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Assessment of Drinking Water Quality in Ganes Shareg Area Blue Nile State–Sudan -2018

A thesis Submitted in Fulfillment of The Requirements for M.Sc. in Environmental Health

By

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الاية الكريمة

بسم الله الرحمن الرحيم

(ثُمَّ قَسَتْ قُلُوبُكُم مِّن بَعْدِ ذَٰلِكَ فَهِيَ كَالْحِجَارَةِ أَوْ أَشَدُّ قَسْوَةً ۚ وَإِنَّ مِنَ الْحِجَارَةِ لَمَا يَتَفَجَّرُ مِنْهُ الْأَنْهَارُ ۚ وَإِنَّ مِنْهَا لَمَا يَشَّقَّقُ فَيَخْرُجُ مِنْهُ الْمَاءُ ۚ وَإِنَّ مِنْهَا لَمَا يَهْبِطُ مِنْ خَشْيَةِ اللَّهِ ۗ وَمَا اللَّهُ بِغَافِلٍ عَمَّا تَعْمَلُونَ)

سورة البقرة الاية (74)

Dedication

- ♥ To my parents (Doura and Modathir).
- ♥ To my family (brothers, sisters, Aunts, uncles and all relatives).
- ♥ To my Friends.
- ♥ To every one working for children wellbeing.
- ♥ To all of those, I dedicate this thesis (very simple work).

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Abbreviations

Abbreviation	Referent
AOC	Assimibable Organic Carbon
APHA	American Public Health Association
AWWA	American Water Works Association
BDOC	Bio Degradable Organic Carbon
BGB	Brilliant Green Bile
BOD	Bio chemical Oxygen Demand
CAWST	Center for Affordable Water and Sanitation Technology
CDC	Center for Diseases Control and prevention
CDW	Committee on Drinking Water
CEHA	Center for Environmental Health Activities
CFC	Colony forming unit Count
CNS	Central Nervous System
COD	Chemical Oxygen Demand
CPCB	Central of Pollution Control Board
CRS	Congressional Research services
CT	Contact Time
DAEC	Diffusely Adherent Escherichia Coli
DDT	Dichloro Diphenyle Trichloroethane
DES	Department of Environmental Services
DHEC	Department of Health and Environmental Control
DI	De Ionized
DNA	Deoxy ribo Nucleic Acid
DO	Dissolved Oxygen
DPD	N'N Diethyle –P-Phenlene Diamine
DS	Dissolved Solids
DWQS	Drinking Water Quality Standards
EAEC	Entero Aggregative Escherichia Coli
EC	Electrical Conductivity
EHEC	Entero Hemorrhagic Escherichia Coli
EHP	Environmental Health Perspectives
EIEC	Entero Invasive Escherichia Coli
EMB	Earthen Methylene Blue
EMRO	Eastern Mediterranean Regional Office
EPEC	Entero Pathogenic Escherichia Coli
ETEC	Entero Toxogenic Escherichia Coli

FTU	Formazin Turbidity Unit
GI	Galvanized Ion
GV	Guidelines Value
HAV	Hepatitis A Virus
HEV	Hepatitis E Virus
HIV	Human Immune Virus
IPCC	Intergovernmental Panel on Climate Change
IPV	Inactivated Polio Vaccine
IWSC	International Water and Sanitation Center
L	Liter (s)
MF	Membrane Filtration
MF	Micro Filtration
Mg	Milligram (s)
ML	Milliliter (s)
MWR	Ministry of Water Resources
NIEHS	National Institute Environmental Health Sciences
NTU	Nephelometric Turbidity Unit
OD	Oxygen Demand
ORT	Oral Dehyderation Therapy
OT	Orthro Toludine Test
P-A	Presence- Absence tests
PCR	Poly myrase Chain Reaction
PV	Permanganate Value
PV	Polio Vaccine
PVC	Poly Vinyl Chloride
UF	Ultra-Filtration
UN	United Nation
UNHCR	United Nations High Commission for Refugees
UNICE	United Nation's International Children's Fund
USEPA	United State Environmental Production Agency
MDG	Millennium Development Goal
DWS	Drinking Water Safety
NGOs	Non-Governmental Organizations
INGOs	International Non-Governmental Organizations
AHP	Analytical Hierarchy Process
TC	Total coliform
AAS	Atomic Absorption Spectroscopy
E.coli	Escherichia coli

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Abstract:

Safe and improved water is important for public health, whether it is used for drinking, household use, food preparation or recreational purposes. Improved water supply and sanitation and good water resources management can contribute in enhancing economic growth, and poverty reduction. Everyone has the right to adequate, sustainable, secure and acceptable water, which can be obtained at affordable prices, both for personal use and for domestic use. This descriptive cross sectional and analytical study, was conducted to assess the drinking water quality and to identify the sources of drinking water in Ganess Sahreg area. The samples size in this study designed base one the type of analysis according to WHO guide lines and water quality monitoring and surveillance which recommended by The World Health Organization. This study was conducted during the period from May 2015 to May 2018, we used the principle of counting colonies and the principle of appearance and absence of bacterial content, Photometer 7500 was used for chemical analysis, electronic turbidity analyzer, thermal thermometer, and TDS (EC). Also, we used various methods such as environmental inspection, interviews, records, laboratory analysis. Some of tests were conducted in the field at the source site. The collected data were analyzed by electronic statistical programs such as Excel and statistical analysis program then The results were classified and presented in tables and graphical forms for easy comparison.

The study revealed on many findings, the most important are drinking water in the area are groundwater in the form of hand pumps, surface sources It is

a shallow outlet on the bank of the Blue Nile (Moshara), there is a small treatment plant in the area that serves a small number of users. Environmental Inspection The survey found that all surface sources recorded a very high-risk rate and required urgent Action, Bacterial quality is very poor for surface sources than in groundwater sources. Water hardness has the highest levels in groundwater sources. The turbidity was Very high in surface sources and excellent in ground water, and the content of nitrates and fluoride was very safe and under the allowed limits, also the rate of total dissolved solids and electrical conductivity of all sources is safe and within the allowed limits. The study also found that 98% of the samples are excellent for pH. The iron (Fe) ratio is relatively high in all sources, except only 4 sources that recorded safe ratios. According to the results of this study, we recommend that: activation the water quality monitoring and surveillance system in the area, improvement of treatment operations in the treatment plant, conduct awareness campaigns to urge citizens to use safe water and involve the community in the planning and implementation of water safety programs.

المستخلص :

تعتبر المياه الآمنة والمحسنة من اساسيات المحافظة على الصحة العامة ، سواء كانت تستخدم للشرب أو للاستخدام المنزلي أو إعداد الطعام أو الأغراض الترفيهية. تحسين الإمداد بالمياه و خدمات الصرف الصحي والإدارة الجيدة للموارد المائية يمكن أن يسهم في تعزيز النمو الاقتصادي والحد من الفقر.

لكل فرد الحق في الحصول على مياه كافية ومستدامة وآمنة ومقبولة ، والتي يمكن الحصول عليها بأسعار معقولة ، سواء للاستخدام الشخصي أو للاستخدام المنزلي. أجريت هذه الدراسة الوصفية والتحليلية المقطعية لتقييم جودة مياه الشرب ولتحديد مصادر مياه الشرب في منطقة قنيص شرق بمحلية الرصيرص بولاية النيل الازرق. تم تصميم حجم العينة في هذه الدراسة بالاستناد على توصيات منظمة الصحة العالمية الوارة فى دليل رصد ومراقبة جودة المياه. أجريت هذه الدراسة خلال الفترة من مايو ٢٠١٥ إلى مايو ٢٠١٨ ، و قد تم استخدام مبدأ حساب المستعمرات ومبدأ المظهر (وجود و عدم وجود) للمحتوى بكتيري ، استخدمنا جهاز Photometer 7500 للتحليل الكيميائي ، و جهاز العكارة الالكتروني لقياس العكارة ، مقياس الحرارة (الثيرموميتر) لقياس حرارة المياه ، و جهاز قياس الموصلية الكهربائية و الاملاح الكلية الزائبة فى الماء .كما استخدمنا أساليب مختلفة مثل التفتيش البيئي ، والمقابلات ، والسجلات ، والتحليل المختبري. أجريت بعض الاختبارات في الحقل في موقع المصدر . تم تحليل البيانات التي تم جمعها عن طريق البرامج الإحصائية الإلكترونية مثل برنامج اكسل و تم تصنيف النتائج وعرضها في جداول و اشكال بيانية و ذلك للتوضيح و سهولة اجراء المقارنة.

