (2020).

Total hardness related to the concentration of predominantly calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) ions/ multivalent metallic cations present in water or solution. Based on the analyzed result of this study, all water samples (100%) were within acceptable limits of WHO and ES national standard for drinking water quality, which is 300mg/L. The value ranges from 24mg/L to 87mg/L, and with overall mean value of 66.769mg/L. A related study on pot ability of spring water and its health implication in a hilly village of Uttarakhand, India, obtained hardness of the water samples ranged between 20 and 36.8 mg/l with an average of 28.32 mg/l(Singh, Tarun and Neha, 2020). Therefore, relatively lower hardness records obtained may be due to the existence of dissolved calcium and magnesium exists in low concentration in study area water samples. The overall value for calcium ion concentration of this study was (35.23± 13.41) and in the range of 15mg/L to 62mg/L within acceptable limit of WHO and ESDWQ standard, which is 100mg/L. whereas, magnesium ions also had overall mean value of (31.56 ±12.10) and the recorded range was from 9mg/L to 44mg/L. Therefore, all analyzed water samples were within permissible limit as recommended by WHO and ESDWQ standard. A related study conducted on Hand dug well water in Kafta Humera Woreda; Tigray, Ethiopia obtained 75.88mg/L calcium ions and 25.7mg/L of magnesium ion concentration Gebresilasie *et al*, (2021). High calcium concentrations in water may lead to the formation of solid scales in pipes and kitchen utensils and increased soap consumption. In contrast to this result very high concentration of calcium ions was obtained 943mg/L in a rural area of Western Niger (Adamou *et al.*, 2020).

The nitrate concentration in current study in the form of NO_3-N in all water samples were observed in minimum concentration or very low. The maximum value record was 2.98 ± 0.1125 mg/L and range from 0.25-2.98mg/L were very low. As a result, existence of nitrate concentration of water samples in present study was in low level acceptable limit of WHO and ESDWQ standard, which is 50mg/L. A similar study conducted in Digalu-tijo Woreda (District), Oromia Regional State, Ethiopia (34mg/l) nitrate concentration was recorded (Dobo and Bedewi, 2020). When this compared to the present study result, it was relatively higher. In contrast to this 0 result, high nitrate recorded in Jimma zone, Southwest Ethiopia in similar study was 102.11 mg/l(Yasin al et, 2015). Similarly, in all water sample (100%) phosphate also existed in acceptable limit as recommended by WHO and ESDWQ standard which is 2mg/L. The overall mean value for phosphate was 0.223± 0.104mg/L.

The analyzed values of iron ion concentration for (84.6%) of water samples were above the maximum permissible level by WHO and ES national standard limit for drinking water, except at two sampling point protected dug well (DW05) and at distribution line (DL12), (0.205 mg/L and 0.225mg/L) respectively, which were in the range of acceptable limit as WHO recommended and ES national standard for drinking water, which is, 0.3 mg/L. The high value of iron concentration in water samples of this study area was from soil compartment of the environment, it may, from soil type, weathering of iron rich minerals, rocks and sediments. So that, presence of iron in high concentration in drinking water were make a water to have bitter taste, and community consuming from these water sources having high iron concentration were suffering from unpleasant test, color, corrosion of plumbing system and heart disease. Therefore, this was may be the reason for unpleasant test slight yellow color on cloth observed in tape water in Seka town. A study conducted in Hand dug well water samples of Kafta Humera woreda, Tegria, Ethiopia showed that, iron concentration in the range of 0.33mg/L- 1.86mg/L (Gebresilasie *et al.*, 2021)

The analyzed values of manganese ion concentration 69.23% water samples were above the range of permissible limit for drinking water as recommended by WHO standard 0.05-0.1 mg/L and 30.77% of water samples were within the acceptable limit. The presence of high manganese concentration in drinking water is objectionable to consumers, if it is deposited in water mains and causes water discoloration. A study conducted on assessment of drinking water quality in Rajshahi District, Bangladesh was contrasts with this study, which was high manganese concentration was observed there in the range of 0.35-3.43mg/L (Chowdhury and Chowdhury, 2021).

