JIMMA UNIVERSITY

SCHOOL OF POST GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULITY OF CIVIL AND ENVIRONMENTAL ENGINEERING

ENVIRONMENTAL ENGINEERING CHAIR

Analysis of drinking water quality by using Canadian water quality index: A case of Dincha River, Bonga, Ethiopia

By

Zeitemariam Muluneh Agonafir

Thesis submitted to the school of postgraduate studies of Jimma University in partial fulfillment of the requirements for the degree of Master of Environmental Engineering

July, 2021

Jimma, Ethiopia

JIMMA UNIVERSITY

SCHOOL OF POST GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

ENVIRONMENTAL ENGINEERING CHAIR

By

Zeitemariam Muluneh Agonafir

Thesis submitted to the school of postgraduate studies of Jimma University in partial fulfillment of the requirements for the degree of master of environmental engineering

Main advisor

Dr. Zerihun Asmelash (PhD, Ass.Professor)

Co-advisor

Mr. Million Ebba (MSc)

July, 2021

Jimma, Ethiopia

DECLARATION

I, Zeitemariam Muluneh declare that, this research is my own original work and prepared with my effort as well as do not presented in any university to fulfill a degree of masters.

By

Zeitemariam Muluneh Agonafir signature…………..Date………

Main advisor

Dr. Zerihun Asmelash (PhD, Ass.Professor) signature…………..Date……….

Co-Advisor

Mr. Million Ebba (MSc) Signature…………..Date………

ACKNOWLEDGEMENTS

First of all, I have heartfelt thanks to Glory God, who enables me from first child age till now. Next to God, I have deepest thanks for Jimma university institute of technology who give me these golden chances to follow my MSc academic class within the environmental engineering chair. Next to this, I would like to supply great respect and thanks to my main advisor Dr. Zerihun Asmelash (PhD, Ass. professor) and co-advisor Mr. Million Ebba (MSc), who helps me by giving advising and sharing necessary information and data for my thesis preparation. Lastly, I have unforgotten respect and appreciate for Jimma town water supply and sewerage office all staffs and lab technicians who collaborate their laboratory rooms to do my experimental work.

ABSTRACT

Water is essential for all living things and any activities for preserving several environments' resource. World water resources quality could be polluted with both natural and man-made factors. The quality of water supplied to consumers' was not comfortable and supported by world health organization standard of guidelines in case of color and taste. The purpose of the study was analysis of drinking water quality by using Canadian water quality index in case of Dincha River, Bonga, Ethiopia. Dincha River is a well-known river in Bonga town in all peoples who live in this town use it for several purposes. Water sample was collected from three selected sampling stations such as Sheka, Sheta and Dincha respectively. During the study primary and secondary data's were taken by site observation, Bonga city municipal administration as well as from several journals. This study was guided by Canadian council minster of environment water quality index and it contains the elements such as scope, frequency and amplitude of the analyzed results to its recommended rank. From five analyzed physical parameters 40% were failed and whereas from eight analyzed chemical parameters 62.5% of them were failed according to Canadian water quality index in all stations. The water quality level ranges according to Canadian index from excellent to poor for drinking use. The analyzed value of Canadian water quality index for Dincha River in all stations was less than 44. Therefore, Dincha River quality exists in all stations for the selected parameters were recorded as poor conditions. As the result, according to this study the source was not accepted for dinking use.

***Key words**: Bonga; Canadian Council Minster of Environment; Dincha River; Physio-Chemical; Water Quality Analysis*

TABLE OF CONTENTS

CONTENTS **PAGE**

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

CCME	Canadian Council of Ministers of the Environment
CCMEWQI	Canadian Council of Ministers of the Environment Water Quality Index
CSA	Central Statistical Agency
CWQI	Canadian Water Quality Index
DO	Dissolved Oxygen
EC	Electrical Conductivity
ES ISO	Ethiopia Standard International Standard Organization
FAO	Food and Agricultural Organization
GPS	Geographical Position System
MoWR	Ministry of Water Resources
NABU	Nature and Biodiversity Conservation Union
NRC	National Resource Conservations
SNNPR	South Nations Nationalities and Peoples Region
TDS	Total Dissolved Solids
UN	United Nations
UNEP	United Nations Environmental Program
UNICEF	United Nations International Children’s Emergency Fund
WHO	World Health Organization
WQI	Water Quality Index

CHAPTER ONE

1 INTRODUCTION

1.1 Background

"Water" the term is most important and one of the needs of a human being surviving in this global village (satish, *et al.*, 2017). Water is the highest phenomena under the earth's surface and exists on or under the ground surface. Water covers more than two-thirds of the earth's surface, but mostly salty and undrinkable (Olumana, 2018). Water is a key component of the environment which its quality must be maintained and free from pollution (Igwe, *et al.*, 2017). Water is essential for all living things and any activities as well as for preserving the environment and its resources (Marcello and George, 2013). Ethiopia is "water tower" of Africa, but only a quarter of the country's population has improved access to water sources (WHO, 2014).

World water resources quality could be polluted with different both natural and man-made factors. Globally, at least four billion people do not have access to water that is safe to drink, or that it is perceived as not safe to drink without point-of use treatment system (Asit, *et al.*, 2019). The water borne diseases and mortality rate caused by its quality is increasing time to time. Each year, two million people die from water borne diseases and billions more suffer illness-most are children under five (WHO, 2011).

In developing countries the almost all children's health problem death rate proceeded by water borne diseases. In Africa, more than 315,000 children die every year from diarrheal diseases caused by unsafe water and poor sanitation (Corah and Carolyn, 2016). Ethiopia's current population is about 115 million and is expected to surpass 200 million by the end of 2049 (UN WPP, 2021).

Drinking water quality is one of the greatest factors affecting human health in the world, continental and country level. However, in many countries, especially in developing countries are not desirable and poor drinking water quality has induced much waterborne disease (Peiyue and Jianhua, 2019).

Water quality is defined as the physical, chemical and biological characteristics of water, usually in respect to suitability for a designated use (Roy, 2019). The water quality of any specific area or specific source can be assessed using physical, chemical and biological parameter (Sivaranjani *et al*., 2015). Water quality is identified in terms of its physical, chemical and biological parameters (Sarita, *et al*., 2015).

Water quality analysis is to measure the required parameters of water by following standard methods to check whether they are in accordance with the standard or not (Roy, 2019). It is analyzed from the reference point of physical, chemical and biological parameters according to different international standard and regulations to save humans and environmental health. Water quality index is the most effective tools to express water quality and can be used as an important parameter for the assessment and management of the water source, give a good idea of the evolutionary tendency of water quality to evolve over a period of time (Robert and pirro, 2013).

The water quality index is a single number that expresses water quality by integrating the water quality variables. Its purpose is to provide a simple and concise method for expressing the water quality for different usage (Gorde and Jadhav, 2013).

The water quality index would provide recommendations for policy reform, while developing methods to assess the suitability of water supplies or the intended use and to recommend more effective management of water resources and river basins by formulating pollution control strategies (Amare, *et al*., 2017).

A water quality index provides a convenient means of summarizing complex water quality data and facilitating its communication to a general audience. The CCME Water Quality Index (1.0) is based on a formula developed by the British Columbia Ministry of Environment, Lands and Parks and modified by Alberta. The Index incorporates three elements: Scope - the number of variables not meeting water quality objectives**;** Frequency - the number of times these objectives are not met; and Amplitude - the amount by which the objectives are not met. The index produces a number between 0 (worst water quality) and 100 (best water quality) (CCME WQI, 2017).

The aim of this study is to ensure the River water source quality within laboratory experiment on different physio-chemical parameters in case of drinking purposes and to put possible scientifically based recommendations for all stake holders of the community. Based on the result, justification was given to Dincha River either good or bad according to three dimensional (such as scope, amplitude and frequency) attitudes of Canadian council ministers of the environmental water quality index.

1.2 Statement of the problems

Water quality problem were the issues that causes to death and waterborne disease in the world. Both surface and ground water sources can be used for drinking purposes depending upon their quality and availability status. Surface water source quality can be disturbed by either anthropogenic or natural factors directly or indirectly. River source is mostly exposed to pollution by various human activities while leading their life. The cause of man-made problem in Dincha River had been polluted and turbid during crossing the study area. The aim of water quality analysis in this study is to distinguish the water source weather it is used for drinking purpose or not. The cause of this study in Bonga town was the issues associated with quality that supplied to the consumer for drinking use in case of color and taste. Parameters were selected to indicate River quality both physically and chemically to various sources that has the contribution to the pollution of River from upstream to downstream of study area when passing through the town.

1.3 Objectives

1.3.1 General objective

The main objective of the study is analysis of water quality on Dincha River by using Canadian water quality index.

1.3.2 Specific objectives

- To characterize the physio-chemical parameters of the Dincha river;
- To determine the Dincha River quality by using Canadian water quality index; and
- To identify the pollution level of Dincha River and to give possible recommendation.

1.4 Research question

1. What is the importance of characterizing the physio-chemical water quality parameters?
2. Why need to determine the quality of Dincha River? and
3. Is the River status has polluted on various stations?

1.5 Significance of the study

Most of the time water quality problems may lose a huge number of people's life and it causes for several diseases in case of world, continental and country level. Included Water quality parameters in the study are characterized according to their simple expressions as physio-chemical for making it easily understandable each of them with their categories. The aim of this study is determination of water quality parameters at Dincha River based on Canadian water quality index and to check whether it is acceptable for drinking purpose or not according to analyzed result. The significance of the study is to identify the status of River pollution relative to Canadian water quality index for drinking purposes and to decide the acceptability or rejection of the source based on analyzed value.

1.6 Scope of the study

The existing supplied water to the consumer and its quality status were the portion of the study relative to identified parameters. Quality based determination on Dincha River was carried out with both physio-chemical water quality parameters. Identification of pollution level status could be assessed at each station points in terms of analyzed result.

1.7 Limitation of the study

The study was limited to previously similar title that was conducted on Dincha River by another researcher to support the current study. In addition, CCME WQI has only a limited number of parameters could be determined within the range of 8-20 as the result, in this study only 13 physio-chemical parameters could be able to carry out and discussed.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Source of Water

Water can be grouped into Surface water comprising of oceans, rivers, lakes, reservoirs, lagoons, streams and many others, Ground water which is considered mostly as purer than the surface water and lastly the rain water which falls as a result of condensation and precipitation of the clouds (Stanistski *et al.,* 2000). Surface water is a general term describing any water body that is found flowing or standing on the surface, such as streams, rivers, ponds, lakes and reservoirs (Gray,2008). Rivers are the major sources of water to satisfy human needs such as domestic, drinking, agriculture, recreation, and transport (Kumar and dua,2010).

Water resources are threatened nowadays by pollution that comes from domestic, industrial, and agricultural discharges without prior treatment. This pollution causes of water quality (Allaramadji *et al.,* 2020).

Water resources management is the scientific field that can assist in a rational equitable and efficient way of water resources development, treatment and use, safeguarding the sustainability of water resources and the environment (Marcello and George, 2013). Water pollution problems are expected to worsen, especially in the rapidly growing urban areas of developing countries this mean that when the number of population doubles, pollution load tends to five-ten times (Andreas, 2001).

2.2 Physio-chemical water Quality parameters of Drinking Water

The physio-chemical water quality parameters provide important information about the health of a water body relative to different desired purposes. Amount of contaminants in water may cause adverse health effects in humans because of prolonged exposure through drinking water. These include, both organic and inorganic chemicals including some pesticides. Some of them are toxic to humans or affect the aesthetic quality of water. In this regard, the WHO has put forward guideline values that limit many contaminants in drinking water. Ethiopia has also ready its own drinking water quality specification in line with the international norms and values (Girma *et al.,* 2011).

2.2.1 **Physical parameters**

I. **Color**

Color is due to the presence of colored substances in solution, such as vegetable matter and iron salt. It does not cause necessarily have detrimental effects on health. Color intensity could be measured through visual comparison of the sample with distilled water. The Colored water is not acceptable for drinking (Aesthetic as well as toxicity reasons). Therefore, Drinking water should be colorless (WHO, 2012). Intended for the purposes of investigation of public water supplies, it is useful simply to note the presence or lack of observable color at the time of sampling. Changes in the color of water and the appearance of new colors serve as indicators that additional investigation is needed (WHO, 2004).

Color in drinking-water may be due to the presence of colored organic matter, e.g. humic substances. Drinking-water should be colorless from the reference point of various rule and regulations. For the purposes of surveillance of community water supplies, it is useful simply to note the presence or absence of observable color at the time of sampling. Changes in the color of water and the appearance of new colors serve as indicators that further investigation is needed (WHO, 1997).

II. **Electrical Conductivity**

Electrical conductivity is measures the ionic process of a solution that allows it to transmit current. Electrical conductivity is a numerical expression of an aqueous solution's capacity to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of the liquid. Solutions of most inorganic acids, bases, and salts are relatively good conductors. Conductivity is the inverse of resistance, the unit of conductance is µS/cm (Gorde and Jadhav, 2013). Electrical conductivity is a quantification of the ability of water to carry an electric current. Most electrical conductivity tests are accomplished with an instrument (Robert, 2007). The Electrical Conductivity value is an index that represents the concentration of soluble salts in water. A high concentration of dissolved solids greatly affects the taste of the drinking water (Robles *et al.*, 2011). According to CCMEWQI standards the electrical conductivity value should be 400µS/cm (CCME WQI, 2017).

III. Total Dissolved Solids

The total dissolved solids (TDS) are the solids in the filtrate from the TSS test. The health risks are not significant as the value of TDS is much less than 1,000mg/l, which is the WHO standard maximum permissible limit (Mohammed *et al*., 2013). No agreement has been developed on bad or an optimistic effect of water that exceeds the WHO standard of maximum permissible level is 1,000 mg/l. A total dissolved solid in drinking water originates in numerous ways from sewage and urban industrial wastewater. Hence, TDS test is mostly an indication to control the general quality of the water (Muhammad *et al*., 2013). According to Canadian council of the environment water quality index the maximum permissible value of total dissolved solid is 500mg/l (CCME, 2017).

IV. Turbidity

Turbidity is one of the most important physical parameters for water quality, defining the presence of suspended solids in water and causing the muddy or turbid appearance of a water body (Twari and Singh, 2014).Turbidity is the most important parameter that determinates the rating of water quality, exceeding the standards of drinking water (Robert and Pirra, 2013). Turbidity is described as the appearance of cloudiness within water due to the presence of suspended solids within it. Turbidity is the cloudiness of water caused by a variety of particles and is a key parameter in drinking water analysis (Rahmanian, 2015).

Turbidity in water can be caused by suspended matter such as silt, clay, organic matter, organic compounds, or dissolved inorganics. It is determined by the optical property that causes light to be scattered, adsorbed or reflected rather than transmitted in a straight line through or into a liquid (Robert,2007). High turbidity may result from sediment bearing run-off, or nutrients inputs. Turbidity is a measure of the cloudiness of water (Joel *et al.,* 2000). Cloudiness is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in the water (Sushil and Zachary, 2011).

The turbidity value that recommended for water to be disinfected, the turbidity should be reliably less than 5NTU and preferably have a median value of less than 1NTU (WHO, 2012). According to Canadian council of minister of the environment water quality index (CCMEWQI) the maximum permissible limit of turbidity is 5NTU (Idris and Mirac, 2016).

V. **Temperature**

Temperature is the measurement of coldness and hotness property of the natural state of matter. The temperature of water is an important factor as it governs almost all physical, chemical and biological reactions. Any sudden variation in this parameter causes a disturbance in the balance of the water ecosystem and mainly influences climatic variations (Allaramadji *et al.,* 2020). The temperature of surface waters is influenced by latitude, altitude, and season, time of day, air circulation, cloud cover and the flow and depth of the water body. Surface waters are usually within the temperature range 0°C to 30°C (Chapman and Kimstach, 1996).

2.2.2 Chemical parameters

i. **Iron**

Iron is a fairly abundant element in rocks in the form of silicates, oxides and hydroxides, carbonates and sulfides. Iron is soluble in the Fe^{+} ion state (ferrous ion) but in soluble in the Fe^{+} state (ferric ion). The value of the oxidation-reduction potential of the medium therefore, conditions its solubility and the iron content of the water. Captive aquifers isolated from exchanges with the surface see reduced conditions: their water is ferruginous (Allaramadji *et al*, 2020).

According to CCME, WQI the maximum permissible value of iron is 0.3mg/l (CCME WQI, 2017). The World Health Organization (WHO) originally set a guideline at 0.3mg/l based on taste thresholds, although in the latest revision a guideline value has been removed as the taste and appearance of water is severely affected below the health-based value (WHO, 2004).

ii. **Dissolved Oxygen**

DO is the dissolved gaseous form of oxygen. DO enter water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants (Gorde and Jadhav, 2013). Dissolved oxygen can be expressed in terms of percentage saturation, and consumers can usually detected levels less than 80 per cent saturation in drinking water as a result of poor odor and taste (Chapman and Kimstach, 1996). Dissolved Oxygen is an important indicator for water quality assessment as well as water body's ability to support aquatic life. It is noted that WHO and CCME standard for drinking purposes are 6 mg/Land 5 mg/l respectively (Alam *et al.*, 2007; CCMEWQI, 2017).

iii. Total Hardness

Water hardness is a traditional measure of the ability of water to react with soap to produce lather, and for most consumers the problems associated with washing are the major factors of concern. An alternative measure of hardness is total dissolved solids (TDS), which is a measure of the total concentration of ions in water (Gray, 2008). Total hardness is the sum of calcium and magnesium concentrations expressed in mg/l of CaCO3. It is generally a measure of the capacity of water to precipitate soap. Hardness is either calculated from the results of separate calcium and magnesium tests or is determined from a color change when titrating a sample with ethylenediaminetetracetic acid (EDTA) (Robert,2007).

The hardness or softness of water varies from place to place and reflects the nature of the geology of the area with which the water has been in contact. In general, surface waters are softer than ground waters. Hard water needs more soap and detergents for home laundry and washing (Anhwange *et al.*, 2012). The hardness of water was originally measured by the ability of the water to destroy the lather of soap, as this is one of the principal problems of very hard water. Although hardness does neutralize the lathering power of soap it does not affect modern detergent formulations. Hard waters are associated with chalk and limestone catchment areas, whereas soft waters are associated with impermeable rocks such as granite (Gray, 2008). According to CCME WQI the maximum permissible value of total hardness of water should be 500 mg/l (CCMEWQI, 2017).

(WHO, 1984) set a maximum recommended concentration of 500mg/l in drinking water on aesthetic, not health, grounds. In the second revision (WHO, 1993) again no health-related standard was felt necessary but a guideline of 200mg/l was suggested to avoid scale deposition in distribution systems. In the latest revision the WHO (2004) has made no health-based guideline for hardness but acknowledges that the degree of hardness can affect acceptability to the consumer in terms of taste and scale deposition. Hardness is very much linked to taste, and many consumers in hard water areas love the unique taste that hardness imparts to their water, likewise those in soft water areas (Gray, 2008).

iv. **pH**

The pH scale commonly ranges from 0 to 14. The scale is not linear but rather it is logarithmic. For example, a solution with a pH of 6 is ten times more acidic than a solution with a pH of 7. Pure water is said to be neutral, with a pH of 7. Water with a pH below 7.0 is considered acidic while water with pH greater than 7.0 is considered basic or alkaline (Gorde and Jadhav, 2013).