كشفت الدراسة عن العديد من النتائج ، أهمها ان اكثر مصادر مياه الشرب في المنطقة من المياه الجوفية على شكل مضخات يدوية والمصادر السطحية علي شكل مأخذ ضفة النيل الأزرق (مشارع) ، وهناك محطة معالجة صغيرة في المنطقة و هي تخدم عددًا صغيرًا من المستخدمين. و بعد اجراء التفتيش البيئي وجد أن المصادر السطحية قد سجلت معدل مخاطر مرتفع للغاية وتتطلب تدخلات عاجلة ، والجودة البكتيرية ضعيفة للغاية بالنسبة لمصادر السطحية و هي افضل حالا في المصادر الجوفية. و قد سجل عسر الماء أعلى المستويات في المصادر الجوفية. و كانت العكارة عالية جدا

في المصادر السطحية وممتازة في المياه الجوفية ، محتوى النترات والفلورايد كان آمن جدا وتحت الحدود المسموح بها ، كما أن معدل المواد الصلبة الذائبة الكلية الموصلية الكهربائية لجميع المصادر آمن وضمن الحدود المسموح بها . وجدت الدراسة أيضا أن ٩٨ ٪ من العينات ممتازة للأس الهيدروجيني. نسبة الحديد (Fe) عالية نسبياً في جميع المصادر ، باستثناء ٤ مصادر فقط سجلت نسب آمنة للحديد. ووفقاً لنتائج هذه الدراسة ، فإننا نوصي بما يلي: تفعيل نظام مراقبة ومراقبة جودة المياه في المنطقة ، وتحسين عمليات المعالجة في محطة المعالجة ، وإجراء حملات توعية لحث المواطنين على استخدام المياه المأمونة وإشراك المجتمع في التخطيط وتنفيذ برامج سلامة المياه.

Chapter 1

1- Introduction

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve drinking-water that is as safe as practicable.

Safe drinking-water, as defined, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Those at greatest risk of waterborne disease are infants and young children, people who are debilitated and the elderly, especially when living under unsanitary conditions. Those who are generally at risk of waterborne illness may need to take additional steps to protect themselves against exposure to waterborne pathogens, such as boiling their drinking-water.

Safe drinking-water is required for all usual domestic purposes, including drinking, food preparation and personal hygiene. However, water of higher quality may be required for some special purposes, such as renal dialysis and cleaning of contact lenses, or for certain purposes in food production and pharmaceutical use. (WHO and UNICEF, 2000)

Access to safe drinking-water is important as a health and development issue at a national, regional and local level. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, since the reductions in adverse health effects and health care costs outweigh the costs of undertaking the interventions.

This is true for major water supply infrastructure investments through to water treatment in the home. Experience has also shown that interventions in improving access to safe water favor the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies.

The quality of drinking-water may be controlled through a combination of protection of water sources, control of treatment processes and management of the distribution and handling of the water.

All members of the population receive drinking-water by some means—including the use of piped supplies with or without treatment and with or without pumping (supplied via domestic connection or public standpipe), delivery by tanker truck or carriage by beasts of burden or collection from groundwater sources (springs or wells) or surface sources (lakes, rivers and streams). It is important for the surveillance agency to build up a picture of the frequency of use of the different types of supply, especially as a preliminary step in the planning of a surveillance program.

1.2- Problem statement

Safe water is a precondition for health and development and a basic human right, yet it is still denied to hundreds of millions of people throughout the developing world. Water related diseases caused by insufficient safe water supplies coupled with poor sanitation and hygiene cause 3.4 million Deaths a year, mostly among children.(UNICEF , 2008) Despite continuing efforts by governments, civil society and the international community, over a billion people still do not have access to improved water sources. The scale of the problem of water quality is even larger. It is increasingly clear that many of the existing improved sources in developing countries do not provide water of adequate quality for domestic purposes.

The principal cause of concern is microbiological contamination, especially from feces.

An increasing number of sources and systems used by people for drinking and cooking water are not adequately protected from faecal contamination. This is due to a variety of factors, including population pressure, urbanization and the inadequate construction, operation and maintenance of water systems.

Deteriorating of water quality threatens the global gains made in improving access to drinking water. From 1990 to 2004 more than 1.2 billion people gained access to improved water sources but not all of these new sources are necessarily safe. Unsafe handling and storage of water compounds the problem. Water drawn from protected sources may be contaminated by the time it is ultimately consumed in households.

Deteriorating water quality also threatens the MDG water target of halving the proportion of people without sustainable access to safe water. While the world is currently on track to meet the target in terms of numbers of sources constructed, it may not be on track if the quality of water in new sources is fully taken into account.

In spite of concerted efforts to improve access to safe drinking water, an estimated 1.1 billion people lack access to an improved water source. Over three million people, mostly children, die annually from water-related diseases. Almost two million of these deaths are the result of diarrhoeal diseases, which are caused by the ingestion of water contaminated by faecal matter, as well as by inadequate sanitation and hygiene.

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 and storage.

The consequences of poor water quality go beyond health. Chronic bouts of water-related diseases impose significant social and economic burdens both on victims themselves and society as a whole. Poverty alleviation and the other Millennium Development Goals will be difficult to achieve without improvements in water quality.

1.3- Rationale

Sudan has over 38,000 water sources including groundwater, surface water and rainwater, with some cases including water that needs to be desalinated. Open defecation and poor management of wastes from human settlements including from septic tanks, wastes from industry and agriculture all pose challenges for DWS, as does the over-use of water resources, conflicts over water and climate change. (FMOH 2017)

Ganess Shareg area was one of the most affected areas of acute watery diarrhea outbreak in 2015. So The rationale of this study:

- supporting the field of water quality and safety in the area, this kinds of studies helps to reflect water quality issues for stakeholders and community specially governmental line-miniseries and decisions makers .
- There is no active system for water quality monitoring and surveillance in the area, so establishing of this study will help in understanding of this system and facilitating in putting the basis for water quality surveillance system.

- Assessing the current situation of drinking water quality in GanessShareg area and compare the result with SSMO standard and the global (WHO) standard to determine the quality position
- Share and provide information about the current drinking water situation in the area , so that NGOs and INGOs need this type of data to develop interventions plans
- No previous study conducted in this area
- Finally this study will also provide opportunities for future studies to fill the gaps that this study could not address, also will be published both in regional and international journals (i.e.) the academicians and scientific community will benefit from results of this study.

1.4 - Hypothesis

The hypothesis of this study is the drinking water quality in Ganess Shareg area is not fully identical to SSMO water quality standard and there is a huge variation to the global (WHO) standards.

1.5- Objectives

1.5.1-General objective:

To Assess drinking water quality in Ganess Shareg area at Alrosairis locality.

1.5.2- Specific objectives:

1. To identify on sources of drinking water and level of safety.
2. To assess microbial quality of drinking water.
3. To measure concentration of some chemical parameters like (Fe, F, NO3, pH and degree of hardness) in drinking water.

4. To determine level of turbidity in drinking water.
5. To measure the total dissolved solids (TDS) and electrical conductivity (EC) in drinking water.

Chapter (2)

Literature Review

2.1- Sources of drinking water.