Based on the sanitary inspection at water sources, the risk score as described by WHO (2012) most dug wells sources were in a high risk level 63.6%, which is (6-8) and Borehole 33.33 %(3/9), reservoir 8.3% (1/12) distribution line 20% (2/10) and tap point 15% (1/10, 2/10, 2/10 and 1/10). In addition, borehole and springs sources were in intermediate risk level, which is (3-5). Generally, tap point, at reservoir point and distribution line was at low risk level which is 0-2.Therefor, during water sources sanitary assessment, the identified factors were area around and uphill of the source was eroded, there was human activity in the vicinity, in some sources there was insanity (open defecation), fence missing for the source, flood collection around the area, diversion above water sources absent, there was solid waste disposal near the sources and masonry faulty for some spring sources, cement floor cracks, pump loose and drainage channel cracks for dug well sources. For tap points nearest latrine, nearest sewer and main pipe exposed were the identified factory by sources survey assessment checklist. The sanitary inspection score for each water source type were had a correlation with microbial quality of water drinking water with significant level at $p < 0.01$ and $p < 0.05$. This study in contrast with study conducted in the Southern Region of Ethiopia and indicates that the sanitary condition does not necessarily predict the microbial quality of water and it is an indication that other routes of contamination of water sources are more important Alemayehu *et al.*, (2020), but in this finding there is strong correlation between sanitary score and the presence of faecal coliforms.

6. Conclusions

In this study, the presence of positive faecal and total coliform from samples taken in drinking water sources in Seka woreda/ district was found to be high. A significant proportion of water samples were subjected to faecal and total coliform contamination at water sources. The bacteriological quality of all water samples analyzed in the current study for total coliform and fecal coliform bacteria were did not meet/ agree with the set standard as recommended by WHO and ESDWQ for coliform bacteria in drinking water, which is zero CFU/ 100ml of water sample. Bacteriological count of current study shows, tape point including its source, reservoir and distribution line were grossly contaminated by total coliform. In most of analyzed water samples yellow color colon forming were observed, which is an indication of E-coli/ Escherichia coli and farther confirmed by different tests, the water was contaminated by fecal matter. Based on, bacteriological quality and sanitary risk evaluation the water source classified as, high risk, intermediate and no risk. The sanitary inspection score for each water source type were had a strong correlation between sanitary score and the presence of faecal coliforms in drinking water sources with significant level at $p < 0.01$ and $p < 0.05$. Therefore, factors such as uphill area of the source eroded, human activity in the vicinity or insanity (open defecation), fence missing for the source, flood collection around the sources, diversion absent, solid waste disposal near sources, masonry faulty, cement floor cracks, pump loose, derange channel cracks, nearest latrine, nearest sewer and pipe exposed were the identified factors. The analyzed result for physicochemical parameters indicates, most of the parameters were within the level of permissible limit set by WHO guideline and ESDWQ standard for drinking water, except for pH, turbidity, and temperature, iron and manganese ion concentration. So that, long term exposure can affect health problems on the community relaying on those water sources having pH, turbidity, and temperature and iron ions concentration out of the permissible limit. Generally, based on the analysis of multivariate logistic regression the factors associated with drinking water quality problems were the materials from which latrine floor constructed and the distances between latrine to water sources were identified as factors which had significant association with presence of faecal coliform in drinking water sources with p – value less than 0.05($p < 0.05$).

7. Recommendations

Based on this study finding, the following recommendation forwarded.

To Jimma Zonal and Woreda Water and Energy Resources, office

- We recommended that proper chlorination/ disinfection of the drinking water supply system need attention, the water should be well treated before being pumped out and distributed to consumers/ community and providing sustainable and continuous water supply needed to avoid discontinuity water supply.
- Protecting animals' entry into water sources by strengthen the fence, protecting water sources from inflow and runoff by cutting cruncher above water sources,
- Improving the services and construction of water sources, safeguarding the water sources by preventing animals, flood, and any contaminants entering in to the facilities, from point and non-point sources of pollutants, such as from agriculture, use of fertilizer, construction

To Seka Wereda Public Health Offices and health extensions

- Regular monitoring of the water quality, provision of toilets and waste disposal systems, and intensive health education on sanitation and hygiene practices for the community needed.
- Water sources need continuous sanitization and protecting open defecation and solid waste disposal near water sources.
- Awareness creating about latrine utilization and its impact towards prevention of communicable diseases needed.