According to CCMEWQI standards, pH of water should be 6.5-9 (CCME WQI, 2017). The pH measurement reflects a change in the quality of the source. Very acidic or very alkaline water produces sour or alkaline tastes (Kumari *et al*., 2011).The maximum permissible limit of pH value is generally within the range 6.5–8.5 (WHO, 2006; ES, 2011).

V. **Phosphate**

Phosphate (PO_4^{3-}) is an important plant nutrient which regulates the growth of aquatic plants such as microphytes and algae (Tibebe *et al*., 2019). Phosphates in surface waters mostly originated from sewage effluents, which contains phosphate, based synthetic detergents, from industrial effluents, or from land runoff where inorganic fertilizers have been used in farming (Alan *et al*., 2000). Phosphates do not pose a human or health risk unless in very high concentration (Leta and Dibaba, 2019).The CCME maximum permissible value of phosphate is 0.05mg/l (CCME, 2017).

vi. **Nitrate**

Nitrate (NO_3) is one of the extreme significant disease causing parameters of drinking water quality, particularly blue baby syndrome in babies and has been used as an indicator for the presence of organics. Nitrates can cause methemoglobinemia at greater than 100 mg/l where a baby cannot take breaths enough oxygen (Roberts, 2006). Higher levels of nitrate in drinking water may cause serious illnesses such as methemoglobinemia or “blue baby syndrome”, cancer risks, increased starchy deposits, and hemorrhaging of the spleen (Yang and Wang, 2010). The World Health Organization (WHO) recommended maximum limit for nitrate in drinking water is 50 mg/l, and waters with higher concentrations can represent a significant health risk (Chapman and Kimstach, 1996; Alan *et al*., 2000).The sources of nitrate are industrial waste, nitrogenous fertilizers. The maximum permissible limit value of nitrate according to CCMEWQI is 50mg/l (Mohammad *et al*., 2013).

vii. **Nitrite**

Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of the atmosphere is nitrogen gas. Nitrogen gas diffuses into water where it can be "fixed" (converted) by blue-green algae to ammonia for algal use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia (Gorde and Jadhav, 2013).

The Nitrite (NO_2) combines with hemoglobin in red blood cells to form methaemoglobin, which is unable to carry oxygen and so reduces oxygen uptake in the lungs (Gray, 2008). Higher levels of Nitrite in drinking water may cause serious illnesses such as methemoglobinemia or "blue baby syndrome", cancer risks, increased starchy deposits and hemorrhaging of the spleen (Yang and Wang, 2010).The WHO and CCMEWQI guidelines maximum permissible value of nitrite in drinking water is 3mg/l of nitrite (Alan *et al.,* 2000; Mohammad *et al*., 2013).

viii. **Sulphate**

One of the most important parameter that influences taste and odor in drinking water is sulphate (Bouslah *et al*., 2017). Sulphate concentrations in natural waters are usually between 2 and 80 mg/1, although they may exceed 1,000 mg/l near industrial discharges or in arid regions where sulphate minerals, such as gypsum, are present. High concentrations (> 400 mg/l) may make water unpleasant to drink (Chapman and Kimstach, 1996).The CCME WQI Guidelines maximum permissible value of sulphate for drinking water is 500mg/l (Mohammad *et al*., 2013). Excess sulphate can cause respiratory illness (Sarda and Sadgir, 2015).

2.3 Drinking Water quality

According to Roy (2019) study, water quality can be defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use. Safe and qualified water is very essential for life existence and survival of human being on this earth's surface. To get this quality based water source for drinking purpose the sample must be taken to laboratory and has to be check for both Physio-chemical parameters to the source is good or not for its desired purposes. The water quality from the Rivers has a considerable importance for the reason that these water resources are generally used for multiple matters such as: drinking domestic, residential water supplies, agricultures (irrigation), hydroelectric power plants, transportation and infrastructure, tourism, recreation, and other human or economic ways to use water (Andrea, 2018).

Water quality is measured by assessing the physio-chemical and biological properties of water against a set of standards, is used to determine whether water is suitable for consumption or safe for the environment (Nitasha and Sanjiv, 2014). Potential pollution sources that pose threats to drinking water are open field defecations, animal wastes, plants residues, economic activities (agricultural, industrial and other businesses) and even wastes from residential areas as well as transportation systems (Ademe and Alemayehu, 2014).

The drinking water quality is measured with reference to world health organization as well as other rule and regulations of different countries. Drinking water quality is defined as water that is free from disease producing chemical substances deleterious to health (Tebutt, 1983). Drinking water is well defined as having adequate quality in relation to its physical, chemical and bacteriological parameters to be safely used for drinking and cooking (Addisie, 2012).

The quality of water is the degree of its portability and is determined by the amount and level of physio-chemical and microbial parameters and metals (which included suspended and dissolved substances in the water). Determining water quality parameters is important to identify the quality, conditions and pollution level of surface waters. Related data must be processed and the results should be presented to specialists. One of the simplest methods to assess water quality conditions is by using water quality indices (Salman *et al.,* 2015).

Even fully protected sources and well-managed systems do not guarantee that safe water is delivered to households. The majority of the world's people do not have reliable household water connections and many of these must still physically carry water and store it in their homes. Studies show that even water collected from safe sources is likely to become faecally contaminated during transportation, container and storage (Mathew, 2011). Safe sources are important, but it is only with improved hygiene, better water storage and handling, improved sanitation and in some cases, household water treatment, that the quality of water consumed by people can be assured (Mathew *et al.,* 2011).

2.4 Factor affecting water source quality

Anthropogenic activities such as discharge of wastes from urbanized areas, industries, and agricultural runoff are factors that have a significant contribution to the deterioration of water quality (Mustapha and Aris, 2013).

Water quality is affected by both point and nonpoint sources of pollution in rural and urban areas. Some of these sources include sewage discharge, industrial activity, mining activities domestic wastes and agricultural runoff. Surface runoff from urban and agricultural areas deteriorates water quality of water bodies and this diffuse pollution is difficult to control. Since various land uses in a river catchment contribute to water pollution, it is important to look at the catchment as a whole when protecting River quality (kotti, 2005).

Runoff of pesticides leads to contamination of surface water. Pesticides are carried as dust by wind over very long distances and contaminate aquatic systems thousands of miles away (FAO, 1996). Increases in water temperature and changes in the timing and amount of runoff are likely to produce unfavorable changes in surface-water quality, which will in turn affect human and ecosystem health. The threats posed by climate change will serve as an additional stressor to many already degraded systems, particularly those in developing countries (Meehl *et al*. 2007).

Industrial activities are a significant and growing cause of poor water quality. Industry and energy production use accounts for nearly 20 percent of total global water withdrawals and this water is typically returned to its source in a degraded condition (UN WWAP, 2009).

A major activity that leads to widespread water quality problems is the disposal of human waste. Fecal contamination often results from the discharge of raw sewage into natural waters and a method of sewage disposal common in developing countries, and even in more advanced countries like China, India, and Iran (Carr and Neary, 2008).Water quality also affected by floods and droughts, as well as lack of awareness among end users (Nitasha and Sanjiv, 2015).

There are several factors, both environmental and manmade, that influence water quality. Some of the biggest Factor includes: sedimentation, runoff, erosion, DO, pH, Temperature, pesticide, detergents, household cleaners. While factors like sedimentation and run off are natural environmental process, manmade factor, including detergent and pesticides (Rooter, 2017). The challenges that disrupt the natural quality of water source so many cases. Ground and surface water quality in rural and urban environments is affected by both natural processes and anthropogenic influences. Because of this, water is becoming scarcer as the population increases across the world. Natural processes leading to changes in water quality include weathering of rocks, evapotranspiration, depositions due to wind, leaching from soil, and run-off due to hydrologic factors (Nitasha and Sanjiv, 2014).

2.5 Canadian water quality index

The Canadian Council of the Minister of the Environment Water Quality Index provides a mathematical framework for assessing ambient water quality conditions relative to water quality guidelines. It is flexible with respect to the type and number of water quality parameters to be tested, the period of application, and the type of water body (stream, river, lake). Based on the recent review of the sensitivity and behavior of the Canadian Council of Minister of the Environment Water Quality Index, it is recommended to use at least eight but not more than 20 parameters (CCMEWQI, 2017).

The selection of appropriate water quality parameters for a particular region is necessary for the CCME WQI to yield meaningful results. Clearly, choosing a small number of parameters for which guidelines are not met than if a large number of parameters are considered of which only some do not meet guidelines. It is up to the professional judgment of the user to determine which and how many parameters should be included in the CCME WQI to most adequately summarize water quality in a particular region (CCMEWQI, 2017).

The concept of the Water Quality Index (WQI) is to simplify understanding of water quality issues by merging a large amount of data and generating a score, which describes water quality conditions in simple terms such as excellent, fair, poor (Sumayah, 2018).

Water quality indices (WQIs) are necessary for simplifying the reporting of complex and technical water quality information. They are scientifically based communication models that are capable of converting multi-variable water quality data to produce a single unit less digit score that describes overall water quality (Talent and Muthukrishna, 2020).

The specific parameters, guidelines, and time period used in the CCME WQI are not specified and indeed, could vary from region to region, depending on local conditions, purpose of the use of the index, and water quality issues. The Canadian Council of the Minister of the Environment

Water Quality Index (CCME WQI) can be used for both tracking changes at one site over time and comparisons among sites. If used for the latter purpose, care should be taken to ensure that there is a valid basis for comparison. Sites should be compared when the same parameters and guidelines, time periods and numbers of samples are used. Otherwise, each site should be measured against its ability to meet relevant guidelines (CCMEWQI, 2017).The Canadian council minsters of environment water quality index relies on measures of the scope; frequency and amplitude of excursions from guidelines. The classification of its value justified as excellent, good, fair, marginal, poor based on numerical range of CCME (CCME WQI, 2001).

Table 2.1: CCME WQI categorization scheme

Rank	CCME WQI value	Description
Excellent	95-100	Water quality is protected with a virtual absence of treat or impairment; conditions very close to natural or pristine levels.
Good	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65-79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	Water quality is frequently threated or impaired; conditions often depart from natural or desirable levels.
Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Source: CCME WQI, 2017

2.6 Water quality analysis

Water quality describes the physical, chemical, and biological characteristics and conditions of Water and aquatic ecosystems, which influence the ability of water to support the uses designated for it (CCME, 2006). However, in this thesis water quality analysis is the basic methods to characterizing it accordingly to physio-chemicals means by using Canadian council minister of environment water quality index. The Canadian council of minster of the environment water quality index is a well-accepted and universally applicable model for evaluating water quality (Robert and Pirro, 2013). Assessment of water quality is essential to check the suitability of a water source for designated use. Several water quality parameters are assessed and compared with their standard values to determine the acceptability of the water to be used (Roy, 2019).

Water quality index is a means to summarize large amount of water quality data into simple terms (e.g., 'Good' or 'Bad', 'Clean' or 'Contaminated') for reporting to authorities, management and the public in a consistent manner (Gajendran, 2011).

The chemical, physical, and biological characteristics of water with respect to its suitability describe its quality (Poonam *et al.,* 2012). CCME WQI values reflected the composite assessment of changes in individual parameter concentrations along the river. Necessity of water quality analysis is to check the untreated water resource quality relative to certain parameters. At the current time people using untreated water resource at global level, continental level, country level and even local community level (Davies, 2006).

2.7 Water pollution and water borne diseases

Water is the basic needs for human beings to live with life and resist several challenges and to lead the healthy life. The main cause for water pollution is anthropogenic activities relative to naturally occurred factors. Water is considered polluted if some substances or conditions are present to such a degree that the water cannot be used for specific or desired purposes. It is created by industrial and commercial water, agricultural practices, everyday human activities and most notably, models of transportation (Owa, 2014). The pollution of water body is referred to as any physical chemical and biological change in the water body that can disrupt water quality from its desired purposes. The main actors in water pollution are anthropogenic activities relative natural phenomena. The life and activities of plants and animals, including humans, contribute to the pollution of the earth, assuming that pollution is defined as the deterioration of the existing state (Robert, 2007). There are different water body quality disturbance at source due to entrance of surface runoff as well as domestic sewage. Water pollution affects drinking water, rivers, lakes and oceans all over the world, which consequently harms human health and the natural environment (Taruna and Alankrita, 2013).

Water quality is affected by both point and non-point sources of pollution in rural and urban areas. Some of these sources include sewage discharge, industrial discharge and agricultural runoff (Nitasha and Sanjiv, 2014). As the result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells (Meride and Ayenew, 2016).

Human beings can lead the life for a number of days without food while without water cannot lead more than three days. Due to this water became named as life for all living things if it is safe in its quality. Water-borne diseases are the most prevalent infectious disease in the developing countries especially in new settlements along the river (Ejaz *et al.,* 2011).

Child diarrheal disease is a major public health concern and the leading cause of childhood mortality in much of the developing world. Globally, diarrheal disease accounts for nearly 1.6 million of the 10 million children under the age of five who die needlessly each year (Williams and Ashley, 2009). Water borne diseases are among the leading killers of children under five years old and more people die from unsafe water annually than from all forms of violence, including war (WHO, 2002). 1.8 million people a year, 90% of whom are children under five, mostly living in developing countries, die from diarrheal diseases (including cholera); 88% of diarrheal illnesses are caused by poor water quality, poor sanitation and poor hygiene (WHO,2020).

Up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water (WHO, 2004). Due to use of contaminated water, human population suffers from water borne diseases (Gorde and Jadhav, 2013).Several studies have confirmed that water-related diseases not only remain a leading cause of morbidity and mortality worldwide, but that the spectrum of diseases is expanding and the incidence of many water- related microbial diseases is increasing (WHO, 2003).

Many diseases have been associated with poor drinking water quality including diseases caused by diarrhea genic pathogens, especially in developing countries where access to a consistent water supply is a problem (Stephen and Tahiru, 2020). Diarrheal diseases represent a major health problem in developing countries and also a high risk to travellers who visit these countries (Taruna and Alankrita, 2013). Water quality and the risk to waterborne diseases are critical public health concerns in many developing countries. Today, close to a billion people most living in the developing world do not have access to safe and adequate water (UNICEF/WHO, 2012). Diarrhea remains a major killer in children and it is estimated that 80% of all illness in developing countries is related to water and sanitation; and that 15% of all child deaths under the age of 5 years in developing countries results from diarrheal diseases (WHO, 2003). In Ethiopia over 60% of the communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation Practices (WHO, 2004).

The aim of study is to ensure the quality level of the river and to check whether the river is polluted from the first point of study station up to end station. The quality level of the river can determine by Canadian water quality index. The study is established scientifically based prediction and estimation of at which point the source became more polluted and at which point the river source became less polluted. Lastly for highly polluted point what remedies should take and around less polluted point what mechanisms would take to enhance the mitigating or protecting systems of the mechanisms that give its contribution for polluting the source.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 The Study area

3.1.1 Location

Bonga city is located in the Southern Nations, Nationalities and People's Region (SNNPR) and is one of the zonal cities of kaffa and far at a distance of 454 and 784 kilometers southwest of Addis Ababa and Hawassa respectively. The city is also found at a distance of 123 and 115 km from Mizan and Jimma respectively. The Town is located between $07^{0}11^{'}$ 03''- 07^{0} 22' 05'' North latitude and between 36^{0} 11' 44'' - 36 $^{0}15^{'}$ 57 East longitudes of the zone. (Source: Bonga city asset management plan 2013-2015).

The study was carried out on the river locally named Dincha. Dincha River is a well-known River in Bonga town for all people who live in this town use it for several purposes. This River come from upstream of locally named Sheka and after some distance journey it could mixed with other the tributary. The River passing through periphery of the town up to certain kilometer distance and crossing the asphalt road and connect Mizan and Jimma road at single line locally name Sheta.

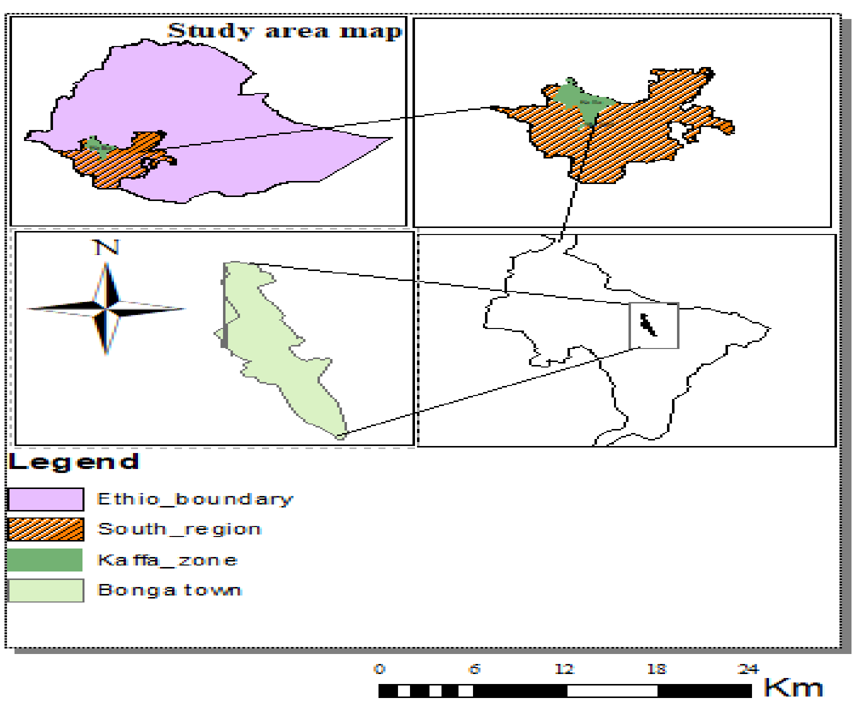


Figure 3.1: The study area

3.1.2 Climate condition

In all parts of Kaffa zone the climate condition is mostly cold, rainy and less dry season round the years. Bonga has a temperate climate, with a rainy season from May until the end of September and dry season from October to April. The average annual temperature is about 20^0C. Topographically it lies at an altitude of 1650 meters above the mean sea level and annual rainfall is 1750mm (Source: Bonga city asset management plan 2013-2015).

3.1.3 Socio economic activity

The Kaffa societies were predominantly agricultural society. Nevertheless, they also engaged in other kinds of economic activities such as livestock, exporting coffee, Civet oil, Korerima, Honey and Slaves up to Jimma carrying it on back of Donkeys and Mules (Source: Bonga city asset management plan 2013-2015). Bonga is the capital of Kaffa zone and economically important center for surrounding Twelve Woredas, and that of newly constructed Asphalt road connects capital of Ethiopia, Addis Ababa through Jimma to Mizan towns which gives better opportunity of economic activities; thus, coffee, cardamom/korerima, timiz and cultural forest Honey are the main foreign currency earning crops in this area (NABU, 2017).