Water is the internal medium for almost the organisms, and principal external medium for several organisms. a large proportion of about 70% of the body weight of most organism including man is constitute of water is also an important substance in directing the energy follow in the living system since its one of the constitute in reaction of photosynthesis which capture energy from the sun, in fact life on this plant could have been possible only because of the presence of abundant water. All the organism use water for their metabolic process and all the biochemical reaction in the body of the organisms take place in the water medium. Water has got an exceptional quality of dissolving a number of substances without changing their chemical nature and therefor plays an important role in transporting materials in the body. blood is mostly water through which food and oxygen supplied to the cells .hormones or chemical messengers also travel through blood stream . sperms are also mobile in water medium , waste product in the body are removed dissolved in the water . in the higher plants nutrients are carried from roots to other parts in water through xylem . (GOEL, 2006 & WEDC 2004)

Water is the substance which present in all the three state of matter i.e. gaseous (water vapors) , liquid and solid (ice) within the range of temperature and pressure common to the earth . Approximately 97% of the total water existing in gigantic oceans. This water is of very little importance in the daily requirement of man, remaining 3% of water is distributed in the form of ice sheets, underground atmosphere lakes, rivers and biological water contained in the living organisms. The surface freshwater in the lakes and rivers is hardly 0.01% of total water supply in the earth. since our demand of water are mostly for freshwater , we have to depend mainly for the tiny fraction of the total water present on this plant , further the uneven distribution of water on surface of the earth make it a scarce commodity at several places . Any kind of will further add to the difficulty of procuring this precious resource. (GOEL, 2006)

2.1.1-Hydrological cycle

Water is not locked permanently on the various components of the earth but is constantly moving through various pathways in the atmosphere biosphere and lithosphere, thus uniting the components of the ecosphere into a whole. This neutral follows of water through various components resulting in the global circulation is called water cycle or hydrological cycle. (Chapman &Wolson, 2005). Solar energy evaporate the water from oceans, rivers and lakes in to the atmosphere where it form the clouds. the winds transport the clouds to various part of the earth. the vapuors in the clouds condense precipitate in the form of earth dew , rain , snow or hail on the earth . a large part of precipitation takes place over the oceans themselves, while the remaining precipitates on the land masses. The water falling on the land masses is potential supply which is determined by the routs by which it is again returned to the atmosphere. Of the water falling on the land surface some is evaporated again and some is returned by surface run-off to drains, stream , rivers and lakes reaching finally to the oceans . the remaining water is in-filtered into the soil and percolate deep into the ground water levels from where a part of it may seep into stream, lakes or directly to the oceans . some water on the land absorbed by planet and consumed by the animals , this water , however , is released again into the atmosphere by respiration and evapotranspiration. The global water cycle is operate rapid rate with average 10 days residence time of water vapours in the atmosphere. The total; global water is regarded to be present of a series of storage tanks interconnected be the transfer processes of evaporation moisture transport, condensation , perception and run-off. (GOEL, 2006 & Thompson, 2007)

As regard to the fresh water resources on the earth, precipitation on the land masses is critical since, out of total precipitation, about 75% falls directly on the oceans and only 25% comes to land surface. Distribution of this precipitation on the land is highly uneven, therefor; the pattern of natural follow may be an important factor for the resource point of view. In fact the water management practice is based on the manipulation of hydrological cycle on a local scale (Shiklomanov, 1998)

More than 71% of earth's surface water is covered by water while surface water makes-up the major part of the earth's water supplies , large amount also exist in the atmosphere , the soil and on all living forms of life. Surface, subsurface and atmosphere water in all its forms is collectively called hydrosphere surface water refer to oceans, lakes, rivers, glaciers and polar icecaps. Surface water consist of ground water including the soil moisture son the continents. Atmosphere water may occur as gas (water vapour) , as liquid (rain drops, cloud and fog) or as solid (snow and ice) . (GOEL, 2006)

2.1.2- Ground water

Groundwater is fresh water (from rain or melting ice and snow) that soaks into the soil and is stored in the tiny spaces (pores) between rocks and particles of soil. Groundwater accounts for nearly 95 percent of the nation's fresh water resources. It can stay underground for hundreds of thousands of years, or it can come to the surface and help fill rivers, streams, lakes, ponds, and wetlands. Groundwater can also come to the surface as a spring or be pumped from a well. Both of these are common ways we get groundwater to drink. About 50 percent of our municipal, domestic, and agricultural water supply is groundwater. (epa.gov)

Scientific and economic uncertainty in understanding the benefits of groundwater and the inherent complexity make it difficult to design policies to encapsulate all aspects of this essential resource. Moreover, the lack of reliable quantitative information on the value of groundwater benefits is a barrier to the use of cost–benefit analysis in the groundwater and contaminated land sectors and in assessing the impacts of policy drivers such as the Water Framework Directive. (Environment Agency 2007)

2.1.3- Atmosphere water

All water in the environment passes through the atmosphere at some time during the hydrological cycle. The atmosphere water is important in determine the condition in the environment that affect our life supporting system. Through atmosphere ware is not considered as a direct source of water supply, it is the ultimate source of all freshwater supplies on the earth that come in the form of precipitation. The quality of this water is considered to be purest. Other important function of this water is to keep the temperature moderate. Water in the atmosphere makes it possible for the air to absorb and hold vast amount of heat. Because of the presence of water vapor the temperature of atmosphere remains within the hospital range for most living organisms. (GOEL, 2006)

2.2- Water Requirements

The quantity of water collected and used by households has an important influence on health. There is a basic human physiological requirement for water to maintain adequate hydration and an additional requirement for food preparation. There is a further requirement for water to support hygiene, which is necessary for health. (WHO 2003)

Estimates of the volume of water needed for health purposes vary widely. In deriving World Health Organization (WHO) guideline values, it is assumed that the daily per capita consumption of drinking-water is approximately 2 litters for adults, although actual consumption varies according to climate, activity level and diet. Based on currently available data, a minimum volume of 7.5 liters per capita per day will provide sufficient water for hydration and incorporation into food for most people under most conditions. In addition, adequate domestic water is needed for food preparation, laundry and personal and domestic hygiene, which are also important for health. Water may also be important in income generation and amenity uses.(WHO 2011)

2.2.1- Minimum Water Requirements

The minimum requirement for water is the amount that equals losses and prevents adverse effects of insufficient water, such as dehydration. There are numerous limitations associated with the requirement estimates used to make recommendations. (WHO, 2004)

The primary determinant of maintenance water requirement appears to be metabolic, (Segar, 1957) but the actual estimation of water requirement is highly variable and quite complex. Because the water requirement is the amount necessary to balance the insensible losses (which can vary markedly) and maintain a tolerable solute load for the kidneys (which may vary with dietary composition and other factors), it is impossible to set a general water requirement.(WHO 2003)

Given the extreme variability in water needs which are not solely based on differences in metabolism, but also in environmental conditions and activity, there is not a single level of water intake that would ensure adequate hydration and optimal health for half of all apparently healthy persons in all environmental conditions. (Grandjean,2004)

2.2.2-Factors That Affect Water Requirements

For sedentary to moderately active individuals under temperate conditions, water is lost from the body via urine, feces, respiration, and evaporation. During increased physical activity and in conditions other than temperate, sweat loss contributes to body water loss. The minimal amount of fluid loss that can occur is referred to as the obligatory water loss. However, a variety of factors can affect obligatory loss. For example, obligatory urine loss occurs because of the need to remove various solutes from the body. The minimum water required for urine is dependent on the daily solute excretory load, primarily determined by diet, and the maximum urinary concentration achievable. Urinary concentrating ability varies with age and with renal disease. Under normal conditions, fecal water loss is quite small, estimated at about 100 mL/day. (GOEL, 2006 & Benelam 2010)

Table (2-1): Minimum water quantities for institutions and other uses

Health centers and hospitals	5 liters per outpatient 40–60 liters per inpatient per day Additional quantities may be needed for laundry equipment, flushing toilets, etc.
Cholera centers	60 liters per patient per day 15 liters per carer per day
Therapeutic feeding centers	30 liters per inpatient per day 15 liters per carer per day
Reception/transit centers	15 liters per person per day if stay is more than one day 3 liters per person per day if stay is limited to day-time
Schools	3 liters per pupil per day for drinking and hand washing (Use for toilets not included: see Public toilets Below
Mosques	2–5 liters per person per day for washing and Drinking
Public toilets	1–2 liters per user per day for hand washing 2–8 liters per cubicle per day for toilet cleaning
All flushing toilets	20–40 liters per user per day for conventional flushing toilets connected to a sewer 3–5 liters per user per day for pour-flush toilets
Anal washing	1–2 liters per person per day
Livestock	20–30 liters per large or medium animal per day 5 liters per small animal per day

(Sphere 2011)

2.3- Uses of water

There is considerable confusion in the water literature about the terms use, need, withdrawal, demand, consumption, and consumptive use. Great care should be used when interpreting or comparing different studies or assumptions about water use. The term water use, while common, can mean many different things, referring at times to consumptive use and at times to withdrawals of water. (GLEICK 2003).