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Annex: Questioner

Dear Sir/madam;

My name is **Sheleme Beyera,** and I ‘m from Jimma University. I am conducting an assessment on fecal contamination of drinking Water due to utilization at household level among Seka woreda. Your household has been randomly chosen to participate in postgraduate student research under the title” *Drinking water Quality assessment: the case of seka chekorsa Jimma zone, south west Ethiopia”*, and you are kindly requested to be included in the assessment which has great importance in improving community health. The interview will take a maximum of 5-10 minutes. No information concerning you as an individual will be passed to anther individual or institution. Your participation will be based on your willingness and you have the right not to participate fully or partially. Are you willing to participate in the study?

Yes_____ No______

If yes, we will continue the interview

If no, thank you!

Thank you for your cooperation!

Name of the interviewer ------------------------ Date -----------

Name of the supervisor ------------------------- Date ------------- Signature ------------

JIMMA UNIVERSITY

INSTITUTE OF HEALTH SCIECNCES

PUBLIC HEALTH FACULTY

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGIES

QUESTIONNAIRE FOR ASSESSMENT DRINKING WATER QUALITY ASSESSMENT, THE CASE OF SEKA CHOKORSA WOREDA JIMMA ZONE, SOUTH WEST ETHIOPIA

Town_________1.2 Kebele__________1.3 Zone _____________1.4. House number _____

1.5. Nature of the House Own______ Rent__________ Other (Specify) _____

I. Demographic and socio-economic characteristics

Region __________; Zone __________; Woreda __________; Kebele__________; House No __________, No of family members __________

Sex: Male _____; Female _____ ; Age (years) _____

0. Marital status:

- Married
- Divorced
- Widowed
- Single

1.1 Religion

- Muslim
- Protestant
- Orthodox
- Others, specify

1.2 Ethnicity

- Gurage
- Amhara
- Oromo
- Dawro
- Kefa
- Other specify

1.3 Educational level of the household head

- Illiterate
- Only Read & write
- Grade 1 to grade 4
- Grade 5 to grade 8
- Grade 9 to grade 10
- Grade 11 to grade 12
- Grade 12^+
- Other specify

1.4 Occupation of the household head

- Government employee
- Merchant
- Student
- Farmer
- Day labored
- Other specify

1.5 Average annual income of the family (Birr): _____

II. WATER SUPPLY

2.1 Source of water supply

- Dug well
- Spring
- Tap water
- River
- Other, specify ______

2.2 Distance (m) between the water source and the household

- Less than or equals to 1000 m (1 Km)
- Greater than 1000 m (1 Km)

2.3 Time taken to fetch water from the source to the household

- Less than or equals to 30 minutes
- Greater than 30 minutes

2.4 Volume (liter) of water collected and stored per each fetching round trip: _____

2.5 Number of round trips to fetch water per day: _______

2.6 Length of water storage at the household:

- Daily
- Twice a week
- Three times a week
- Other, specify ______

2.7 Type of material from which the water collection container is made of:

- Plastics
- Clay
- Metal
- Other, specify ______

2.8 Does the family clean the water collection container? Yes: __ ; No: __

If yes; proceed with questions 2.8.1 and 2.8.2

2.8.1 Method of cleaning

- With water only:
- Other, specify
- With water and detergent:

2.8.2 Frequency of cleaning the water collection container:

- Daily
- Twice a week
- Three times a week
- Other, specify: ______

2.9 Type of material from which the water storage container is made of:

- Plastics
- Clay
- Metal
- Other, specify ______

2.10 Does the family clean the water storage container?

Yes: __ ; No: __

If yes; method of cleaning

- With water only:
- With water and detergent:

2.10.1 Frequency of cleaning the water storage container:

- Daily
- Twice a week
- Three times a week
- Other, specify: ______

3 EXCRETA MANAGEMENT

3.1. Does the family have latrine? Yes: __ ; No: __

If yes to 3.1, proceed with ---------------

3.1.1. Type of the latrine:

- Traditional pit latrine
- Ventilated Improved Pit latrine
- Pour flush latrine
- Other, specify ______

3.1.2. Total number of seats: _____

3.1.3. The floor is made of:

- Wood
- Earth/ mud
- Concrete
- Other, specify _____

3.1.4. The wall is made of:

- Wood
- Earth/ mud
- Concrete
- Corrugated iron sheet
- Other, specify ______

3.1.5. What is status of the latrine?

3.1.5.1. Functional with no need for maintenance.

3.1.5.2. Functional but need maintenance.

3.1.5.3. Specify the required maintenance: _______________________

3.1.5.4. Not functional: if so, specify the reason _________

3.1.6. Are there fly and odor problems of the facility? Yes _____ No _____

3.1.7. Do the families clean the latrine? Yes _____ ; No _____

If yes, to question No 3.1.5, proceed with ----------

3.1.7.1. How frequent do they clean the latrine?

- Every day
- Three times a week
- Twice a week
- Other, specify ____

3.1.7.2. Do they apply both water and detergent to clean the latrine: Yes ___; No ___

3.1.7.3. Do they wash hands with water & detergent after cleaning the latrine? Yes ___; No__

3.1.8. What is the distance (in meters) between the latrine and the water source: _____?

3.1.9. What is distance (in meters) between the facility and the living units: _____

If no, to question No 3.1; proceed with -----------------

3.2. How do the family store or collect excreta? ______________________

3.2.1. What is the reason for lack of facility to store or collect excreta generated by the family?

- Due to lack of space for construction
- Due to fly and odor problems associated with the facility
- Other, specify _________

IV. ONSITE HANDLING& STORAGE OF DOMESTIC SOLID WASTE

4.1. Is there onsite solid waste storage container? Yes _______; No_______

If yes to question 3.1; proceed with questions 4.1.1

4.1.1. What is the solid waste container type?

- Tin
- Sack
- Plastic bag
- Other, specify: _________

4.1.2. Do the family members clean the solid waste storage container?

Yes _______; No_______

If yes to question 4.1.2: proceed with questions 4.1.2

4.1.2.1. How frequent is the storage container cleaned?

- Once in a week
- Every two weeks
- Twice in a week
- Other, specify

4.1.3. What is the method of storage container cleaning?

- With water only
- Other, specify: _______
- With water & detergent

4.1.4. Conditions of solid waste storage area

- No splash of solid waste
- There is splash of solid waste
- The container is not overfilled
- The container is overfilled
- Other, specify _______

4.1.5. Location of the storage container:

- Distance (in meter) from the source of water supply_______
- Distance (in meter) from the living unit/ house____________

If no to question 4.1; proceed with question 4.2

4.2. Is there municipal service for solid waste collection and disposal? Yes __; No__

If no to question 4.2, proceed with questions 4.2.1 and 4.2.2

4.2.1. Who is responsible to collect and dispose the solid waste? ____________

4.2.2. How frequent is the solid waste collected?

Once in a week

- Others, specify ____________

Twice in a week

4.3. Is there recovery or reuse of solid waste? The source of water supply_______

4.3.1. Which component of the solid waste is recovered or reused? _______

Yes ____; No___

If yes to question 4.3: proceed with questions 4.3.1 and 4.3.2

4.3.2. What is the purpose of solid waste recovery or reuse? _____

4.4. What is the available method of solid waste disposal facility?

Composting

Refuse pit

Incineration

Open dumping

Backyard

Other, specify _____

4.5. Location (distance in m) of the solid wwaste disposal facility from:

4.6.

The living unit/ house____________