In Bonga town, the major economic activities are mainly related to selling and buying agricultural products, merchandising trade of consumable goods. Economic activities related to traditional natural forest, coffee harvesting and that of honey trade is also practiced in Bonga town (NRC, 2006).

3.1.4 Population

Recently zonal applicable population data obtained from department of Kaffa zone finance and economy development, Kaffa zone water mine and energy department and Bonga town water supply and sewerage enterprise; the population number of the Bonga town is 20,885 (CSA,2007).

3.2 Research period

The research was emphasis on river water quality analysis on Dincha, Bonga for drinking purposes. This study could take five months from March up to July 2021 according to different quality parameter laboratory experiment for both winter and summer seasons from proposal preparation to final thesis defense. The laboratory experiment was carried out with the collaboration of Jimma city water and sewerage office on Boye water treatment plant laboratory center.

3.3 Research design

The frame work of the study contain from sampling stage to laboratory result analysis could be proceeded. At the end of these study the parameters analysis were conduct to check whether they are meet the Canadian Council of the Minister of the Environment Water Quality Index (CCME WQI) standards or not and discussion could be given at the end based on both two round (winter and summer season) experiment result. In this frame work of the study from source selection until result analysis including conclusion as well as possible recommendation was shown with below flow diagram of the study.

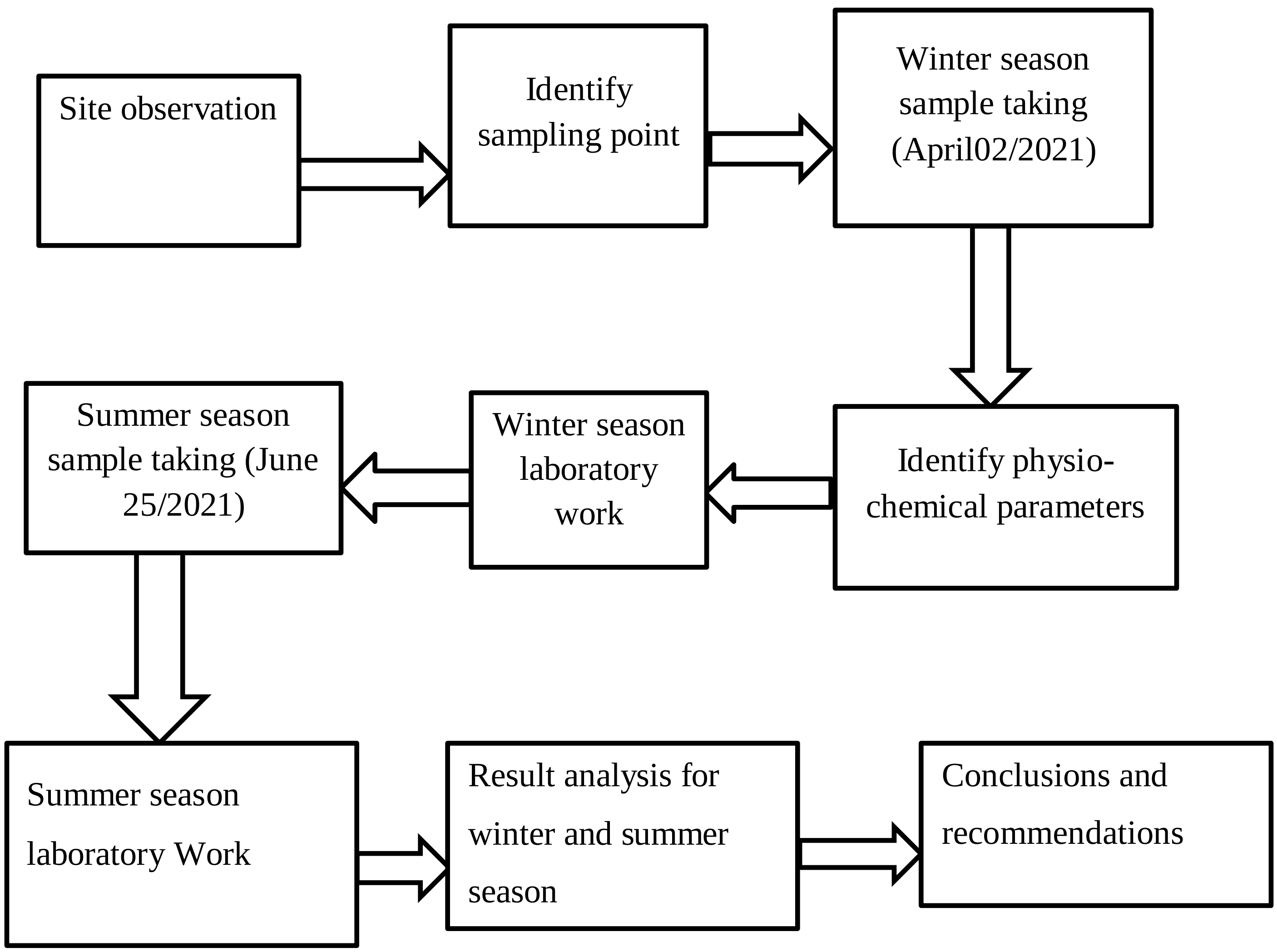


Figure 3.1: Flow diagram of the study

3.4 Existing water supply quality

The water consuming at the current situation by the community is colored, contain unpleasant taste relative to drinking water standard. According to world health organization (WHO) and CCME WQI rules and regulations, if water has color is not acceptable for drinking purpose. The source of water supply in Bonga town was a ground water resource and originated from borehole's located around Sheta. Even if ground water resources are more suitable for drinking purpose, relative to surface water resource, it didn't meet the requirement of safe water standards to drink. In the drinking water, if it has color it could contain total dissolved solids in it and while, if water has a taste it could iron content more than required standards in accordance to both national and international guideline. Therefore, the quality of the existing water supplied to the consumer is not suitable relative to drinking water standards of world health organization as well as the rules and regulations of the Ethiopia standards.

3.5 Sampling point

The criteria of selecting sampling points were based on the population density, areas of industrial or anthropogenic activities such as minerals and mining activities, and the river catchment areas (Rahmanian *et al.*, 2015). Due to these in the study area of the town there were no any industrial, mining and mineral activities, but the considerable points were agricultural area, domestic wastes from densely settled populations. Three sampling points from the River basin were selected for analyzing the physio-chemical water quality parameters of drinking water. The selected sampling points were: Sheka (1^{st} station point) the point before the river cross the Bonga town, Sheta (2^{nd} station point) the point during the River crossing the town and Dincha (3^{rd} station point) the River after crossing the town. The sample station within different River parts including coordinates and elevations reported as the following table.

Table 3.1: coordinates and elevations of different sampling stations

No	Station	X-coordinate (m)	Y-coordinate(m)	Elevation(m)	Distance of station to station (km)
1	Sheka	195411.459	805268.8095	1666	0
2	Sheta	194691.738	806197.76	1601	2.291
3	Dincha	194391.8895	806070.5679	1590	1.005

3.6 Sample collection

Dincha River sample was collected from three sampling station points namely Sheka, Sheta and Dincha were collected by one liter plastic bottles from each sampling point to represent the whole River status at winter and summer season. These collected samples from all station were transported to the laboratory room for analysis on April (winter) season and on June (summer) season to check physio-chemical water quality parameters according to WHO and CCME WQI guidelines and regulations. During taking of the sample from each station the photo was taken on site and represented at annex A.

3.7 Methods of data collection

3.7.1 Primary data

The primary data's were collected from observing of Dincha River basin at three selected station points. The selected site (Sheka, Sheta and Dincha) easting, northing and elevations data were taken with global position system (GPS) and also the distance between of each station was measured on the Google earth.

3.7.2 Secondary data

The data taken from primarily documented by other people or several developed websites are said to be secondary data. In this investigation work the data was taken from Bonga city municipal administration (managed document all about Bonga town), several journals and articles that are directly and indirectly related with the selected topic for the research, and different lecture notes that are received during continuous class attendance and others.

3.8 Variables

3.8.1 Dependent Variables

The dependent variable is the response variable for once investigations work. It is the factor which is observed during the determination of the analysis the effect of the independent variables. It is the variable that would change as a result of variations in the independent variable. The variable that is expected as a result at the end of the analysis in this thesis work is water quality assessments for drinking purposes.

3.8.2 **Independent variables**

Independent variables are the factors that can affect the dependent variables, both negatively and positively. With this study the independent variables are taken as the factors that determine quality analysis of water for drinking purpose. According to the standard of Canadian water quality index and water quality disturbance or variability could be carried out by both physio-chemical parameters (Color, Electrical conductivity, Turbidity, Temperature, pH, Total dissolved solid, DO, Iron, Nitrate, Nitrite, Sulphate, Phosphate, Total hardness). The water quality at each sampling station point, the dosage of reagent used in laboratory, sanitation of the materials that hold the samples, equipment used in the laboratory, temperature of the samples during transportation services, season of analysis, standard of the equipment and others could determines the water quality analysis in the study.

3.9 Physical parameters

The drinking water should be fairly clear (i.e., of low turbidity and color) and contain no compounds that cause offensive taste, odor, free of substances as well as organisms that causes Corrosion or encrustation of water supply system (MOWR, 2002). The physically categorized water quality parameters are, Turbidity, Color, Electrical conductivity and Temperature. Below shown as the following table it is describes that the physical parameters winter and summer seasons and maximum permissible level of Ethiopian standards model.

Table 3.2: Physical Characteristics of Drinking Water Quality

Characteristics	Maximum permissible level (MPL)	Test methods
Color(TCU)	15	ES ISO 7887
TDS (mg/l)	1000	ES ISO 609
Turbidity(NTU)	5	ES ISO 7027

Sources: National Drinking Water Quality monitoring and surveillance strategies, 2011, Addis Ababa

3.10 Chemical parameters

Chemical impurity of drinking water supply sources may be caused due to natural sources such as; certain industries and agricultural exercises. While toxic chemicals are present in drinking water, there is the risk that they may cause either acute or chronic health effects. Chronic health effects are more common than acute effects because the levels of chemicals in drinking water are rarely high enough to cause acute health effects (Benignos, 2012). Several of the inorganic elements for which maximum permissible levels have been settled are recognized to be essential elements in human nutrition. No attempt has been made here to define a minimum desirable concentration of such substance in the drinking water. The chemically categorized water quality parameters are Nitrate, Nitrite, Total hardness, Iron, Phosphate, pH, and Sulphate. Below the following table describes that the chemical parameters, maximum permissible level and its test methods.

Table 3.3: Chemical Characteristics of Drinking Water Quality

Characteristics	Maximum permissible level (MPL)	Test methods
Nitrite	3	ES ISO 6777
Iron	0.3	ES ISO 6332
Total hardness	300	ES ISO 607
Nitrate	50	ES ISO 7890-3
Sulphate	250	ES ISO 9280
pH	6.5-8.5	ES ISO 1052-3

Sources: National Drinking Water Quality monitoring and surveillance strategies, 2011, Addis Ababa

3.11 Physio-chemical Water Quality parameters and laboratory procedures

Water quality analysis is progressed at the laboratory after samples was obtained from different station point for several desired purposes according to world as well as country level rules and regulations. All laboratory experiments were done with the collaboration of Jimma zone water supply and sewerage authority at Boye water treatment center. Determining water quality parameters is important to identify the quality, conditions and pollution level of surface waters (Salman *et al.*, 2015). The procedure, apparatus and reagent were tabulated at the annex B1 and B2 while the laboratory experiment for both physical and chemical parameters were carried out and presented in image format at annex C1 and C2.

3.12 Determination of the CCME WQI

The Water Quality Index (WQI) is calculated using the Canadian Council of Ministers of the Environment Index method. After the body of water, the period of time, and the parameters and guidelines have been defined, each of the three factors that make up the CCME WQI must be calculated. The calculation of F1 and F2 is relatively straightforward, while F3 requires some additional steps. It has been determined that the contribution of the first term (F1) to the final CCME WQI score is greater than the contribution of the other two terms. The following expressions are used to determine the WQI for this study.

F1 (Scope) represents the percentage of parameters that do not meet their guidelines at least once during the time period under consideration ("failed parameters"), relative to the total number of parameters measured.

$$\mathbf{f1} = \left(\frac{\textbf{number of failed parameters}}{\textbf{total number of parameters}}\right) * \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3.1$$

F2 (Frequency**)** represents the percentage of individual tests that do not meet guidelines ("failed tests"):

$$\text{f2} = \left(\frac{number\ of\ failed\ tests}{total\ number\ of\ test}\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3.2$$

F3 (Amplitude**)** represents the amount by which failed test values do not meet their guidelines.
F3 is calculated in three steps.

There are three steps to calculating f3:

I. Calculate the amount of excursion: that means the number of times by which an individual concentration is greater than (or less than, when the guideline is a minimum) the guideline is termed an "excursion" and is expressed as follows.

a) When the test value must not exceed the guideline (less than) :

$$\text{Excursion} = \frac{\textbf{failed test value i}}{\textbf{objective j}} - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3.\ 3$$

b) For the cases in which the test value must not fall below the guideline (greater than) :

$$\text{Excursion} = \frac{objective\ j}{failed\ test\ value\ i} - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3.4$$

Calculation of the normalized sum of excursions (nse): the collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their guidelines and dividing by the total number of tests (both those meeting guidelines and those not meeting guidelines). This parameter, referred to as the normalized sum of excursions, or nse, is calculated as

$$nse = \sum_{i=1}^{n} \left(\frac{excrusioni}{number\ of\ tests}\right) \quad \text{………………………………………………….. 3.5}$$

II. Calculation of F3: F3 is calculated by an asymptotic function that scales the normalized sum of the excursions from guidelines (NSE) to yield a range between 0 and 100.

$$f3 = \frac{nse}{0.01nse + 0.01} \quad \text{……………………………..……………………………….3.6}$$

F1, F2, and F3 are combined to determine the CCME WQI using the following formula**:**

$$CCME\ WQI = 100 - \frac{\sqrt{f1^2 + f2^2 + f3^2}}{1.732} \quad \text{……………………………………...... 3.7}$$

Where, the factor 1.732 is used to normalize the WQI 0 to 100.

Table 3.4: Standard value of water quality according to international agency

Parameters	SI units	CCME	WHO
Color	TCU	15	15
EC	µS/cm	400	400-1200
Temperature	^{0}C	25	30
TDS	mg/l	500	1000
Iron	mg/l	0.3	0.3
Turbidity	NTU	5	5
Nitrite	mg/l	0.05	3
Sulphate	mg/l	500	250
DO	mg/l	5	6
Total hardness	mg/l	500	300
Nitrate	mg/l	50	50
Phosphate	mg/l	0.05	0.05
pH	mg/l	6.5-9	6.5-8.5

Source: WHO, 2014; CCME, 2017

CHAPTER FOUR

4 RESULTS AND DISCUSSIONS

4.1 Characterization of physio-chemical water quality Parameters

The water quality can be characterized based on different physio-chemical and biological parameters. However, under this study only certain physio-chemical parameters were analyzed to decide the Dincha River according to drinking purposes. Water quality parameters were analyzed with reference to Canadian index for drinking purposes and the geographical location of the sampling points were selected based on considerable pollution sources during flow of the River from upstream to downstream environment of the study area. Therefore, in Dincha River the laboratory investigation is carried out on three stations with consideration of farmland waste, surface runoff and domestic waste. The parameters are investigated according to world health organization and Canadian council of minister of water quality index. The following figure represents that certain both physical and chemical parameters carried out to this thesis work.

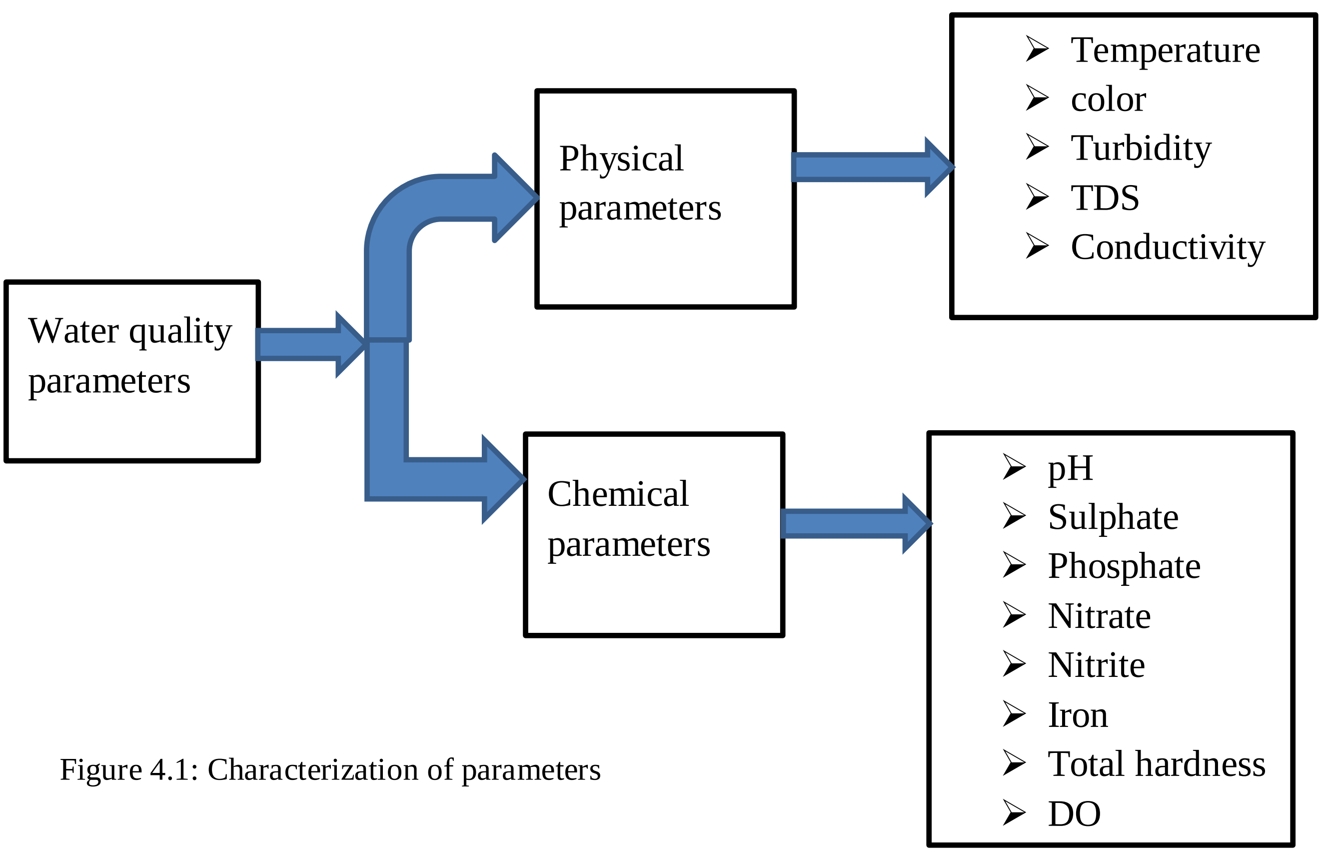


Figure 4.1: Characterization of parameters

4.1.1 **The River basin and sampling stations of Dincha River**

The Dincha River in the Bonga town flows across and around all peripheries of settlement of the town. During crossing the town, river could able to contamination probability firstly at station one or Sheka due to the appearance from the upper stream of the River source to contamination point with the town's surface runoff, residential and domestic wastes. As the result of entrances the above man-made and natural factors, at all three various stations point namely Sheka, Sheta and Dincha the same numbers of thirteen parameters were analyzed on Boye laboratory room. The following figure 4.2 represents the station points of sampling and their distance from each of them that measured on Google earth.