The manner in which man utilize the water can broadly be categorized in two ways

A- Withdrawal (off-channel) use.

B- Non-Withdrawal (on-site) use.

The withdrawal use of water is the amount of water that’s taken out of a stream or pumped out of an underground or surface reservoir in order to reach its point of use .the major use of water in this category is in public water supply (domestic consumption) , irrigation , livestock and industry .In case of non-withdrawal use , the water is used without being removed from where it is naturally present , such as navigation and transport , swimming , boating and other recreational purposes , wild life habitat , aquaculture , and for waste dilution , the use of water in general in hydroelectric power is also non-withdrawal use , since the water remain In the system . The dumping of domestic wastes and industrial effluent is a single greatest nonwithdrawal use of water which significantly affect the quality of water. (GOEL, 2006)

2.3.1- Domestic use:

The use of water for drinking and other domestic purposes by human beings is generally conceded to be it highest and most essential use .the average person drink or otherwise uses about 70,000 liters of water during his live time . In U.K demand for domestic water in 2000 A.D has been about 235 liter per person per day while it was only 156 liters in 1966 .however in warmer regions of the world, the domestic demand may go up to 500 liter. (GOEL, 2006)

2.3.2- Agricultural use

Total quantity used for irrigation is rather large .according to an estimate 41% of all the water used in USA is for irrigation . in India agriculture account for over 80% of total water use it is estimated that nearly 3500 liter per person per day is used just for irrigation the quantity is several times higher than the average domestic demand . (GOEL, 2006)The importance of efficient water use is further emphasized by the fact that agriculture is the major water-consuming sector. (HRISTOV 2014)

2.3.3- Industrial use

Industrial water use has leveled off or declined in many wealthier countries, but is growing rapidly in much of the developing world. (Postel, 1996)

Industry use more water than any other commodity according to estimates , more than 630 billion liters of water consumed per day by industry in the USA . one ton of steel making consume about 300,000 liter of water , to making an average automobile 4,50,000 liters of water is needed most of the water use by industry is for cooling for example water cools the hot gases produced in refining oil and hot steel in steel mills . (GOEL, 2006)

2.4- water quality

2.4.1- The importance of water quality

Access to safe drinking-water is important as a health and development issue at national, regional and local levels. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, as the reductions in adverse health effects and health-care costs outweigh the costs of undertaking the interventions. This is true for investments ranging from major water supply infrastructure through to water treatment in the home. Experience has also shown that interventions in improving access to safe water favor the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies. (WHO 2011)

2.4.2- Drinking Water quality

Water quality is a growing concern throughout the developing world. Drinking water sources are under increasing threat from contamination, with far-reaching consequences for the health of children and for the economic and social development of communities and nations. (Corcoran, 2010)

Unsafe handling and storage of water compounds the problem. Water drawn from protected sources may be contaminated by the time it is ultimately consumed in households. Deteriorating water quality also threatens the MDG water target of halving the proportion of people without sustainable access to safe water. While the world is currently on track to meet the target in terms of numbers of sources constructed, it may not be on track if the quality of water in new sources is fully taken into account. (UNICEF 2008)

2.4.2.1- Physical quality (Acceptability aspects)(Taste, odour and appearance)

The ordinary consumer judges the water quality by its physical characteristics. The provision of drinking water that is not only safe but also pleasing in appearance, taste and odour is a matter of high priority. The supply of water that is unsatisfactory in this respect will undermine the confidence of consumers, leading to use of water from less safe source. The acceptability of drinking water can be influenced by many different constituents. (PARK 2015)

The provision of drinking-water that is not only safe but also acceptable in appearance, taste and odour is of high priority. Water that is aesthetically unacceptable will undermine the confidence of consumers, will lead to complaints and, more importantly, could lead to the use of water from sources that are less safe. To a large extent, consumers have no means of judging the safety of their drinking-water themselves, but their attitude towards their drinking water supply and their drinking-water suppliers will be affected to a considerable extent by the aspects of water quality that they are able to perceive with their own senses. It is natural for consumers to regard with suspicion water that appears dirty or discolored or that has an unpleasant taste or smell, even though these characteristics may not in themselves be of direct consequence to health.(WHO, 2004 & World bank ,2012) Some substances of health concern have effects on the taste, odour or appearance of drinking-water that would normally lead to rejection of the water at concentrations significantly lower than those of concern for health .The concentration at which constituents are objectionable to consumers is variable and dependent on individual and local factors, including the quality of the water to which the community is accustomed and a variety of social, environmental and cultural considerations. However, WHO guideline values have been established for some substances that may cause taste or odour in drinking-water at much lower concentrations than the guideline value because there is such a wide range in the ability of consumers to detect them by taste or odour. It is important to consider whether existing or proposed water treatment and distribution practices can affect the acceptability of drinking-water and to manage change and operations to minimize the risk of problems for acceptability as well as health. (WHO 2011)

Monitoring of such substances should be undertaken in response to consumer complaints. Taste and odour can originate from natural inorganic and organic chemical contaminants and biological sources or processes (e.g-. aquatic microorganisms), from contamination by synthetic chemicals, from corrosion or as a result of problems with water treatment (e.g. chlorination). Taste and odour may also develop during storage and distribution as a result of microbial activity. (WHO 2008)

Taste and odour in drinking-water may be indicative of some form of pollution or of a malfunction during water treatment or distribution. It may therefore be an indication of the presence of potentially harmful substances. The cause should be investigated and the appropriate health authorities should be consulted, particularly if there is a sudden or substantial change. Colour, cloudiness, particulate matter and visible organisms may also be noticed by consumers and may create concerns about the quality and acceptability of a drinking- water supply.(WHO, 2004)

Biologically and chemicals derived contaminants

There are a number of diverse organisms that often have no public health significance but which are undesirable because they produce taste and odour. As well as affecting the acceptability of the water, they indicate that water treatment and/or the state of maintenance and repair of the distribution system are insufficient.(WHO 2011)

1- Actinomycetes and fungi
2- Cyanobacteria and algae
3- Invertebrate animal life1
4- Iron bacteria

Chemically derived contaminants

5- Aluminium

6- Ammonia

7- Chloramines

8- Chloride

9- Chlorine

10- Chlorobenzenes

11- Chlorophenols

Color

Drinking-water should ideally have no visible color. Color in drinking-water is usually due to the presence of colored organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. color is also strongly influenced by the presence of iron and other metals, either as natural impurities or as corrosion products. It may also result from the contamination of the water source with industrial effluents and may be the first indication of a hazardous situation. The source of color in a drinking-water supply should be investigated, particularly if a substantial change has taken place. Most people can detect color above 15 true color units (TCU) in a glass of water. Levels of color below 15 TCU are often acceptable to consumers. High color from natural organic carbon (e.g. humics) could also indicate a high propensity to produce by-products from disinfection processes. No health-based guideline value is proposed for color in drinking-water.(WHO 2011)

Hardness

Hardness caused by calcium and magnesium is usually indicated by precipitation of soap scum and the need for excess use of soap to achieve cleaning. Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions. In particular, consumers are likely to notice changes in hardness. The taste threshold for the calcium ion is in the range of 100–300 mg/litre, depending on the associated anion, and the taste threshold for magnesium is probably lower than that for calcium. In some instances, consumers tolerate water hardness in excess of 500 mg/litre. (WHO 2008)