Figure 2.2: Extracted Google earth map of River basin and location of stations

The selected thirteen physio-chemical parameters at all stations point are conducted for 1st season on April 2/2021 and 2nd season June 25/2021 on Boye laboratory rooms and the results of them were shown in detail on the following tabular format.

Table 4.1: Physio-chemical lab result in both winter and summer season

Winter (April) season lab results of Dincha on thirteen physiochemical parameters				
Parameters	SI units	1st station (Sheka)	2nd station (Sheta)	3rd station (Dincha)
Turbidity	NTU	6	12	4
DO	mg/l	8.01	8.02	8.02
Color	TCU	100	150	63
Temperature	°C	19.6	19.8	19.7
TDS	mg/l	150	125	160
EC	µS/cm	315	260	324
pH	-	8.41	7.72	6.94
Iron	mg/l	0.7	1.7	1.9
Phosphate	mg/l	2.6	0.25	0.71
Nitrate	mg/l	0.77	0.26	0.91
Nitrite	mg/l	0.06	0.12	0.08
Sulphate	mg/l	26	32	28
Total hardness	mg/l	460	520	560
Summer (June) season lab results of Dincha on thirteen physiochemical parameters				
Parameters	SI units	1st station (Sheka)	2nd station (Sheta)	3rd station (Dincha)
Turbidity	NTU	23	16	13
Color	TCU	210	138	129
TDS	mg/l	86.1	109	110
EC	µS/cm	174.1	218	220
Temperature	°C	18.1	17.4	17.3
pH	-	6.81	6.76	6.46
Iron	mg/l	0.53	0.74	0.3
Phosphate	mg/l	0.81	1.34	0.96
Sulphate	mg/l	27	18	34
Nitrate	mg/l	1.06	0.91	0.34
Total hardness	mg/l	570	556	540
DO	mg/l	11.58	11.4	11.38
Nitrite	mg/l	0.23	0.47	0.02

The overall characterized parameters and lab experiment value of Dincha River at stations for both seasons were graphically represented at annex F1, F2, F3 respectively.

4.1.2 **Physio- chemical parameters**

The physio-chemical parameters directly related to the safety of the drinking water to human consumption. The physio-chemical water quality parameters provide important information about the health of a water body. These parameters are used to find out the quality of water for drinking purpose. The physical and chemical water quality parameters analyzed in the laboratory were color, Turbidity, Temperature, Electrical Conductivity (EC), Total Dissolved solid (TDS), pH, Total hardness, Nitrate, Nitrite, Phosphate, Sulphate, Dissolved oxygen and Iron.

I. Physical parameters

a. Electrical conductivity

The value of electrical conductivity in water body depends on the amount of total dissolved solids in it and represented as the following table.

Table4.2: Electrical conductivity

Electrical Conductivity (µS/cm)			
	station -1	station -2	station -3
Standards	400	400	400
Winter	315	260	324
Summer	174.1	218	220

The observed values of Electrical Conductivity value in Sheka vary from 315µS/cm to 174.1 µS/cm, in Sheta 260 µS/cm to 218 µS/cm and in Dincha the electrical conductivity value could vary from 324 µS/cm to 220µS/cm. All station points (Sheka, Sheta and Dincha) have electrical conductivity values of 174.1, 200, 218, 220, 315, 324 µs/cm respectively. At all station the electrical conductivity values are decreased in summer season because the EC capacity of light enters into a water body became decrease as total dissolved increases. All the recorded values are within the range of CCME WQI maximum permissible value of 400µs/cm .Therefore, there May not critical or risky to quality matter according to the Canadian water quality standard.

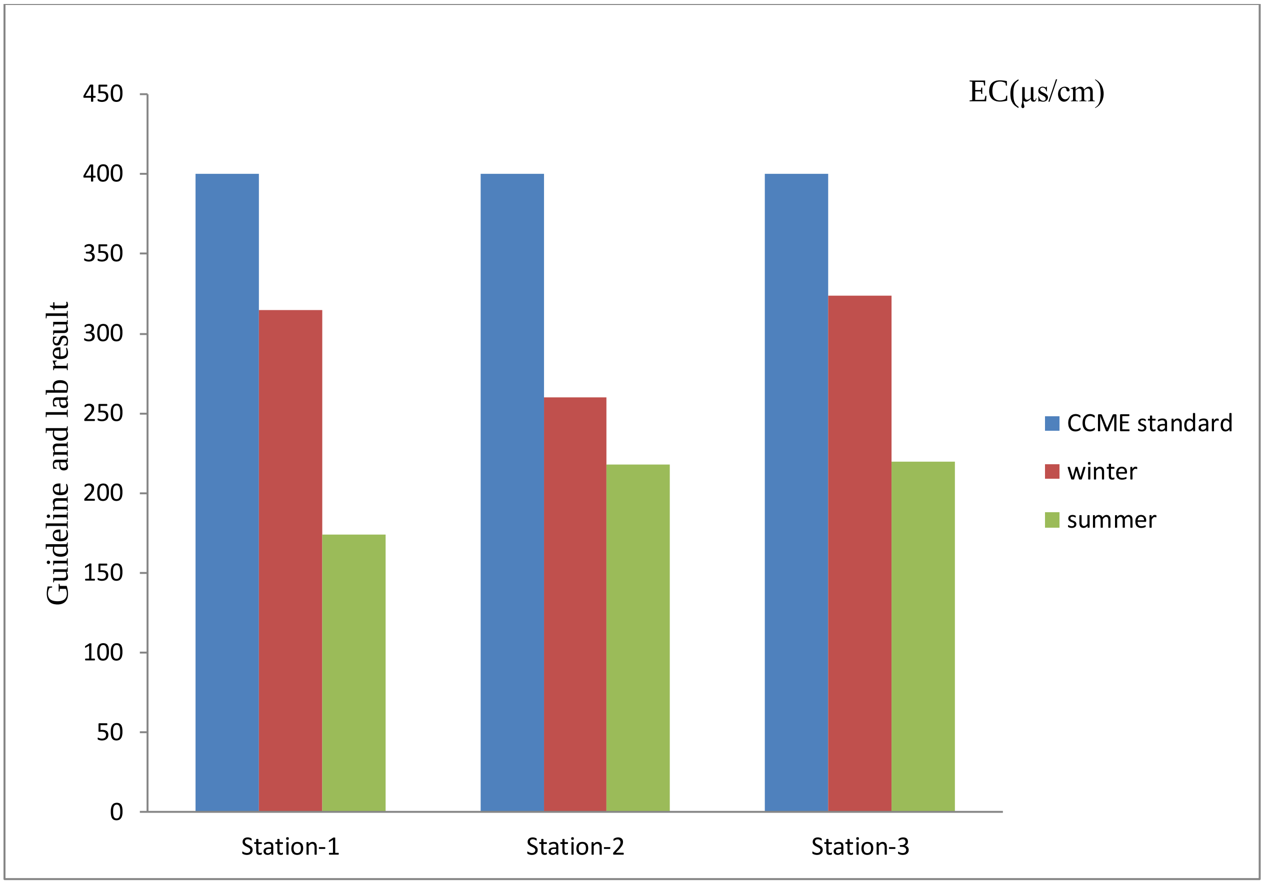


Figure 4.3: Electrical conductivity lab results and CCME standard

As we see from this graph, the electrical conductivity value in both winter and summer season does meet the CCME, WQI guideline. However, relative to summer the highest value recorded in winter season in all station.

b. Temperature

Table 4.3: Temperature

Temperature (°C)			
	station -1	station -2	station -3
standards	25	25	25
Winter	19.5	19.8	19.7
summer	18.1	17.1	17.3

The analyzed value of temperature in Sheka was19.5° C in the winter season and 18.1℃ in the summer season, in Sheta 19.8℃ in winter and 17.4℃ in summer, in Dincha (the last station point) it varies from 19.70℃ to 17.30℃. The temperature value decreased in summer season rather than winter because in summer the weather condition is very cold this leads to temperature value became decreases.

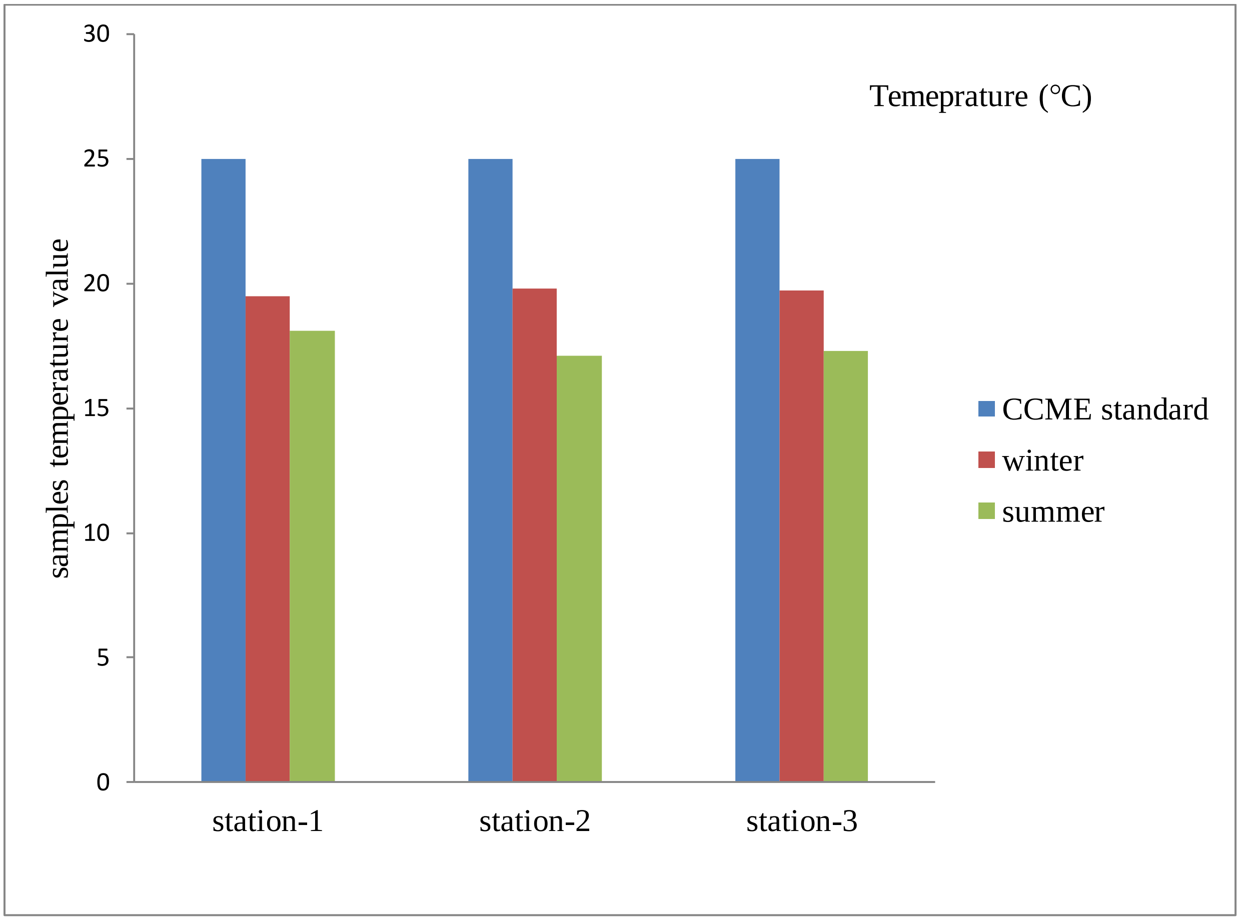


Figure 4.4: Temperature of samples

This figure shows all the analyzed value of temperature was ranging from17.1-19 .8℃, which means the Dincha river meets the maximum permissible limit of Canadian council of minister of the environment (CCMEWQI guideline) 25°C and WHO 30°C. The result recorded above indicates that the temperature at all stations don't impact seriously the other parameters.

c. Turbidity

The CCME WQI allowable maximum turbidity value and laboratory results of different stations turbidity values are recorded as the following tabulated forms.

Table 4.4: Turbidity

Turbidity(NTU)			
	station -1	station -2	station -3
Standards	5	5	5
Winter	6	12	4
Summer	23	16	13

According to the Canadian council of minister of the environment standard for turbidity, maximum allowable permissible limit value must always be low, preferably lower than 1NTU. It is recommended that for water to be disinfected, the turbidity should be reliably less than 5NTU and preferably have a median value of less than 1NTU. The analyzed values of turbidity in Sheka are 6 NTU in winter and 23NTU in summer, in Sheta in winter 12 NTU and 16 NTU in summer season, in Dincha 4 NTU in winter and 13NTU in summer. Except Dincha, at 1st season (winter) all values that recorded are greater than the CCME value 5 NTU.

Turbidity is the relative clarity of the water. It is the result of suspended solids in the water that reduce the transmission of light. Even though, in summer season the maximum turbidity was recorded at station one. This may result from more entrance of agricultural activities and surface runoff from the drainage network directly to this receiving water body. The value of turbidity shows that clearness level of the water source relative to different factors such as suspended solids, particles, inorganic matters. The turbidity values increase in summer relative to winter because turbidity is the cloudiness of water, in summer the water is turbid because high runoff is appearing than winter.

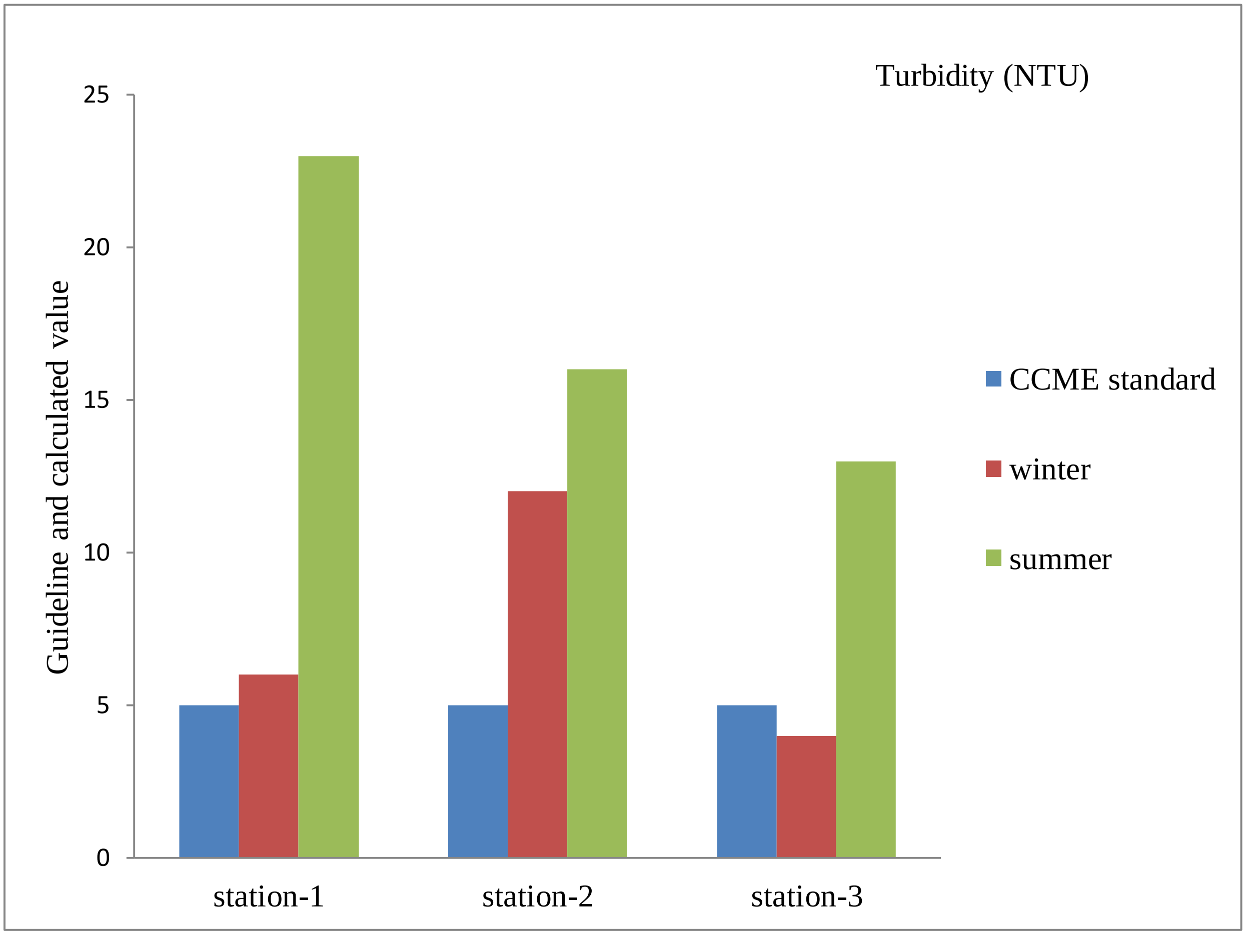


Figure 4.5: Lab results of turbidity at different station

As turbidity increase the amount of contaminant present in the sample also increases. As we understand from the above graph the turbidity value in first station and with summer season the highest value is recorded relative to others. While in winter season the highest value was recorded at the second station. At Station three or Dincha the least turbidity was recorded relative to both Sheka and Sheta station with both winter and summer seasons.

d. **Total dissolved solids**

Total dissolved solids increases the electrical conductivity became decreases as the result of water capacity became low to pass the light through it. The standard values for TDS and determined value of Dincha River basin at various stations points were tabulated as follows.

Table 4.5: Total dissolved solids (TDS)

TDS(mg/l)			
	station -1	station -2	station -3
Standards	500	500	500
Winter	150	125	160
Summer	86.1	109	110

The analyzed values of total dissolved solids in Sheka are 150mg/L in winter and 86.1mg/L in summer season, in the Sheta the TDS value are 125 mg/L, 109mg/L in winter and summer respectively, and in 3rd station (Dincha) the TDS value are160 mg/L, 110 mg/L in winter and summer season respectively. All the recorded values were within the range of CCME WQI maximum allowable drinking water quality ranges of 500mg/l**.** TDS at winter and summer seasons and at each station are presented below with graph with comparisons of CCME WQI standards.

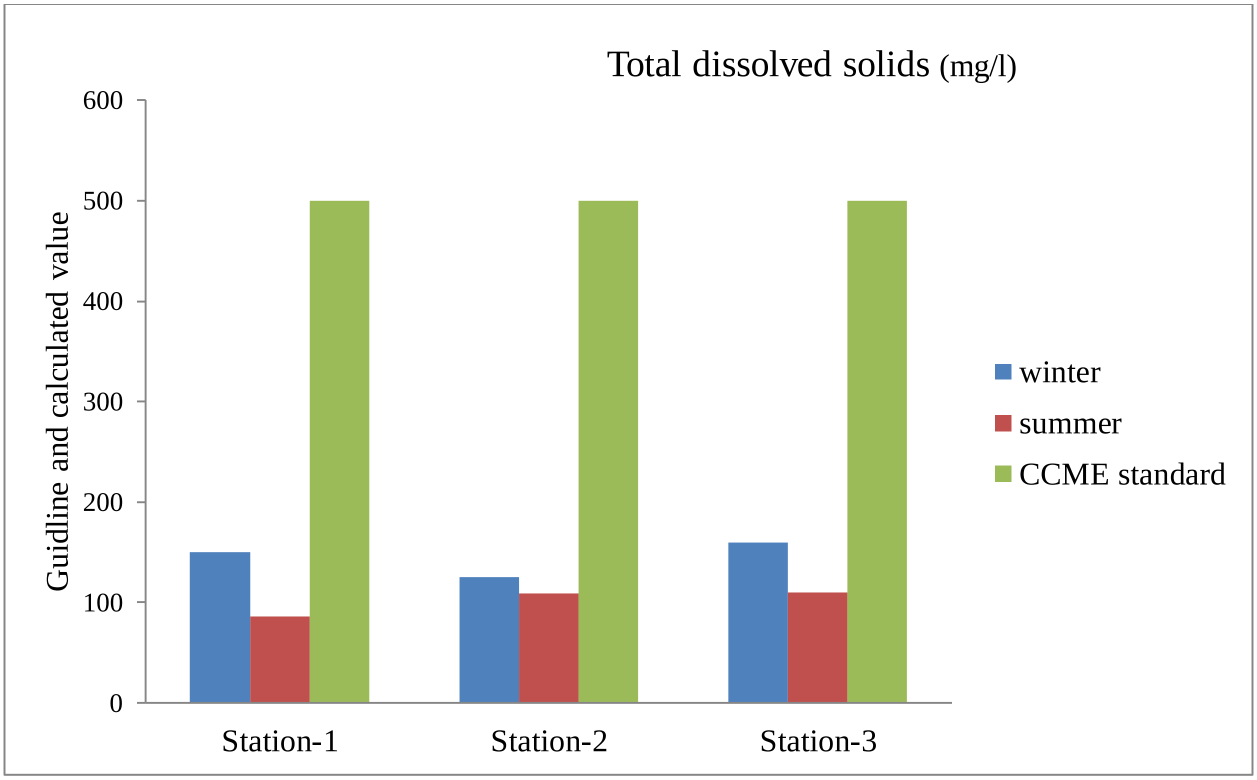


Figure 4.6: Total dissolved solids lab results of Dincha River

A total dissolved solid of the Dincha River was recorded at a range between 86.1-150 mg/l in the laboratory. The health risks are not significant as the value of TDS is much less than 500 mg/l, which is the CCME WQI standard maximum permissible limit. However, the analyzed result of the River was not risks, according to both CCME WQI and WHO standards.

e. Color

Color in any water is the indication of unknown amount of contamination in the water body. For Dincha River the color amount in true color unit for different stations and Canadian quality index standards are tabulated as the following.

Table 4.6: Color

Color(TCU)			
	station1	Station-2	Station-3
Standards	15	15	15
Winter	100	150	63
Summer	210	138	129

If water source having color, it indicates that the existence of contaminants within it at unknown amount. However, the analyzed values in Sheka were 100, 210 TCU in winter and summer season respectively. In Sheta were 150,138 TCU in winter and summer respectively, and while in Dincha are in winter season 63 TCU and in summer 129 TCU. All the value of color in this River is greater than the maximum permissible value of Canadian council of the minister of the environment water quality index value 15 TCU. The color value of Dincha River were decreased from the first station to last station at summer season because of the pollution source at station one has been caused due to the River basin appeared from the upstream of its natural state to developed urban study area that contribute surface runoff including their domestic waste.

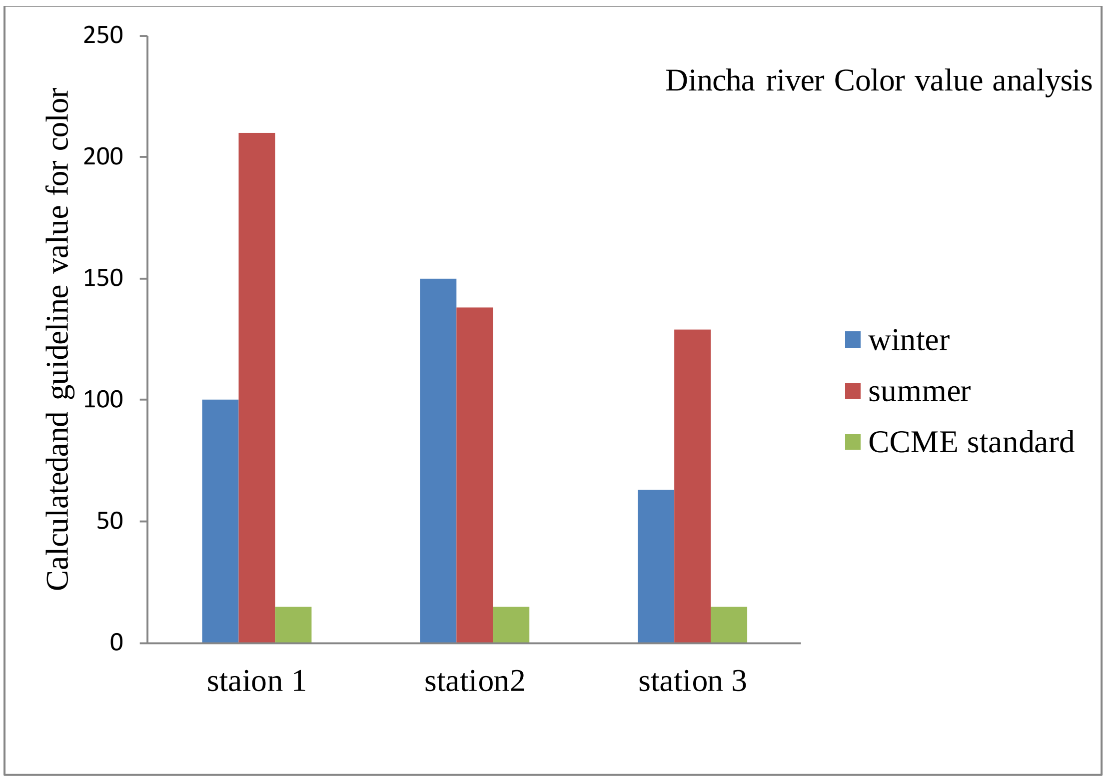


Figure 4.7: Color of the river at various stations

On the above Fig 4.7, the color value in both seasons were greater than the Canadian council of minister of the environment water quality index (CCME WQI) value 15 TCU. Therefore, the River is more turbid relative to the standards.

II. Chemical parameters

A number of parameters are categorized under chemical in a characterization of water source for certain ideas or purposes. The chemical parameters for this thesis of drinking water quality taken as the following: - Hardness, pH, Iron, sulphate, nitrite, nitrate, phosphate and dissolved oxygen.

a. pH

The value of pH governs the neutrality, acidity, and alkanity of the water sample in according to Canadian council minister of environment standards. In all stations below shown in the table represents it is recorded that Dincha River sample was both less acidic and basic conditions according to CCME because of its values were not far from the acceptable range.

Table 4.7: pH

pH			
	station -1	station -2	station -3
Standards	6.5-9	6.5-9	6.5-9
Winter	8.41	7.72	6.94
Summer	6.81	6.76	6.46

In this study, the analyzed values of pH in Sheka are 8.41 in winter and 6.81in summer, in Sheta the pH value are 7.72 and 6.76 in winter and summer respectively, and in Dincha the value of pH are 6.94 and 6.46 in winter and summer respectively. All the values are between 6.46 to 8.41. Certain pH values recorded do not exceed the maximum acceptable pH of the WHO, which ranges from 6.5 to 8.5 for quality drinking water. pH was ranges from acidic 6.46 to alkaline value 8.41. In general expressions the maximum value of pH (8.41 and 6.81) was recorded in the Sheka and minimum (6.94 and 6.46) in Dincha at winter and summer season respectively. The pH values of all the drinking water samples are found to be in the range between 6.46 and 8.41. These indicate that all pH value except at Dincha station on summer season exists within range of CCME, WQI guideline values 6.5 to 9. The lowest and highest values are recorded at Dincha in summer season and Sheka in winter season, respectively.

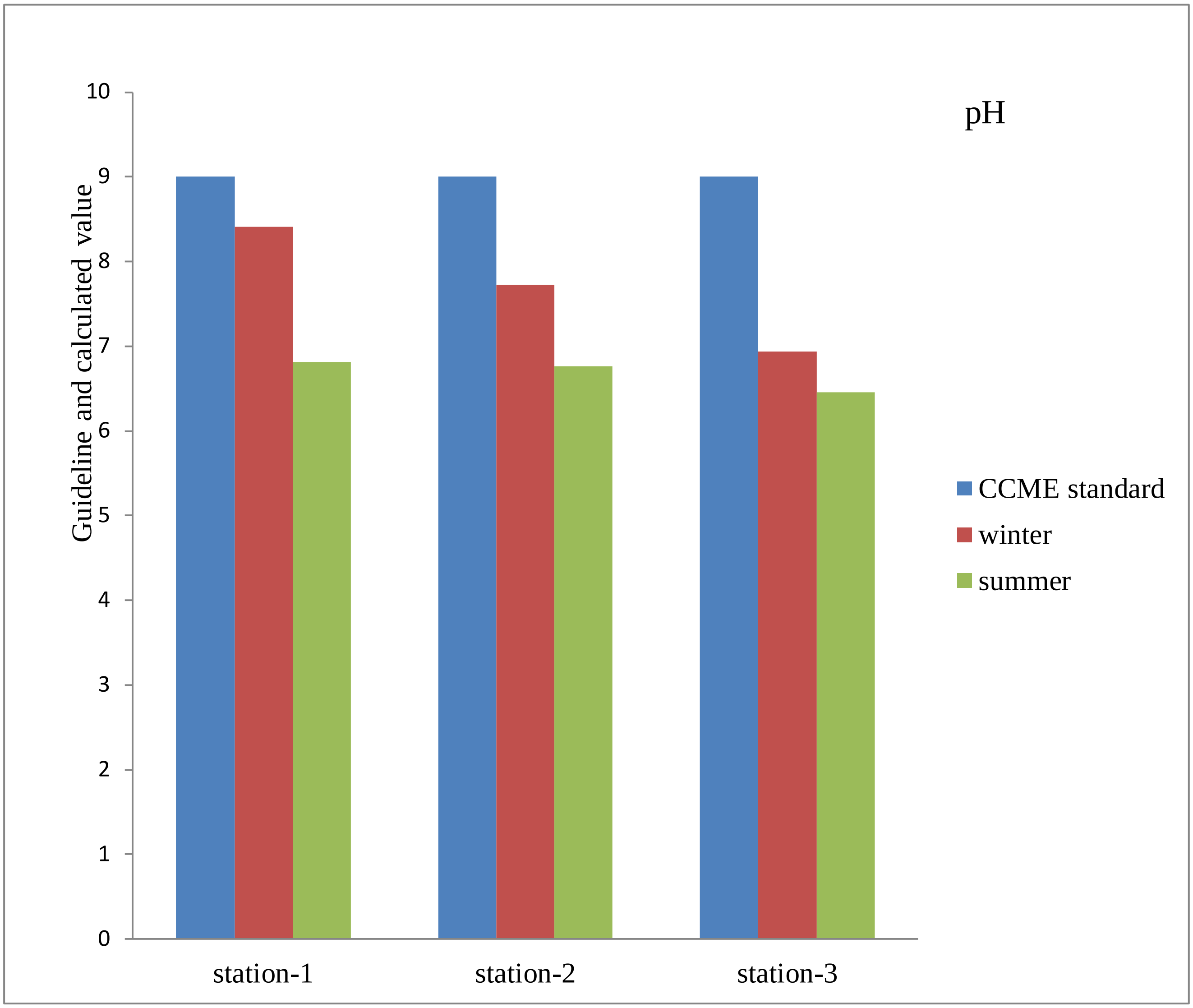


Figure 4.8: pH value of the river at different station

b. Nitrate

Table 4.8: Nitrate

Nitrate(mg/l)			
	station -1	station -2	station -3
Standard	50	50	50
Winter	0.8	0.3	0.9
Summer	1.1	0.9	0.3

In this study, the analyzed values of Nitrate in Sheka are 0.77 in winter and 1.06 mg/l in summer, in Sheta the Nitrate value are 0.26 and 0.91 mg/l in winter and summer respectively, and in Dincha the value of Nitrate are 0.913 and 0.34 mg/l in winter and summer respectively. All the values are between 0.26 to 1.06 mg/l. Therefore, all values are within the range of Canadian council of ministers of the environment guideline of 50mg/l for drinking purpose.

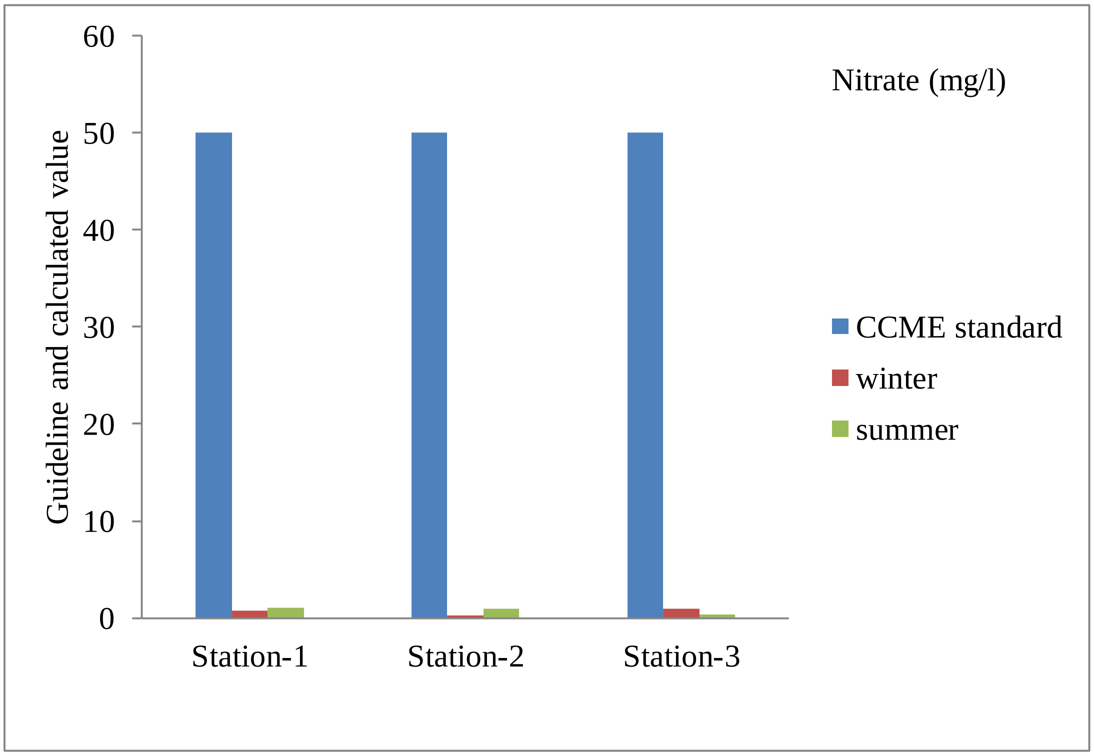


Figure 4.9: Nitrate value on different station of the River

According to CCME the Nitrate value resulted from laboratory was accepted. However, it indicates that no harmful effect on the human being as such manner amount if it present. Therefore, this water source has good manner with Nitrate parameters in all stations.

c. Nitrite

Table 4.9: Nitrite

Nitrite(mg/l)			
	station -1	station -2	station -3
Standards	0.05	0.05	0.05
Winter	0.06	0.12	0.08
Summer	0.23	0.47	0.02

The analyzed values of Nitrite in Sheka are 0.06, 0.23mg/l in winter and summer season respectively, in Sheta are 0.12,0.47mg/l in winter and summer respectively, and the Dincha are in winter season 0.08mg/l and summer 0.02mg/l. Except station three in summer season, all the value of nitrite in this River was greater than the maximum permissible value of Canadian council of the ministers of the environment water quality index value 0.05mg/l.

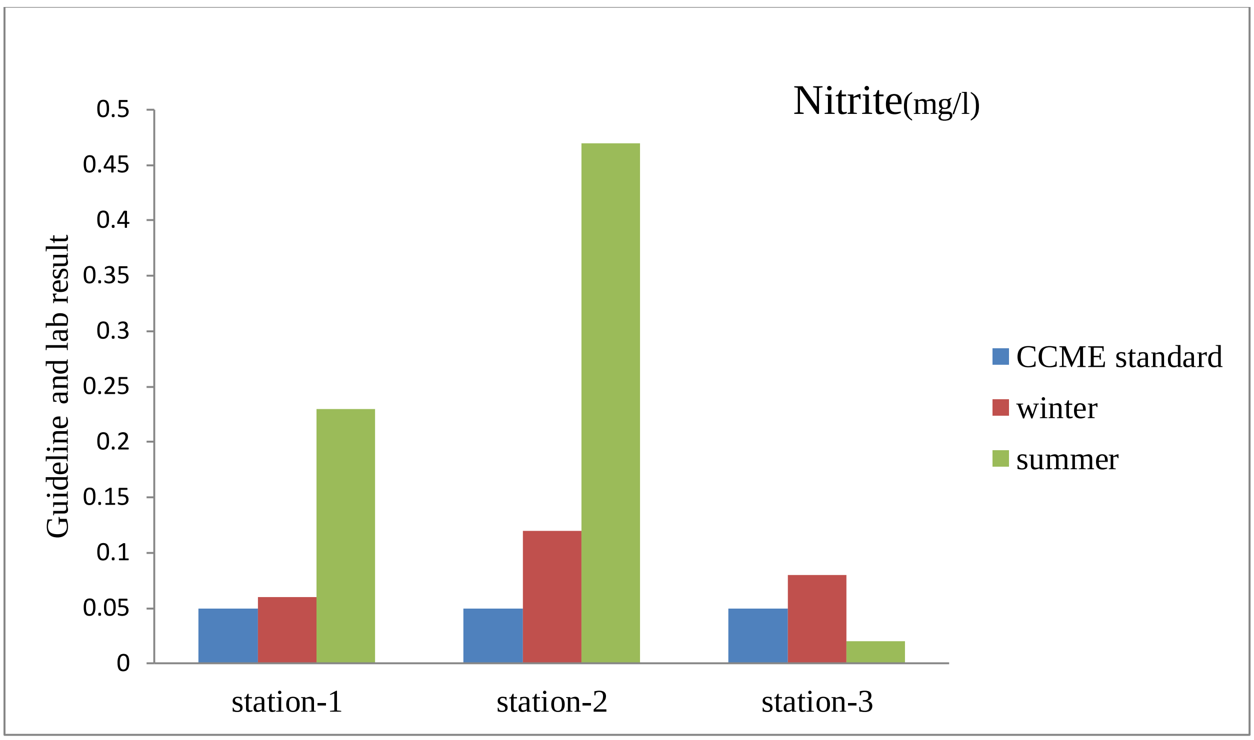


Figure 4.10: Nitrite concentration on samples

d. Total hardness

Table 4.10: Total Hardness

Total Hardness(mg/l)			
	station -1	station -2	station -3
standards	500	500	500
Winter	460	520	560
Summer	570	556	540

The analyzed values of hardness in Sheka are 460mg/l, 570 mg/l in winter and summer season respectively, in Sheta are 520, 556 mg/l in winter and summer respectively, and the point Dincha are in the winter season 560mg/l and in summer 540 mg/l.