Turbidity

Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through the water. It may be caused by inorganic or organic matter or a combination of the two. Microorganisms (bacteria, viruses and protozoa) are typically attached to particulates, and removal of turbidity by filtration will significantly reduce microbial contamination in treated water. Turbidity in some groundwater sources is a consequence of inert clay or chalk particles or the precipitation of non-soluble reduced iron and other oxides when water is pumped from anaerobic waters, whereas turbidity in surface waters may be the result of particulate matter of many types and is more likely to include attached microorganisms that are a threat to health. Turbidity in distribution systems can occur as a result of the disturbance of sediments and biofilms but is also from the ingress of dirty water from outside the system. In addition, turbidity can seriously interfere with the efficiency of disinfection by providing protection for organisms, and much of water treatment is directed at removal of particulate matter before disinfection .(WHO, 2011)

Turbidity is measured by nephelometric turbidity units (NTU) and can be initially noticed by the naked eye above approximately 4.0 NTU. However, to ensure effectiveness of disinfection, turbidity should be no more than 1 NTU and preferably much lower.(WHO 2011 & Henley, W , 2000)

2.4.2.2- Chemical quality

Water quality planners have traditionally focused on ensuring that drinking water is microbiologically safe for consumption. This emphasis was, and still is, justified by the serious health threat posed by microbiological contamination of drinking water and the fact that many people have access only to water that is clearly unsanitary. However, the chemical quality of drinking water cannot be taken for granted. (Howard & WHO , 2003) Yet in many water supply projects, the only chemical parameters tested are pH, and perhaps iron and chloride, because of the aesthetic problems these can cause. It is increasingly recognized that chemical contamination of drinking-water resources can seriously damage health.(WHO, 2007) Unlike microbiological contamination, chemical contamination leads to health problems primarily through chronic exposure. (Nitrate is one exception to this rule, as short-term exposure can cause methaemoglobinaemia). Contamination may persist for years before detection, and when people have developed chronic health problems from unsafe drinking water, it may be too late to restore health simply by switching to a safe water source. There are literally thousands of chemicals that could in theory cause health problems in drinking water. (WHO, 2011)

Priority chemical contaminants

It is not possible to test water for all of the chemicals that could cause health problems, nor is it necessary: most chemicals occur rarely and many result from human contamination of a small area, only affecting a few water sources. However, three chemicals have the potential to cause serious health problems and to occur over widespread areas. These are arsenic and fluoride, which can occur naturally, and nitrate, which is applied to large areas of agricultural land as fertilizer. (UNICEF, 2008 & HOWARD, 2002)

Naturally occurring chemicals:

As water percolates through rock strata or through soil it can dissolve or leach chemical components. These can be inorganic compounds or ions that are frequently found in drinking water but usually at widely varying concentrations. They can also be organic compounds that derive from the breakdown of plant material. The third source is algae in surface water that can give rise to a range of toxins and other products. However, the potential effects on health and the risks to health vary significantly between the different contaminants. (Fawell 2007).

There are a number of sources of naturally occurring chemicals in drinking-water. All natural water contains a range of inorganic and organic chemicals. The former derive from the rocks and soil through which water percolates or over which it flows. The latter derive from the breakdown of plant material or from algae and other microorganisms that grow in the water or on sediments. Most of the naturally occurring chemicals for which guideline values have been derived or that have been considered for guideline value derivation are inorganic. (WHO 2011)

Chemicals from industrial sources and human dwellings:

Chemicals from industrial sources can reach drinking-water directly from discharges or indirectly from diffuse sources arising from the use and disposal of materials and products containing the chemicals. (WHO 2011)

Chemicals from agricultural activities

Chemicals are used in agriculture on crops and in animal husbandry. Nitrate may be present as a consequence of tillage when there is no growth to take up nitrate released from decomposing plants, from the application of excess inorganic or organic fertilizer and in slurry from animal production. Most chemicals that may arise from agriculture are pesticides. (WHO 2008)

2.4.2.3- Microbial quality

Microbial quality is one of the primary indicators for the safety of a drinking water supply. Of all contaminants in drinking water, human and/or animal faeces present the greatest danger to public health.(WHO, 1984) Pathogenic or disease-causing microorganisms (including certain protozoa, bacteria or viruses) may be found in untreated water supplies. Bacteriological monitoring or testing is a way to detect and thereby control pathogenic bacteria in treated drinking water supplies.(Water Security Agency 2017)

Water-related diseases continue to be one of the major health problems globally.(J. Wrightet, 2004) The greatest risk to public health from microbes in water is associated with consumption of drinking-water that is contaminated with human and animal excreta, although other sources and routes of exposure may also be significant. This chapter focuses on organisms for which there is evidence, from outbreak studies or from prospective studies in non-outbreak situations, of diseases being caused by ingestion of drinking-water, inhalation of water droplets or dermal contact with drinking-water and their prevention and control. (WHO 2011)

Microbial hazards associated with drinking-water

Infectious diseases caused by pathogenic bacteria, viruses and parasites (e.g. protozoa and helminths) are the most common and widespread health risk associated with drinking-water.(Suthar, 2009) The public health burden is determined by the severity and incidence of the illnesses associated with pathogens, their infectivity and the population exposed. In vulnerable subpopulations, disease outcome may be more severe Breakdown in water supply safety (source, treatment and distribution) may lead to large-scale contamination and potentially to detectable disease outbreaks. In some cases, low-level, potentially repeated contamination may lead to significant sporadic disease, but public health surveillance is unlikely to identify contaminated drinking- water as the source. Waterborne pathogens have several properties that distinguish them from other drinking-water contaminants :(WHO 2006)

- Pathogens can cause acute and also chronic health effects.
- Some pathogens can grow in the environment.
- Pathogens are discrete.
- Pathogens are often aggregated or adherent to suspended solids in water, and pathogen concentrations vary in time, so that the likelihood of acquiring an infective dose cannot be predicted from their average concentration in water.
- Exposure to a pathogen resulting in disease depends upon the dose, invasivenessand virulence of the pathogen, as well as the immune status of the individual.
- If infection is established, pathogens multiply in their host. Certain waterborne pathogens are also able to multiply in food, beverages orwarm water systems, perpetuating or even increasing the likelihood of infection.
- Unlike many chemical agents, pathogens do not exhibit a cumulative effect.
- The pathogens that may be transmitted through contaminated drinking-water are diverse in characteristics, behaviour and resistance. (WHO 2011)

Microbiological contamination (waterborne infections**) :**

The pathogens that may be transmitted through contaminated drinking-water are diverse in characteristics, behaviour and resistance. (WHO 2011)

Pathogens are micro-organisms that can cause disease in humans. They fall into three major classes:

1- Bacteria are single-celled organisms, typically 1 to 5 μm in size (1000 μm =1mm).
2- Viruses are protein-coated genetic material that lack many cell structures, and aremuch smaller than bacteria – in most cases 10 to 300 nm (1000 nm = 1μm).
3- Parasites are single-celled organisms that invade the intestinal lining of theirhosts. The two main types of parasites are protozoa and helminths (intestinalworms). Parasites have a complex life cycle, and most at some stage form largeprotective cysts or eggs (4-100 μm), which can survive outside of the host bodies.