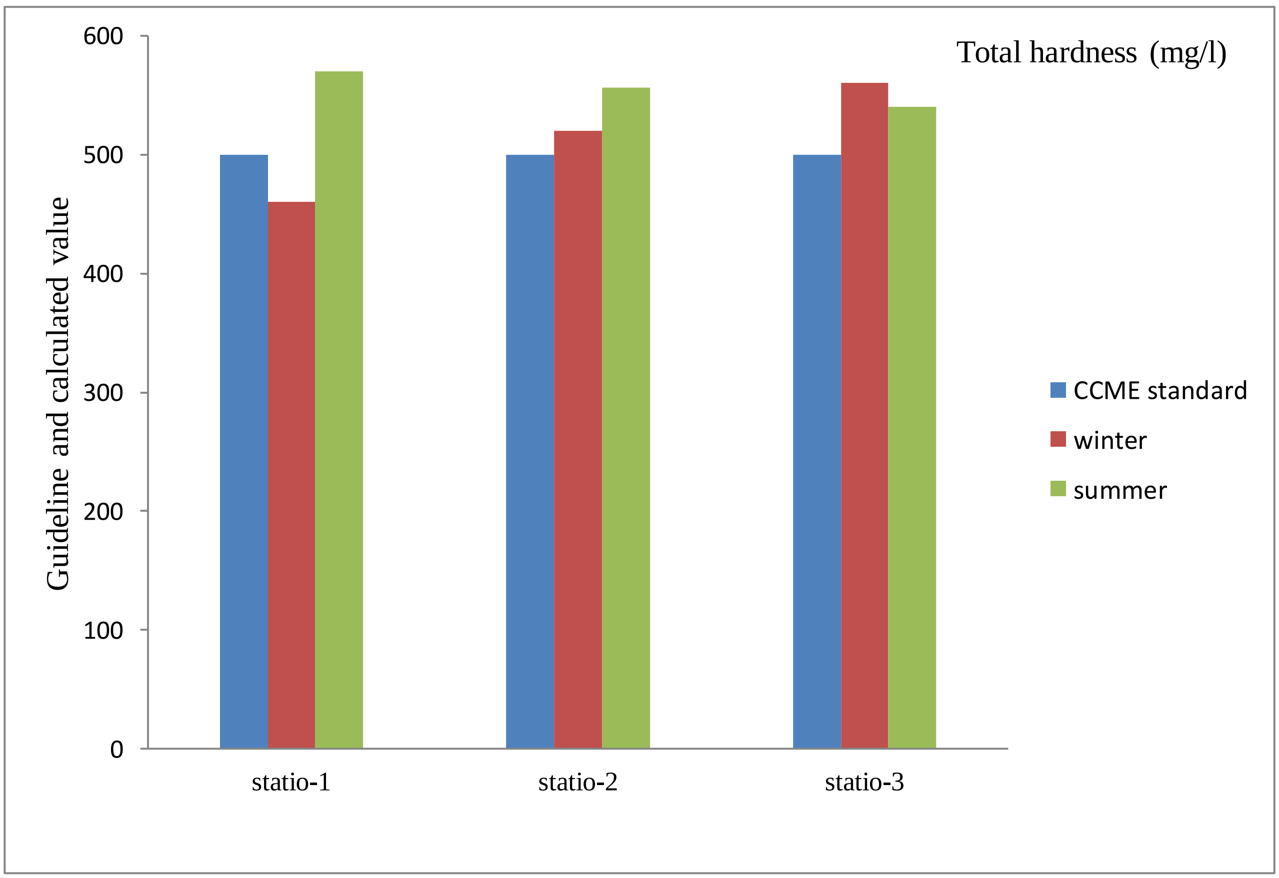


Figure 4.11: Total hardness at various stations on the River

The value of hardness in Sheka is within the objective value in winter season. But, in the 3rd stations the value of hardness in is greater than the maximum permissible value of Canadian council of the minister of the environment water quality index value. Total Hardness of Dincha River was ranging from 460-570 mg/l. Generally, the total hardness in Dincha River source greater than the permissible value which is categorized as excessively hard relative to described on the table 2.1.

e. Phosphate

Table 4.11: Phosphate

Phosphate(mg/l)			
	station -1	station -2	station -3
Standards	0.05	0.05	0.05
Winter	2.6	0.25	0.71
Summer	0.81	1.34	0.96

The analyzed values of phosphate in Sheka are 2.6 in winter and 0.81mg/l in summer, in Sheta the phosphate value are 0.25 and 1.34mg/l in winter and summer respectively, and in Dincha the value of phosphate are 0.71 and 0.96mg/l in winter and summer respectively. All the values are between 0.25 to 2.6 mg/l. All the values are greater than the objective CCMEWQI value of 0.05 for drinking purpose. The maximum value (2.6mg/l) was recorded in the Sheka and minimum value in Sheta. The high values of phosphate in Sheka are mainly due to surface water runoff and agriculture run off. All are greater than objectives of 0.05mg/l.

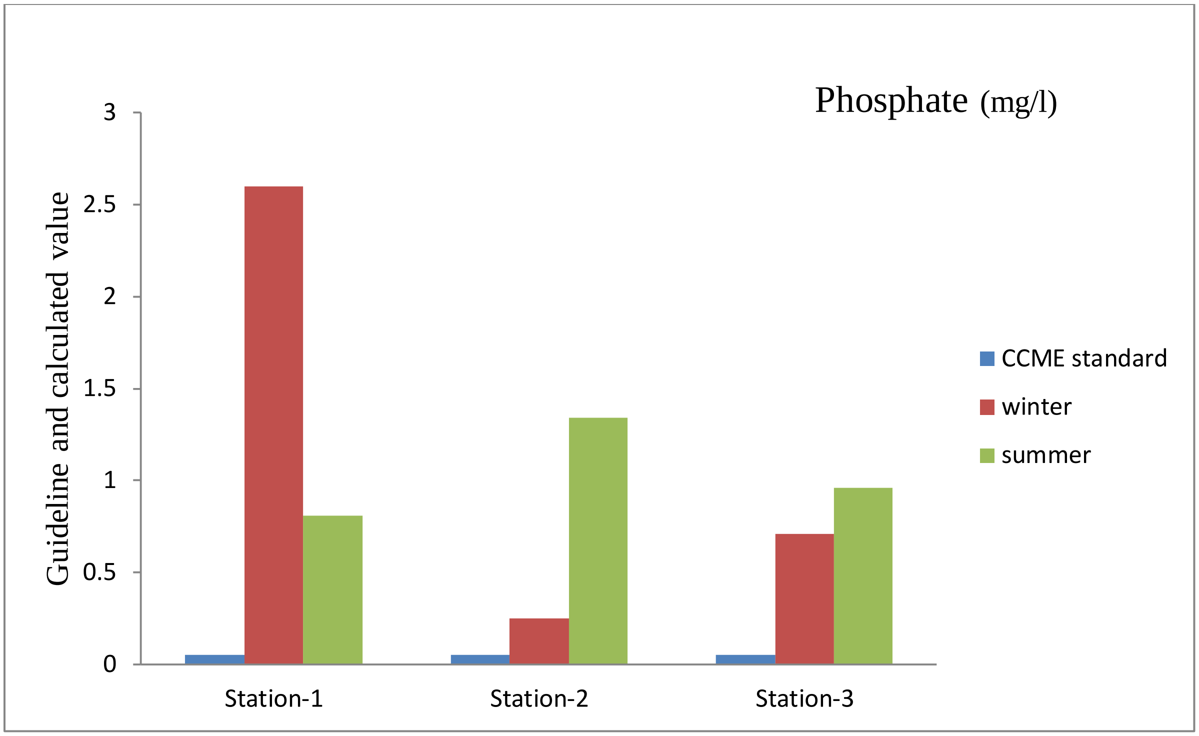


Figure 4.12: Phosphate value at different season and station

This chart indicates that the phosphate value does not meet the CCME WQI guideline; this may be due to detergents used by the population and fertilizers from agricultural land station where the sample was taken.

f. Sulphate

Table 4.12: Sulphate

Sulphate(mg/l)			
	station -1	station -2	station -3
standards	500	500	500
Winter	26	32	28
summer	27	18	34

The analyzed values of sulphate in Sheka are 26 in winter and 27mg/l in summer, in Sheta the sulphate value are 32 and 18mg/l in winter and summer respectively, and in Dincha the value of sulphate are 28 and 34mg/l in winter and summer respectively.

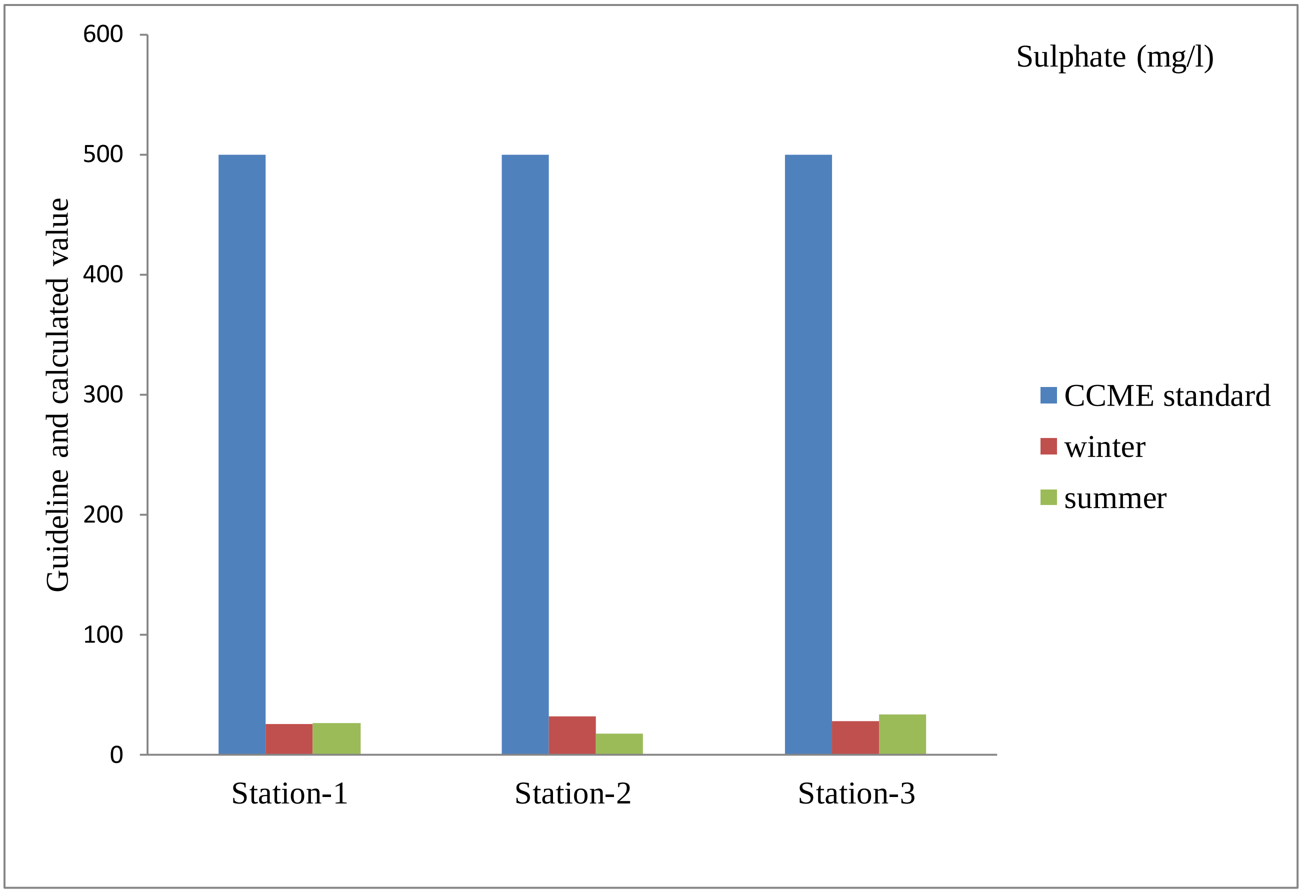


Figure 4.13: Sulphate amount in Dincha River several station

As we see from fig 4.13, the sulphate value of Dincha River ranged from 18 to 34 mg/l; these values are within the acceptable range of CCME WQI guideline of 500mg/l for drinking purpose.

g. Iron

Table 4.13: Iron

Iron (mg/l)			
	station -1	station -2	station -3
standards	0.3	0.3	0.3
Winter	0.7	1.7	1.9
summer	0.53	0.74	0.3

The analyzed values of iron in Sheka are 0.7 in winter and 0.53mg/l in summer, in Sheta the iron value are 1.7 and 0.74mg/l in winter and summer respectively, and in Dincha the value of iron are 1.9 and 0.3mg/l in winter and summer respectively. All the values are between 0.3 to 1.9 mg/l. All the values, except Dincha summer season were greater than the objective value of CCMEWQI 0.3 for drinking purpose.

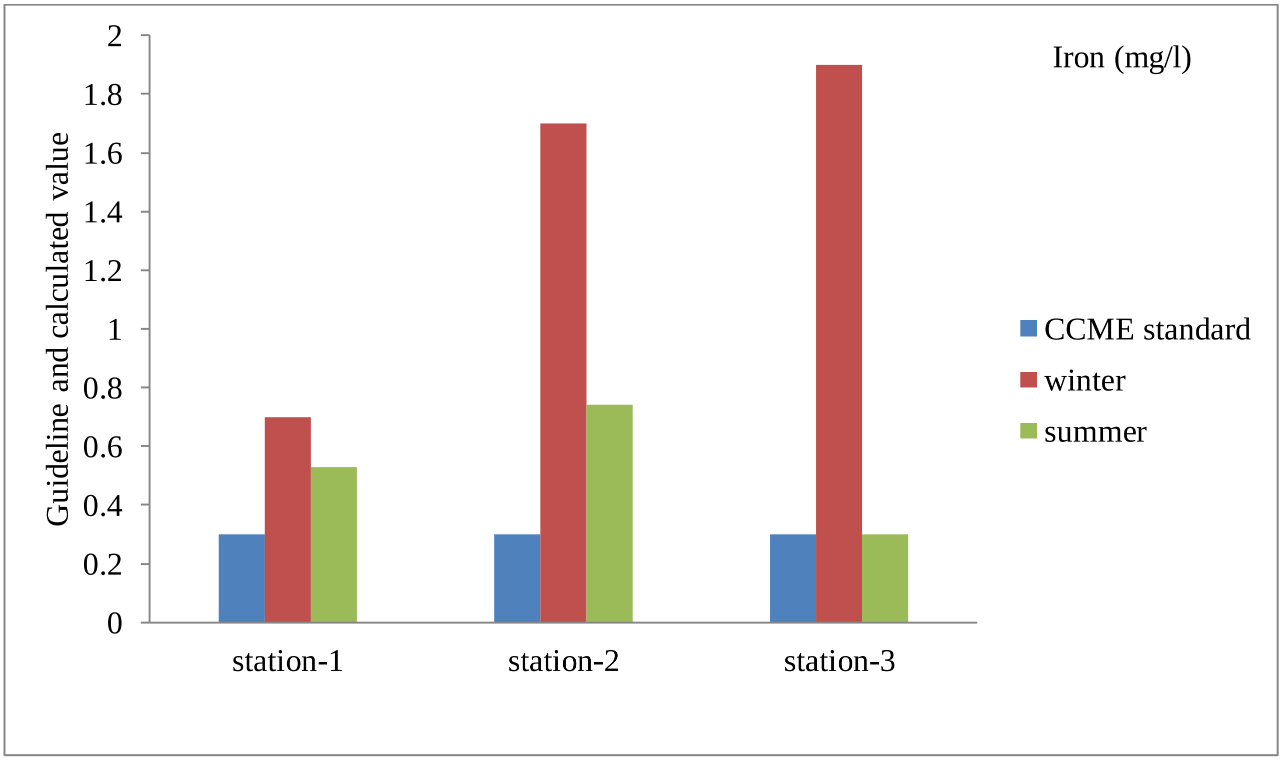


Figure 4.14: Iron concentration in the river

h. Dissolved oxygen

The amount of oxygen present in water as a dissolved form is known as Dissolved oxygen

Table 4.14: Dissolved oxygen

DO(mg/l)			
	station -1	station -2	station -3
standards	5	5	5
Winter	8.01	8.02	8.02
summer	11.58	11.4	11.38

The analyzed values of dissolved oxygen in Sheka are 8.01 in winter and 11.58 mg/l in summer, in Sheta the DO value are 8.02 and 11.4mg/l in winter and summer respectively, and in Dincha the value of DO are 8.016 and 11.38 mg/l in winter and summer respectively. The high DO in summer is due to decrease in temperature. All values are between 8.01 to 11.58mg/l and all the values are greater than the objective CCMEWQI and WHO value of 5mg/l and 6 respectively for drinking purpose.