Indicator bacteria

The indicator bacteria that most surveillance bodies use in routine assessment of the risk of faecal contamination is Escherichia coli (E.coli) or as an alternative, thermotolerant coliforms. E.coli provides the closest match to the criteria for an ideal indicator, however it is not perfect and it is possible to find pathogens in drinking-water supplies when E.coli is absent. In particular, E.coli and thermotolerant coliforms may not provide a good indication of the presence of protozoa or viruses. However, in general, these indicator bacteria at present provide a reasonably reliable indication of the risk of disease from the water supply. However, given the weaknesses in these indicators, water that has no E.coli or thermotolerant coliforms should be seen as low risk, rather than as safe. (HOWARD, 2002)

Types of bacteria used to detect and estimate the level of fecal contamination of water. They are not dangerous to human health but are used to indicate the presence of a health risk. Each gram of human feces contains approximately ~100 billion (1×1011) bacteria. These bacteria may include species of pathogenic bacteria, such as Salmonella or Campylobacter, associated with gastroenteritis. In addition, feces may contain pathogenic viruses, protozoa and parasites. Fecal material can enter the environment from many sources including waste water treatment plants, livestock or poultry manure, sanitary landfills, septic systems, sewage sludge, pets and wildlife. If sufficient quantities are ingested, fecal pathogens can cause disease. The variety and often low concentrations of pathogens in environmental waters makes them difficult to test for individually. (en.wikipedia.org)

Analysis for faecal indicator organisms provides a sensitive, although not the most rapid, indication of pollution of drinking-water supplies. Because the growth medium and the conditions of incubation, as well as the nature and age of the water sample, can influence the species isolated and the count, microbiological examinations may have variable accuracy.(WHO, 2011)

Table (2-2): Guideline values for verification of microbial quality: (WHO,2011)

Organisms		**Guideline value**
All water directly intended for drinking	E.coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample
Treated water entering the distribution system	E.coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample
Treated water in the distribution system	E. coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample

Table (2-3):Sudanese standard for Microbial Quality (SSMO)

Organisms	Guideline Value
1. All water intended for drinking: A/ E. coli or thermotolerant coliform bacteria B/ Pathogenic intestinal protozoa	Must not be detectable in any 100-ml sample
2. Treated water entering the distribution system: A/ E. coli or thermotolerant coliform bacteria B/ Total coliform bacteria C/ Pathogenic intestinal protozoa	Must not be detectable in any 100-ml sample
3. Treated water in the distribution system: A/ E. coli or thermotolerant coliform bacteria B/ Total coliform C/ Pathogenic intestinal protozoa	Must not be detectable in any 100-ml sample Must not be detectable in any 100-ml sample. In the case of large supplies where sufficient samples are examined, must not by detectable in 95% of samples examined throughout any consecutive 12- months period. Must not be detectable in any 100-ml sample.

2. 5- Drinking water pollution

Water pollution is any chemical, physical or biological change in the quality of water that has a harmful effect on any living thing that drinks or uses or lives (in) it. When humans drink polluted water it often has serious effects on their health. Water pollution can also make water unsuited for the desired use.(lenntech.com)

2.5.1- Major water pollutants

There are several classes of water pollutants. The first are disease-causing agents. These are bacteria, viruses, protozoa and parasitic worms that enter sewage systems and untreated waste. A second category of water pollutants is oxygen-demanding wastes; wastes that can be decomposed by oxygen-requiring bacteria. When large populations of decomposing bacteria are converting these wastes it can deplete oxygen levels in the water. This causes other organisms in the water, such as fish, to die.
A third class of water pollutants is water-soluble inorganic pollutants, such as acids, salts and toxic metals. Large quantities of these compounds will make water unfit to drink and will cause the death of aquatic life.
Another class of water pollutants are nutrients; they are water-soluble nitrates and phosphates that cause excessive growth of algae and other water plants, which deplete the water's oxygen supply. This kills fish and, when found in drinking water, can kill young children.
Water can also be polluted by a number of organic compounds such as oil, plastics and pesticides, which are harmful to humans and all plants and animals in the water. A very dangerous category is suspended sediment, because it causes depletion in the water's light absorption and the particles spread dangerous compounds such as pesticides through the water. .(lenntech.com)

No natural water is absolutely pure – the chemical and physical characteristics of water are constantly changing through interaction with the environment. These changes can be positive: water is purified as its percolates down to aquifers and some adsorbed minerals can improve the taste and perceived value of water. Sometimes the changes can result in water that remains safe, but is unacceptable to consumers for aesthetic reasons (taste, smell or colour). And in some cases water can become unsafe for human consumption through contamination by naturally occurring chemicals (such as arsenic) or through pollution from human activities (such as pesticides) Water pollutant may be divided many ways but they fall in one of four general categories: (WHO , 2005 , 2002)

1- Biological agent.
2- Dissolved chemicals.
3- Non-dissolved chemicals and sediment.
4- Heat.

2. 5.2- Sources of water pollutants

Water pollutant sources are either sources point and non-point source

Point source discharge pollutant at specific location through sewers, ditches or pipe in to surface water. Example include factories, wastewater treatment plant that removed some of the pollutants, underground coal and gold mines, offshore oil wells, and oil tankers since point source are mainly in urban areas, they are relatively easy to identify , monitor and regulate .

Non-point source cannot be traced to a single discharge. They are large poorly defined areas that pollute water by runoff, subsurface flow and atmospheric precipitation. Example include the runoff of chemicals in to surface water and percolation into the ground from croplands, livestock feed lots, logged forest, streets lawns, construction sites, parking areas and road ways.

2. 5.3- Water pollutant related health problem:

Biological agent

Water-borne diseases contaminate drinking water causing disease in human. There is a long list of these pathogens. Important water-borne viruses include hepatitis and polio. Terminal infection of piped drinking-water supplies is of paramount importance and is almost universal. As it is the final barrier to the transmission of water-borne bacterial and viral diseases. Normal condition of chlorination can reduce by 99% E.coli and certain viruses but not the cysts or oocysts of parasitic protozoa. More than hundred have been identified in human excreta, and many of these viruses remain alive for some time in swage . Microorganism other than found in the human excreta may also cause problem. Anthrax bacilli or parasites from diseased animals in certain slaughterhouses can enter water supply and cause health problems to animals and people downstream. (**Ramírez e_al, 2015)**

Chemical Toxicity

Many of chemicals that reach water are poisons. Poisons are dangerous no matter in what part of ecosystem they happen to be located. Among the in organic chemicals that can be found in water supplies are arsenic from insect-sides, cadmium from electroplating operations, chlorates from deferent industrial processes, cyanide, lead , selenium mercury , copper , chromium and zinc , these chemicals depend on dose and duration exposure , are toxic to fish and other aquatic animals as well as to human beings, because they interfere with enzyme action and other cellular bio-chemicals. (WHO, 1993)

2.6- Drinking water treatment

Surface water may contain pathogenic organism's suspended matter or organic substances. Except in limestone area, ground water is much less likely to have pathogenic organisms than surface water but it may contain iron and manganese that impart undesirable test and odours, or other mineral impurities which limit its acceptability. In brief, appropriate treatment may be necessary to render the water supply bacteriologically safe and chemically acceptable. Modern technologies provide choices of treatment methods to produce water of a desirable quality from any given sources. The limiting factor is cost. Water may be treated at treatment plant utilizing some or all of the following treatment processes.(Goel, 2008)

Intake

The intake structure varies according to the water source. For rivers the intake may consist of a submerged pipeline used with submerged crib or screened bell-mouth at the open end. Intakes for small streams frequently require the construction of small diversion dams. (WHO, 2002)

Storage

Preliminary storage in a reservoir helps to grantee continues supply of water and provide economical means of sedimentation out some of the suspended particulate material. By simply holding water in reservoir the total bacteria count can be reduced. (WHO, 2002)

Sedimentation

Surface water such as that of rivers and streams contains sand, grit and other suspended solids that can damage pumps, clog filters and pipes and reduce the effectiveness of disinfection sedimentation is the settling and removal of suspended solids, its take place when the water flows slowly through a large tank. (WHO, 2002)

Pre-filtration

Pre-filtration with gravel or other coarse materials before sand filtration provides an effective means of preventing, the rapid clogging and blockage of the sand filter. In small treatment plants, where the turbidity of source is high or subject to fluctuation Pre-filtration is necessary . (WHO, 2002)

Slow sand filtration:

Slow sand filtration significantly improves physical, chemical and microbiological quality of waters. Slow sand filtration is a process of removing suspended matter from the water as it slowly process through a bed of sand. The degree of removal depend on the characteristic and size of filter sand the thickness of the sand and the size and quantity of the suspended particles. (WHO, 2002)