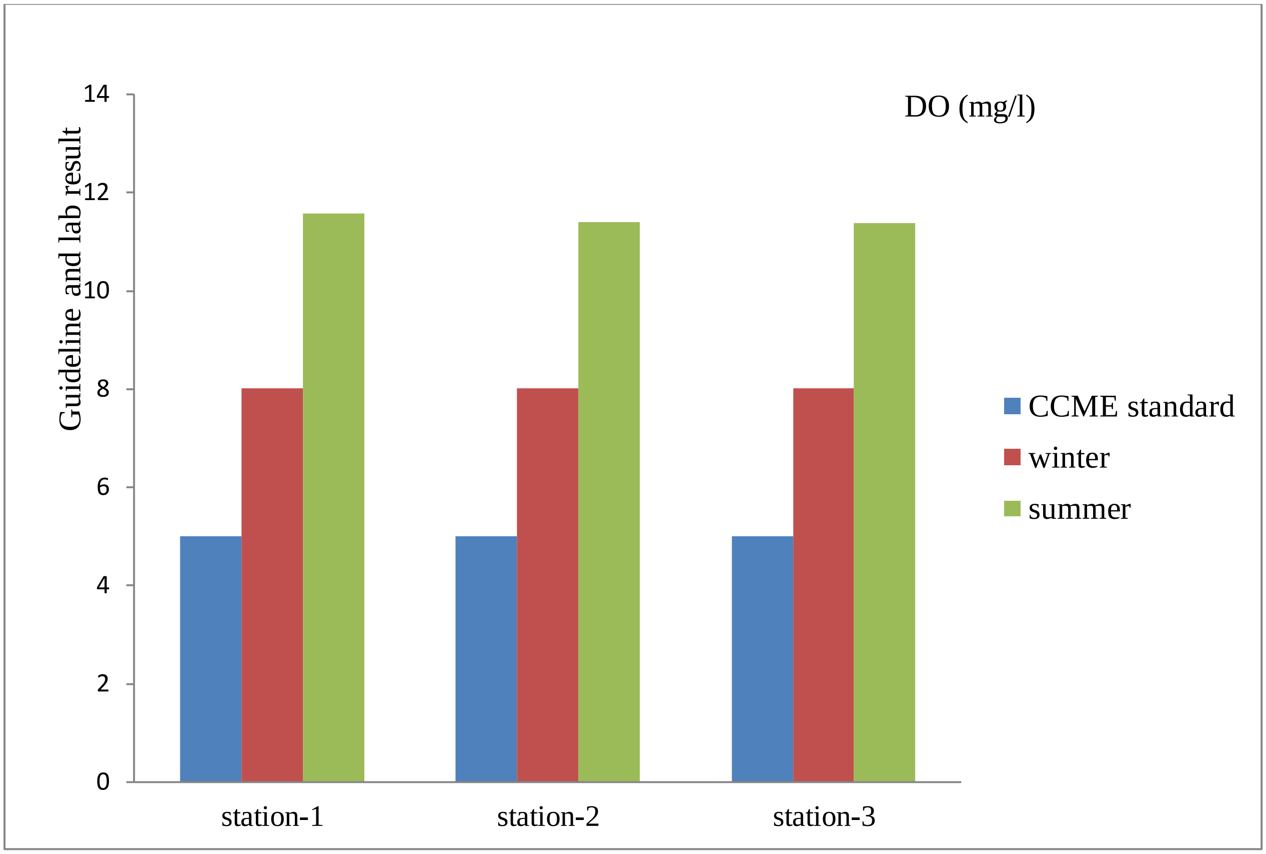


Figure 4.15: Dissolved oxygen in the river

4.2 Determination of Dincha River quality by Canadian water quality index

The water quality was ensured by different organization such as WHO, CCME, and others from century to century. However, any rule and regulations of different countries must accept the guidelines of WHO. This study guided by CCME WQI due to the value accepted or recommended and also exists within the range WHO standard. In the analysis of water quality, several variances were included such as scope, frequency, normalized sum of excursion and the amplitude of the analyzed results for Dincha River. The following table 4.14, 4.15 and 4.16

represents that sample calculation at station one according to CCME, WQI and while for the remaining two stations result were tabulated below at annex E1-E4.

Table 4.15: Laboratory result of physical parameters at station-1

	Physical parameters at station one				
	Color	Temperature	TDS	Turbidity	EC
Standards	15	25	500	5	400
Winter	100	19.5	150	6	315
Summer	210	18.1	86.1	23	174

This table indicates that, from five analyzed physical parameters except color and turbidity all are meet the CCME WQI standards.

Table 4.16: Laboratory result of chemical parameters at station-1

Chemical parameter at station one								
	Hardness	Nitrite	Nitrate	Sulphate	Iron	DO	Phosphate	Ph
Standards	500	0.05	50	500	0.3	5	0.05	6.5-9
Winter	460	0.06	0.77	26	0.7	8	2.6	8.4
Summer	570	0.23	1.06	27	0.53	12	0.81	6.8

At station one from eight analyzed chemical parameters only two (nitrate and sulphate) parameters could able to meet the CCME WQI standards while the remaining couldn't meet. In general expressions from out of thirteen parameters seven of them couldn't meet the standards. By using the equation 3.1 expressed in chapter three, divide seven failed parameters and thirteen total determined parameters in the thesis were calculated as scope (f1)

Scope had been calculated by using equation 3.1

$f1 = \frac{7}{13} * 100$=53.85

The frequency of all determined parameters in both seasons were calculated by using equation 3.2 by dividing total failed test to total determined test in the laboratory as the following. The frequency value was calculated with equation 3.2

$$f2 = \frac{13}{26} * 100 = 50$$

F3 (Amplitude**)** represents the amount by which failed test values do not meet their guidelines. It was calculated by using the equation 3.3 and it has three steps.

Table 4.17: Excursions

fail test value(A)	100	210	570	0.06	0.23	0.7	0.53	8.01	11.6	6	23	2.6	0.81
objectives(B)	15	15	500	0.05	0.05	0.3	0.3	5	5	5	5	0.05	0.05
excursion (A/B-1)	5.67	13	0.14	0.2	3.6	1.33	0.77	0.6	1.32	0.2	3.6	51	15.2
sum of excursion	96.62												

By using equation 3.5 normalized sum of excursion

$$nse = \sum_{n=1}^{26} \left(.\frac{96.62}{26}\right) = 3.72$$

Using equation 3.6 amplitude could be calculated as the following

$$f3 = \frac{3.72}{0.01*3.72+0.01} = 78.80$$

and generally CCME should be determined as equation 3.7

CCME WQI = 100- $\sqrt{}$ ($f1^2$+$f2^2$+$f3^2$)/ 1.732

CCME WQI= 37.79

Table 4.18: General calculated value of CCME WQI in Dincha River

Station	F_1	F_2	nse	F_3	CCME WQI value	Rank
Sheka	53.85	50	3.72	78.8	37.79	Poor
Sheta	53.85	53.85	2.64	72.51	39.29	Poor
Dincha	53.85	42.31	1.99	66.59	43.85	Poor

The water quality level relative to Canadian index ranges from excellent or its natural condition to poor or threatened to human beings. During over all analysis of the river for drinking purpose, the result of water quality level or status were recorded as poor as described as on the above table. This low level of WQI value in Dincha River could be attributed by 13 numbers of variables and 26 number of test along period of the study. As described on the table of scope (f1) value in all station points are the same that means the number of variable and fail variable in all stations are equal, the frequency (f2) is different in all station this is because of the number of fail tests are differ from one each other, if the number of fail tests increase the frequency also increase, normalized sum of excursion are decrease from Sheka to Dincha which is directly related to amplitude (f3). Therefore, if amplitude decrease the normalized sum of excursion also decrease as we see in table and finally amplitudes are inversely related to CCME, WQI value. After all laboratory experiment has been conducted and results analysis, CCME, WQI value for Dincha River at each station were equal to 37.79, 39.29 and 43.85 respectively. Therefore, the quality of river is Poor based on the category of CCME, WQI and this indicates that Dincha River source depart from its natural status or frequently impaired as described on table 4.18.

Table 4.19: The CCME WQI range and analyzed value of Dincha River quality category

Rank	CCME WQI of Dincha River basin	CCME WQI range	Description
Excellent	-	95-100	Water quality is protected with a virtual absence of treat; conditions very close to natural or pristine levels.
Good	-	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	-	65-79	Water quality is usually protected but occasionally threatened; conditions depart from desirable levels.
Marginal	-	45-64	Water quality is frequently threated or impaired; conditions often depart from natural or desirable levels.
Poor	Sheka-37.79 Sheta-39.29 Dincha-43.85	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

4.3 The water quality Status of Dincha River

The overall quality status of Dincha River was analyzed according to thirteen physio-chemical parameters with the experiment that was done on Boye laboratory room that administrate under Jimma town water supply and sewerage offices. For two consecutive winter (April) and summer (June) season's laboratory works were carried out on samples that were taken from three different stations. After determining the water quality index, first of all failed and an accepted value of different parameters could be identified relative to Canadian council of ministers of the environment for all parameters and stations. Therefore, the above table 4.14 and table: 4.15 shows that several parameters that were greater than and accepted value relative to the maximum permissible limit of Canadian council minister of environment at locally named Sheka or station-1 while the remaining were represented with table annex E1-E4. Even if some parameters were exist within the range of CCME WQI, but most of them couldn't meet the requirements of the guideline. Therefore, the quality level of the river at all stations was polluted according to Canadian water quality rule and regulations for desired drinking purposes. The above value indicates that at all stations the quality assurance value shows the failed category to the proposed idea in terms of human being health. The main target of this study was conduct to find out the optional water source for drinking water supply purpose if the result of laboratory permits according to CCME QWI standards. However, the source is not accepted to desired drinking purposes.

CHAPTER FIVE

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Three stations were selected on Dincha River basins to identify and determine the quality of source for drinking purpose in water laboratory room that was conduct on photometer and waterproof instrument. The Sheka station was more polluted relatively because of the River source first join at upstream of study area with the surface runoff from agricultural activities.

The study was conduct for winter and summer seasons to know the variations of River quality in terms of physio-chemical parameters. Among them at summer season the quality was fluctuate at all stations due to the several pollutants load such as surface runoff and domestic wastes were enter into the River.

Thirteen physio-chemical parameters were analyzed within the laboratory on Dincha River sample for drinking purposes. Two physical (turbidity and color) and five chemical (phosphate, nitrite, iron, DO and hardness) parameters were not accepted for drinking purposes according to the reference point of CCME WQI. Therefore, from all analyzed physical parameters 40% of them were exist in failed category and from analyzed chemical parameters 62.5% of them were failed for desired purpose in all stations.

Dincha River status was existing in the range of poor from the reference point of Canadian council ministers of environment as determined value in laboratory that was less than 44. Generally the natural condition of the River were depart from the allowable range between good that is greater than 44 to excellent that equal to 100 in percent

5.2 Recommendations

- The source of Dincha River was more polluted at upstream station site relatively to downstream station site. Therefore, the entrance of agricultural surface runoff into the River should be protecting around the periphery of basin by rejecting the agricultural activities through various fertilizers.
- The most factors that determine the quality of River source is seasonal variation. The summer season runoff concentration is greater than at winter and its amount around the urban area is critically high. So, storm water drainage system has to be required in the town to collect, convey and treat surface runoff before entering to River.
- The Dincha River source has departed from its natural condition according to determined value of Canadian council minister of environment water quality index. Therefore, the stake holder has to take the responsibility and conserve the River’s natural condition.
- The variation of water quality can cause the impact on aquatic ecosystems and alter its environment. Therefore, the community population who live around the River should take care from discharging their domestic waste into it.

REFERENCES

Addisie, M. (2012). Assessment of drinking water quality and determinants of house hold Potable water consumption in Sidima District, Ethiopia.

Ademe, A.S and Alemayehu, M. (2014). Source and determinants of water of water pollution in Ethiopia: distributed lag modeling approach. 2: 110.

Alam, M.JB.Islam, MR., Muyen, Z., Mamun, M., and Islam S. (2007). Water quality parameters along rivers. Int. J. Environ. Sci. Technol. 4(1):159-167.

Alan, C.T., Don, D. R., and Malcolm, J.B. (2000).Water Supply. (5. Eds.).Tokyo.

Allarmadji, B.B., Hongping, W., and Xia, J. (2020). Analysis and control of the physiochemical quality of ground water in the Chari Baguirmi region.

Amir, A.K., Renee, P., and Haseen, K. (2004).Modification and Application of the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) for the Communication of Drinking Water Quality Data in Newfoundland and Labrador. Water Qual. Res. J. Canada.39 (3):285-293.

Amare, S.K., Zebene, K., and Agizew, N.E. (2017). Evaluating water quality of Awash River using Water quality index. International Journal of Water Resource and Environmental Engineering.9 (11):243-253.

Andrea-M.D. (2018).Water pollution and water quality assessment of major trans-Boundary Rivers from Banat (Romania).Journal of chemistry.

Anhwange,B.A.,Agbaji,E.A., and Gimba,E. (2012). Impact assessment of Human activities and seasonal variation on River Benue, whithin Makurdi Metropolis. International Journal of Science and Technology. 2(5):248-254.

Asit, K. B. and Cecilia, T. (2019).Water quality management: a globally neglected issue. International journal of water resource development.35 (6):913-916.

Bouslah, S., Djemili, L., and Houichi, L.(2017).Water quality index assessment of Koudiat Medoar Reservoir, northeast Algeria using weighted arithmetic index method. Journal of Water and Land Development. 35(1):221-228.

Carr, G.M. and Neary, J.P. (2008).Water Quality for Ecosystem and Human Health, 2nd Edition. United Nations Environment Programmed Global Environment Monitoring System.

CCME. (2017). Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, User's Manual. In: Canadian environmental quality guidelines, (1999). Canadian Council of Ministers of the Environment, Winnipeg.

Corah, W. and Carolyn, L. (2016). Africa's failing to close the gap on providing water and sanitation.

CSA. (2007). Central Statistical Agency Population and Censes data. Addis Ababa, Ethiopia.

Chapman , D. and Kimstach, V (1996).Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. In 2nd edition. Selection of water quality variables.

Davies, J.M. (2006). Application and Tests of the Canadian Water Quality Index for Assessing Changes in Water Quality in Lakes and Rivers of Central North America. Lake and Reservoir Management. 22 (4):308-320.

Robert, E.A. (2007). Pollutant classification.In:2nd edition. Water quality control hand book. Alexandria: WEF Press.3.10-3.19.

Ejaz, M.A.Q., Amin, U.K., and Seemal, V. (2011). An investigation into the prevalence of waterborne diseases in relation to microbial estimation of potable water in the community residing near river Ravi, Lahore, Pakistan.5 (8):595-607.

Gajendran, C. (2011).Water quality assessment and prediction modeling of Nambiyar river basin, Tamil Nadu, India. 4:25-37

Girma, A., Bamboro, S., Shimselis, B., Tadesse, C., Mokonnen, M., and Gossa, T.,(2011). National Drinking Water Quality Monitoring and Surveillance Strategy.

Gorde, S.P., and Jadhav, M.V. (2013). Assessment of water quality parameters: A review. International journal engineering research and application. 3(6):2029-2035.

Idris, B.I. and Mirac, A.(2016).Water Quality Index (WQI) for Main Source of Drinking Water (Karaçomak Dam) in Kastamonu City, Turkey. Journal of Environmental & Analytical Toxicology. 6(5):1-8.

Igwe, P.U., Chukwudi, C.C., Ifenatuorah, F.C., Fagbeja, I.F., and Okeke, C.A (2017). A Review of Environmental Effects of Surface Water Pollution. International Journal of Advanced Engineering Research and Science. 4(12):128-137.

Joel, S., Ronnie, L., and Rebecca, G (2000). Drinking water turbidity and gastrointestinal illness in the elderly of Philadelphia. Journal of epidemiology and community health, 54(1):45–51.

Kumar, A., and Dua, A.(2010). Water quality index for assessment of water quality of river Ravi at madhopur (India). Global Journal of Environmental Sciences.8 (1):49-57.

Kumari, B. L., Sudhakar, P., Hanuma, S.M., Satya, K.P. and Sree, N.V (2011). Analysis of physico- chemical parameters of water quality in and around Saltpans of Prakasam (Dt.) A.P. Journal of Ecobio technology 3 (10):01.

Leta, M.K., and Dibaba,W.T.(2019). Assessment of physio-chemical parameters of Awetu River Journal of water sustainability.9 (1):13-21.

Marcello, B and George, T. (2013). Water Quality Modeling for Rivers and Streams. Water Science and Technology Library.70 (2):1-288.

Mathew D.S (2011). Assessing Drinking Water Quality at Source and Point-Of-Use: A Case Study of KoilaBamana, Mali, West Africa, Michigan Technological University.

Meehl, G.A., Stocker, T.F., Collins, W.D., Friedlingstein, P., Gaye, A.T., Gregory, J.M., Kitoh, A., Knutti, R., Murphy, J.M., Noda, A., Raper, S.C.B., Watterson, I.G., Weaver, A.J. And Zhao, Z.C. (2007). Global Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S.D., Z. Chen, M. Marquis, K.B.

Averyt, M. Tignor and H.L. Miller).Cambridge University Press, Cambridge, United Kingdom and New York.

Meride, Y and Aynew, B. (2016).Drinking water quality assessment and its effects on resident's health in wondo genet campus, Ethiopia.5 (1).

Mohammad,R.M.,Reza,S.,Ahmad,M.,Kooshiar,A.V.,Sharareh,L.,Sogol,O.,Mehrnoosh,A.and Azita,M.(2013).Assessment of water quality in ground water resources of Iran using a modified drinking water quality index (DWQI).Journal of ecological indicator.30:28-34.

Mohammed, M., Samir, S., Fayal, A. and Farrukh, J. (2013). Assessment of Drinking Water Quality and its impact on Residents Health in Bahawalpur City.

Morgan, H. (2012). Water in Ethiopia: drought, disease and death. Global majority E-journal.3 (2):110-120.

Munna, G. M.,Chowdhury, MM.I.,Masrur Ahmed,A.A., Sadia, C. and Alom,M. M.(2013).A Canadian Water Quality Guideline-Water Quality Index (CCME-WQI) based assessment study of water quality in Surma River.Journal of Civil Engineering and Construction Technology.4(3):81-89.

Mustapha, A., and Aris, A.Z.(2013). River water quality assessment using environmrtric technics:case study of jakara river basin.

Nitasha, K and Sanjiv, T. (2014). Influences of natural and anthropogenic factors on surface and ground water quality in rural and urban areas. Journal of frontiers in life science. 8 (1):23-39.

NRC, N. (2006). Assessing and reducing risk; in drinking water distribution system. Washington DC: The national academic press.

Olumana, M.D. (2018).Safe drinking water: concepts, benefits, principles and standards.

Owa, F.W (2014). Water pollution: sources, effects, control and management. International letters of natural sciences.3:1-6.

Peiyue, L and Jianhua, W. (2019). Drinking water quality and public health.11:73-79.

Poonam, P., Meenal, C., R.A, Sohony., Indrani, G., and Rakesh, K. (2012). Water quality analysis of surface water. Environmental monitoring and assessment.

Rahmanian N.,Siti Hajar,B.A.,M,Homayoonfard.,N.J,Ali.,M, Rehan.,Y,Sadef.,and A.S, Nizami.(2015). Analysis of physiochemical parameters to evaluate the drinking water quality in the state of Perak, Malaysia. Journal of chemistry.1 (1):1-10.

Robles, E., Ramirez, E., Martínez, B., Sainz, M.G. and Gonzalez, M.E (2011). Comparison of the Water Quality of Two Aquifers Established in Different Development Zones of Mexico. Universal Journal of Environmental Research and Technology. 1(2):203.

Robert, D., and Pirro, I. (2013).Evaluation of water quality index for drinking water.Pol.J.Environ.Stud. 22(4):1045-1051.

Roberts, E. A. (2006). Drinking Water Quality Control Hand Books. (s. Edition, Ed.) New York Chicago San Francisco Lisbon London Madrid Mexico.

Rooter. (2017). The biggest factors that affect water quality.

Roy, R. (2019). An introduction to water quality analysis. International journal for environmental rehabilitation and conservation.11 (2):94-100.

Roy, R.2019. An introduction to water quality analysis. International research journal of engineering and technology. 6 (1):201-205.

Salman, JM., AbdAl-Hussein, N.A., and Al-Hashimi, OAH (2015). Assessment of Water Quality of Hilla River for Drinking Water Purpose by Canadian Index (CCME WQI). International Journal of Recent Scientific Research. 6(2):2746-2749.

Sanchez-Echaniz, J., Benito-Fernandez, J. and Mintegui-Raso, S. (2001). Methemoglobinemia and the consumption of vegetables in infants.Pediatrics, 107, 1024–8.

Sarda,P.,and Sadgir,P.(2015). Assessment of multi parameters of water quality in surface water bodies. International Journal for Research in Applied Science and Engineering Technology. 38(8):331-336.

Sarita, G., S.K, Sharma and M.K,Awasthi (2015). Application of Principal Components Analysis for Interpretation and Grouping of Water Quality Parameters. International Journal of Hybrid Information Technology. 8(4):89-96.

Satish, D., C., SS. Saudi., and M.V.S.Raju (2017). Estimation of water quality index by weighted arithmetic water quality index method: A model study. International journal of civil engineering and technology.8 (4):1215-1222.

Sivaranjani, S., Amitava, R., and Samrath, S. (2015). Water quality assessment with water quality indices. International journal of bio resource science.2 (2):85.

Stephen, T.O and Tahiru, M. (2020). Escherichia coli as a tool for disease risk assessment of drinking water sources.

Sumayah, A. M. (2018). Comparison of Water Quality Indices Bani-Hassan River as a Case Study). Journal University of Kerbala. 16 (1):53-65.

Sushil, T. and Zachary, L. (2011).Water quality monitoring of prairie lake.

Talent, D.B. and Muthukrishna, V.K(2020). Development of Water Quality Indices (WQIs): A Review. Pol. J. Environ. Stud. 29(3):1-11.

Taruna, J and Alankrita, C. (2013). Assessment of water quality and its effects on the health of residents of Jhunjhunu district, Rajasthan: A cross sectional study. Journal of public health and epidemiology.5 (4):186-191.

Tibebe, D., kassa, Y., Melaku, A., and Lakew, S.2019. Investigation of spatio-temporal variation of selected water quality parameters and trophic status of Lake Tana for sustainable management, Ethiopia.Microchemical journal. 148:374-384

Twari, A.K., and Singh, A.K. (2014). Hydro geochemical investigation and ground water quality assessment of Pratapgarh district, Uttar Pradesh. J. Geol. Soc. 83(1),:329–343.

Williams and Ashley, L. (2009). Water quality and water borne disease along the Niger River, Mali: A study of local knowledge and response.

WHO (1997). Guidelines of drinking water quality.2nd edition

WHO (2004). Guideline for Drinking Water Quality.3rd edition.

WHO (2011).Guidelines for drinking- water quality, Fourth edition.

WHO (2020). Water, Sanitation and Hygiene Links to Health.

Yang, Y.S. and Wang, L. (2010). Catchment-scale vulnerability assessment of groundwater pollution from diffuse sources using the drastic method: a case study. Hydrology. Sci. J. 55 (7): 1206.

ANNEXES

Annex A: Sampling from the different points

Annex B-1 Lab procedure in physical parameters

Lab procedure in physical parameters		
Parameters	Procedures	Apparatus
Color	Switch on the photometer Adjust the photometer. Check the instrument with distilled water Add 10mL of sample into a kit Add the reagent into the 10ml kit and shake it well to mix Enter the sample into photometer: Read the color value on photometer	Waterproof Water sample Conical flask
EC	Switch on the waterproof Adjust the instrument with distilled water Prepare the 250ml conical flask Add 100ml sample into conical flask Read EC value from the instrument by inserting it into the sample	Waterproof Water sample Conical flask
Temperature	Switch on the waterproof Adjust the instrument with distilled water Prepare the 250ml conical flask Add 100ml sample into conical flask Read temperature value from the instrument by inserting into the sample	Waterproof Water sample Conical flask
Turbidity	Switch on the waterproof Adjust the instrument with distilled water Prepare the 250ml conical flask Add 100ml sample into conical flask Read EC value from the instrument by inserting it into the sample	Waterproof Water sample Conical flask
TDS	Switch on the photometer Adjust the photometer. Check the instrument with distilled water Add 10mL of sample into a kit Add the reagent into the 10ml kit and shake to mix Enter the sample kit into photometer: Read the TDS value on photometer	water sample Test kit Photometer

Annex B-2: Lab procedure in chemical parameters

Lab procedure in chemical parameters		
Parameters	Procedures	Apparatus and reagents
pH	Switch on the waterproof Adjust the instrument with distilled water Prepare the 250ml conical flask Add 100ml sample into conical flask Read the turbidity on waterproof by inserting into the sample	water sample conical flask Water proof
Total hardness	Switch on the photometer Adjust the photometer. Check the instrument with distilled water Add 10mL of sample into a kit Add the reagent into the 10ml kit and shake to mix Enter the sample into photometer: Read the total hardness value on photometer	conical flask Water sample Photometer Total hardness reagent (HI97735)
DO	Switch on the photometer Adjust the photometer. Check the instrument with distilled water Add 10mL of sample into a kit Add the reagent into the 10ml kit and shake to mix well Enter the sample into photometer Read the dissolved oxygen value on photometer	Test kit Water sample Photometer DO reagent (HI93732-01)
Iron	Switch on the photometer Adjust the photometer. Check the instrument with distilled water Add 10mL of sample into a kit Add the reagent into the 10ml kit and shake to mix Enter the sample into photometer Read the iron value on photometer	Test kit Water sample Photometer Iron reagent powder pillow
Phosphate	Switch on the photometer Adjust the photometer. Check the instrument with distilled water Add 10mL of sample into a kit Add the reagent into the 10ml kit and shake to mix Enter the sample into photometer Read the phosphate value on photometer	Test kit Water sample Photometer Phosphate reagent (HI3833)

Nitrate	Adjust the photometer or multi parameter Check the instrument with distilled water Add 10mL of sample into a glass test tube Add the reagent into the 10ml test tube and shake to mix Enter the sample into photometer: Read the value of nitrate on water proof	Water sample Photometer Nitrate reagent
Nitrite	Adjust the photometer or multi parameter Check the instrument with distilled water Add 10mL of sample into a glass test tube Add the reagent into the 10ml test tube and shake to mix Enter the sample into photometer: Read the value of nitrate on water proof	Water sample Photometer Test kit Nitrite reagent
Sulphate	Adjust the photometer or multi parameter Check the instrument with distilled water Add 10mL of sample into a glass test tube Add the reagent into the 10ml test tube and shake it to mix Enter the sample into photometer: Read the sulphate value on photometer instrument	Water sample Photometer Test kit Sulphate reagents (HI93751-01)

Annex C-1: Experimental analysis by using water proof parameters in lab

Annex C-2: Expermetal analysis by using photometr parameters in lab

Annex D-1: lab result in winter season

Winter season lab result					
Sample date	Parameters	SI unit	Station point1(Sheka)	Station point2 (Sheta)	Station Point3 (Dincha)
April 02/2021	Turbidity	NTU	6	12	4
April 02/2021	DO	mg/l	8.01	8.02	8.02
April 02/2021	Color	TCU	100	150	63
April 02/2021	Temperature	°C	19.6	19.8	19.7
April 02/2021	TDS	mg/l	150	125	160
April 02/2021	EC	µS/cm	315	260	324
April 02/2021	pH	-	8.41	7.72	6.94
April 02/2021	Iron	mg/l	0.7	1.7	1.9
April 02/2021	Phosphate	mg/l	2.6	0.25	0.71
April 02/2021	Nitrate	mg/l	0.77	0.26	0.91
April 02/2021	Nitrite	mg/l	0.06	0.12	0.08
April 02/2021	Sulphate	mg/l	26	32	28
April 02/2021	Total hardness	mg/l	460	Above detected(520)	Above detected (560)

Annex D-2: Lab result in summer season

Experiment date	Parameters	SI units	1st station Sheka	2nd station (Sheta)	3rd station (Dincha)
Jun25/2021	Turbidity	NTU	23	16	13
Jun25/2021	Color	TCU	210	138	129
Jun 25/2021	TDS	mg/l	86.1	109	110
Jun25/2021	EC	µS/cm	174.1	218	220
Jun25/2021	Tempera-ture	°C	18.1	17.4	17.3
Jun25/2021	pH	-	6.81	6.76	6.46
Jun25/2021	Iron	mg/l	0.53	0.74	0.3
Jun25/2021	Phosphate	mg/l	0.81	1.34	0.96
Jun25/2021	Sulphate	mg/l	27	18	34
Ju25/2021	Nitrate	mg/l	1.06	0.91	0.34
Jun25/2021	Total hard-ness	mg/l	570	556	540
Jun25/2021	DO	mg/l	11.58	11.4	11.38
Jun25/2021	Nitrite	mg/l	0.23	0.47	0.02

Annex E-1: Water quality analysis on certain Physical parameters at station two or Sheta

	Physical parameters at station two				
	Color(TCU)	Temperature(°C)	TDS(mg/l)	Turbidity (NTU)	EC(µS/cm)
CCME WQI standards	15	25	500	5	400
Winter	150	19.8	125	12	260
Summer	138	17.1	109	16	218

Annex E-2: Water quality analysis on certain chemical parameters at station two or Sheta

	Chemical parameters at station two							
	Total hard-ness(mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)	Iron (mg/l)	DO (mg/l)	Phosphate (mg/l)	pH
CCME standards	500	0.05	50	500	0.3	5	0.05	6.5-9
Winter	520	0.12	0.26	32	1.7	8.02	0.25	7.72
Summer	556	0.47	0.91	18	0.74	11.4	1.34	6.76

Annex E-3: Water quality analysis on certain Physical parameters at third station or Dincha

	Physical parameters at station three				
	Color(TCU)	Temperature(°C)	TDS(mg/l)	Turbidity(NTU)	EC(μS/cm)
CCME standards	15	25	500	5	400
Winter	63	19.7	160	4	324
Summer	129	17.3	110	13	220

Annex E-4: Water quality analysis on certain chemical parameters at third station or Dincha

	chemical parameters at station three							
	Hardness (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)	sulphate (mg/l)	iron (mg/l)	DO (mg/l)	Phosphate (mg/l)	pH
CCME standards	500	0.05	50	500	0.3	5	0.05	6.5-9
Winter	560	0.08	0.91	28	1.9	8.02	0.71	6.94
Summer	540	0.02	0.34	34	0.3	11.38	0.96	6.46

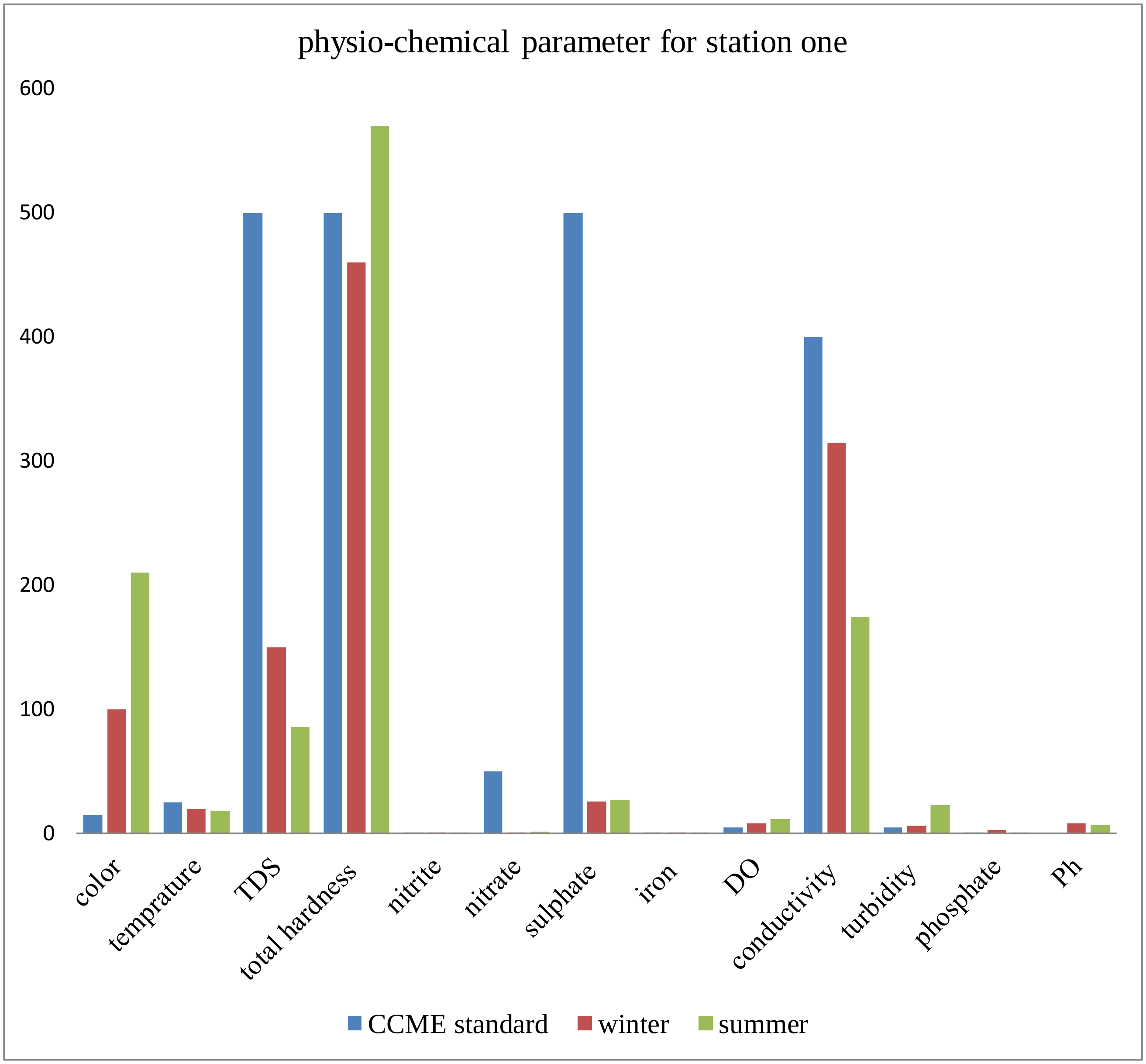
Annex E-5: Normalized sum of the excursion at station two

fail test value	A	150	138	520	556	0.12	0.47	1.7	0.74	8.02	11.4	12	16	0.25	1.34
objectives	B	15	15	500	500	0.05	0.05	0.3	0.3	5	5	5	5	0.05	0.05
excursion	(A/B-1)	9	8.2	0.04	0.11	1.4	8.4	4.67	1.47	0.6	1.28	1.4	2.2	4	25.8
Nse	2.64														

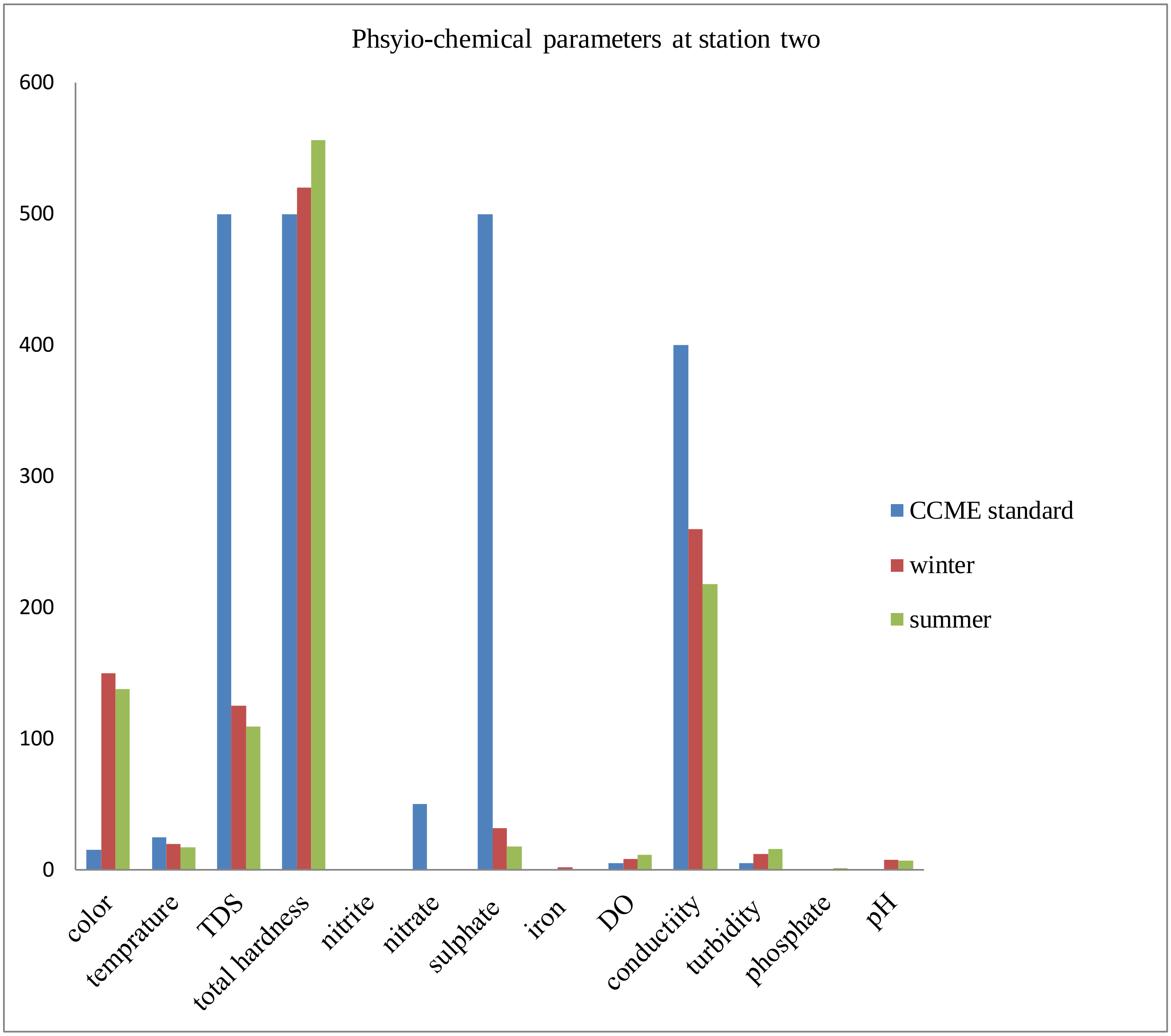
Annex E-6: Normalized sum of the excursion at station three

fail test value	A	63	129	560	540	0.08	1.9	8.016	11.38	13	0.71	0.96
objectives	B	15	15	500	500	0.05	0.3	5	5	5	0.05	0.05
excursion	(A/B)-1	3.2	7.6	0.12	0.08	0.6	5.333	0.603	1.276	1.6	13.2	18.2
Nse	1.99											

Annex F-1 Physio-chemical parameter for station one



Annex F-2 physio-chemical parameters at station two



Annex F-3: physio-chemical parameter at station three (Dincha)