Aeration

Aeration is necessary to promote the exchange of gases between the water and atmosphere in the water treatment plant its practiced for the many reasons like (Control tastes and odours, precipitate iron and manganese , expel carbon dioxide) . In order to aerate water it should come into maximum contact with the air so that it becomes saturated with the oxygen these process can be accomplished by letting the water fail over steps of cascades.(WHO, 2002)

Chemical disinfection

Chemical disinfection of drinking-water includes any chlorine-based technology, such as chlorine dioxide, as well as ozone, some other oxidants and some strong acids and bases. Except for ozone, proper dosing of chemical disinfectants is intended to maintain a residual concentration in the water to provide some protection from post-treatment contamination during storage. Disinfection of household drinking-water in developing countries is done primarily with free chlorine, either in liquid form as hypochlorous acid (commercial household bleach or more dilute sodium hypochlorite solution between 0.5% and 1% hypochlorite marketed for household water treatment use) or in dry form as calcium hypochlorite or sodium dichloroisocyanurate. (WHO, 2011)

Chlorination

Chlorine, used correctly with low- turbidity water, is a very effective disinfectant, chlorine disinfection has a residual effect – it continues to protect against the re-contamination of water over a period of time. This is the primary advantage of chlorine and the reason it is used widely in municipal systems. Chlorination also has disadvantages: chlorine products can be expensive (even bleaching powder can be too expensive for many households), difficult to market and can have a short shelf life. However new approaches to home chlorination programming are overcoming these problems, and have been shown to be successful at reducing diarrhea rates (UNICEF, 2008 & Rangel 2003)

2.7- Water Quality Monitoring and Surveillance

2.7.1- Surveillance

Drinking-water supply surveillance is "the continuous and vigilant public health assessment and review of the safety and acceptability of drinking-water supplies" (WHO, 1976).

This surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, accessibility, coverage, affordability and continuity of water supplies (known as service indicators) and is complementary to the quality control function of the drinking-water supplier. Drinking-water supply surveillance does not remove or replace the responsibility of the drinking-water supplier to ensure that a drinking-water supply is of acceptable quality and meets predetermined health-based targets. All members of the population receive drinking-water by some means—including the use of piped supplies with or without treatment and with or without pumping (supplied via domestic connection or public standpipe), delivery by tanker truck or carriage by beasts of burden or collection from groundwater sources (springs or wells) or surface sources (lakes, rivers and streams). It is important for the surveillance agency to build up a picture of the frequency of use of the different types of supply, especially as a preliminary step in the planning of a surveillance programme. There is little to be gained from surveillance of piped water supplies alone if these are available to only a small proportion of the population or if they represent a minority of supplies. (WHO, 2011)

Information alone does not lead to improvement. Instead, the effective management and use of the information generated by surveillance make possible the rational improvement of water supplies—where “rational” implies that available resources are used for maximum public health benefit. (WHO, 2004)

Surveillance is an important element in the development of strategies for incremental improvement of the quality of drinking-water supply services. It is important that strategies be developed for implementing surveillance, collating, analyzing and summarizing data and reporting and disseminating the findings and that the strategies are accompanied by recommendations for remedial action. Follow-up will be required to ensure that remedial action is taken. Surveillance extends beyond drinking-water supplies operated by a discrete drinking-water supplier to include drinking-water supplies that are managed by communities and includes assurance of good hygiene in the collection and storage of household water. The surveillance agency must have, or have access to, legal expertise in addition to expertise on drinking-water and water quality. Drinking-water supply surveillance is also used to ensure that any transgressions that may occur are appropriately investigated and resolved. In many cases, it will be more appropriate to use surveillance as a mechanism for collaboration between public health agencies and drinking-water suppliers to improve drinking-water supply than to resort to enforcement, particularly where the problem lies mainly with community-managed drinking-water supplies. (WHO, 2006 & HOWARD, 2002)

The authorities responsible for drinking-water supply surveillance may be the public health ministry or other agency, and their roles encompass four areas of activity:

1- Public health oversight of organized drinking-water supplies;

2- Public health oversight and information support to populations without access to organized drinking-water supplies, including communities and households;

3- Consolidation of information from diverse sources to enable understanding of the overall drinking-water supply situation for a country or region as a whole as an input to the development of coherent public health–centred policies and practices;

4- Participation in the investigation, reporting and compilation of outbreaks of waterborne disease.

A drinking-water supply surveillance programme should normally include processes for approval of water safety plans (WSPs). This approval will normally involve review of the system assessment, of the identification of appropriate control measures and supporting programmes and of operational monitoring and management plans.

It should ensure that the WSP covers normal operating conditions and predictable incidents (deviations) and has contingency plans in case of an emergency or unplanned event.(WHO, 1997)

The surveillance agency may also support or undertake the development of WSPs for community-managed drinking-water supplies and household water treatment and storage. Such plans may be generic for particular technologies rather than specific for individual systems. (WHO, 2011)

2.7.2- Types of approaches

There are two types of approaches to surveillance of drinking-water quality: audit-based approaches and approaches relying on direct assessment.
(WHO, 2011)

Audit approach

In the audit approach to surveillance, assessment activities, including verification testing, are undertaken largely by the supplier, with third-party auditing to verify compliance. (WHO, 2004)

Direct assessment

It may be appropriate for the drinking-water supply surveillance agency to carry out independent testing of water supplies. Such an approach often implies that the agency has access to analytical facilities with staff trained to carry out sampling, analysis and sanitary inspection.

Direct assessment also implies that surveillance agencies have the capacity to assess findings and to report to and advise suppliers and communities.(WHO, 2011)

2.8- Water sampling and analysis

Water samples are collected and analyzed to determine the chemical, Microbial and physical composition of a water body, and its suitability for domestic, industrial, and agricultural uses. Water samples are also analyzed to aid in understanding geochemical and hydrologic relationships in natural systems and to evaluate the influence of man's activities on these systems. Interpretation of the analytical reports from a systematic sampling and analysis program may also indicate the nature, source, and variability of both dissolved and suspended matter present in the water body. If, in the course of such studies, samples are obtained which are not truly representative of the entire water body, an error will be introduced which may be the most significant one in the entire data gathering process. (Brown, M. W, 1970)

The most important factor to take into account is that, in most communities, the principal risk to human health derives from faecal contamination. In some countries there may also be hazards associated with specific chemical contaminants such as fluoride or arsenic, but the levels of these substances are unlikely to change significantly with time. Thus, if a full range of chemical analyses is undertaken on new water sources and repeated thereafter at fairly long intervals, chemical contaminants are unlikely to present an unrecognized hazard. (WHO, 1997)

2.8.1- Sampling

Location of sampling points

One objective of surveillance is to assess the quality of the water supplied by the supply agency and of that at the point of use, so that samples of both should be taken. Any significant difference between the two has important implications for remedial strategies. Samples must be taken from locations that are representative of the water source, treatment plant, storage facilities, distribution network, points at which water is delivered to the consumer, and points of use. In selecting sampling points, each locality should be considered individually; however, the following general criteria are usually applicable: (HOWARD, 2002)

- Sampling points should be selected such that the samples taken are representative of the different sources from which water is obtained by the public or enters the system.
- These points should include those that yield samples representative of the conditions at the most unfavorable sources or places in the supply system, particularly points of possible contamination such as

unprotected sources, loops, reservoirs, low-pressure zones, ends of the system, etc.

- Sampling points should be uniformly distributed throughout a piped distribution system, taking population distribution into account; the number of sampling points should be proportional to the number of links or branches.
- The points chosen should generally yield samples that are representative of the system as a whole of its main components.
- Sampling points should be located in such a way that water can be sampled from reserve tanks and reservoirs, etc.
- In systems with more than one water source, the locations of the sampling points should take account of the number of inhabitants served by each source.
- There should be at least one sampling point directly after the clean-water outlet from each treatment plant.

Sampling sites in a piped distribution network may be classified as:

- fixed and agreed with the supply agency;
- fixed, but not agreed with the supply agency; or
- Random or variable.

Each type of sampling site has certain advantages and disadvantages. Fixed sites agreed with the supplier are essential when legal action is to be used as a means of ensuring improvement; otherwise, the supply agency may object to a sample result on the grounds that water quality may have deteriorated in the household, beyond the area of responsibility of the supplier. Nevertheless, fixed sample points are rare or unknown in some countries.

Fixed sites that are not necessarily recognized by the supply agency are used frequently in investigations, including surveillance. They are especially useful when results have to be compared over time, but they limit the possibility of identifying local problems such as cross-connections and contamination from leaking distribution networks.

Sampling regimes using variable or random sites have the advantage of being more likely to detect local problems but are less useful for analyzing changes over time.(WHO, 1997)

Sampling frequency

The most important tests used in water-quality surveillance or quality control in small communities are those for microbiological quality (by the measurement of indicator bacteria) and turbidity, and for free chlorine residual and pH where chlorination is used. These tests should be carried out whenever a sample is taken, regardless of how many other physical or chemical variables are to be measured.(WHO, 1997)

2.8.2 Drinking water testing

Establishing water quality testing as part of your project depends on your objectives and availability of resources. The following are some guiding questions for you to ask when starting out to help select appropriate water quality test methods:

•Why do you need to conduct water quality testing?

o Baseline information

o Planning and policy development

o Management and operational information

o Other purposes

• What water quality information is required?

Historically, conventional laboratories were mainly used to carry out water quality testing.

Now there is a wide variety of good testing kits and products available in the commercial market that allows you to conduct water quality testing on your own without relying on laboratory.

(CAWST, 2009)

2.9 Previous studies

1- Study of Assessment of Drinking Water Quality in Rabak Town, E.coli bacteria was present in 83% of the samples, The level of turbidity in this study was 54.4 NTU in average while in normal drinking water is less than 5 NTU. The PH of drinking water was 7.8 in averages while the optimum level being (6.5-8.5). (Belal,2010)

2- Water Quality: Assessment of the Current Situation in Asia. The study find that many regulatory and economic options are being tested for pollution control, but institutional and social challenges remain, in particular those related to population growth and the various ways in which it is affecting water quality across the region. (Alexandra, 2012)

3- A Comparative Study on Water Quality Assessment of Yamuna River Using AHP and Promethee Techniques., Birla Institute of Technology & Science. Aimed to assess water quality in Yamuna River in India, Various vital water quality parameters were identified and pairwise comparisons of all these indicators, namely BOD, DO, TC and ammonia and location-wise comparisons for each water quality indicator for all sites were analyzed using the AHP method with the goal of water quality assessment, to find the relative weight of water quality indicators. The case study's results showed that total coliform (TC) is the parameter having the highest contribution as a water quality indicator for determining the water pollution. (Ajit Pratap & Parnika Shrivastava 2015)

4- Water Quality Study in Democratic Republic of Timor-Leste conducted by WHO and Ministry of Health Environmental Health Division. Water quality study was conducted in four districts of Timor-Leste. The objective was to gather information necessary for finalization of the Water Quality Monitoring guidelines including development of Water Quality Standards . Nitrate concentration was found to be higher than the standard value in some sources. Flouride was found in some sources but it was less than the standard value. 70% of the sources tested were microbiologically contaminated. The results clearly indicate the importance of including bacteriological testing of the water in the national water quality monitoring system. (WHO, 2010)

5- Assessment of the quality of the drinking water in Khartoum state .Seven sites were selected to represent the area of wells water, relevance to environmental pollution in Khartoum area, Thirteen elements were observed and their concentrations determined in the various locations, those are Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and Zn. The concentration levels for Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn were lower than the detection limits for (AAS), and pre-concentration by physical method was found necessary for these elements. (Abdelmagid,2005)

6- Water chemistry and quality of the Blue Nile at Khartoum. The physical and chemical characteristics of the Blue Nile at Khartoum did not experience any change in its water chemistry. The pH in the Blue Nile was neither acidic nor highly alkaline. It fluctuated in the range 7.2 and 8.6, indicating that the river possesses a relatively high buffering capacity which prevents abrupt changes in its PH, the variation of NO3-N in the Blue Nile showed a definite annual cycle, (Sinada & Yousif ,2013)

7- Study on the effect of seasonal changes on drinking water quality and the prevalence of water-borne diseases in Shendi Town. The study revealed many findings the most important are Bacteriological quality of drinking water is poor and indicators of pollution exceeded the admissible level of WHO and Sudanese standards for drinking water in all seasons, Hardness of drinking water varied from season to another, water- borne diseases and, its prevalence rate in autumn is higher than in other seasons and weakness of knowledge among study population about drinking water quality and water-borne diseases. (Belal, 2015).

8- Bacteriological characterization of drinking water sources in villages of West Kordofan, The results showed that extremely high levels of total coliform were detected at each sample location compared to other faecal pollution indicators. High level of total coliform counts was observed in water sources and cement reservoirs compared to wells and household containers. Higher count was seen at the end of autumn compared to summer season. (Adam, 2013)

Chapter (3)

(Materials and methods)

3- Materials and methods

3.1- Study type and design

Descriptive cross sectional and analytical study. This study designed according to WHO and UNICEF recommendation for Water Quality Monitoring and Surveillance. The study designed to apply level (1) of water quality which aim to assess microbial , physical and chemical quality. See appendixes (1)

3.2 Study area

Ganes shareg area : Located on the east bank of the Blue Nile at a height of 492 meters above sea level , and away from the capital, Khartoum, about 500 km .It evolved with the construction of Alroseires dam, mediating ecological , climatic population diversity. The area of about ($9km^2$) , Includes (11) of neighborhoods and has (33820) of population There are varied sources of drinking water in the area where the Nile and different types of groundwater sources which are (1) treatment plant , (7) hand pump , (1) water yard" deep borehole with mechanic pumping "and (4) local surface water intake.

Ganes area has no sewerage system; the population depend on septic tanks, and traditional pit latrines for disposal of faecal waste and other liquid waste. (Alrosairis Locality Office 2017)

3.3- Study population

Drinking water sources in Ganess shareg area

3.4- Sample size

3.4.1 Bacteriology samples

Base on WHO recommendations for Verification of the microbial quality of drinking-water, the sample size for microbial quality is 12 samples per 500 of population in 12 months

Table (3-4) Bacteriology samples size

#	**Sources**	**Area**	**population**	**Standard**	**Samples per year**
1	HP1	Altaloba	768	< 5000	12
2	HP2	Altaloba	850	< 5000	12
3	HP3	Giessan	4580	< 5000	12
4	HP4	Bakory	2543	< 5000	12
5	HP5	Alengaz	710	< 5000	12
6	HP6	Alsafa	895	< 5000	12
7	HP7	Alraloba	710	< 5000	12
8	Surface 1	Alshatee	3104	< 5000	12
9	Surface 2	Alshatee	3002	< 5000	12
10	Surface 3	Alshatee	3075	< 5000	12
11	Surface 4	Alshatee	3603	< 5000	12
12	Mechanic pump	Almadanein	4991	< 5000	12
13	Station	alshatee	4989	< 5000	12
	Total population		33820	**Total samples**	156

<u>3.4.2 Physical samples</u>:

Has been taken with the same number of the microbial quality samples = 156 sample

3.4.3 Chemical Samples

The number of chemical samples is determined based on WHO water quality guideline recommendations for Periodic testing and sanitary inspection of community drinking-water supplies. Which recommend that (Comprehensive analysis of the chemical quality of all sources is recommended prior to commissioning as a minimum and preferably every 3–5 years)(WHO, 2011)

The samples has been taken as one chemical sample for each source and checked for 7 chemical parameters

3.5 Sampling technique

In this study I used the WHO water quality guideline recommendations for samples it recommend that ". Sampling frequencies are usually based on the population served or on the volume of water supplied. Frequency of testing for individual characteristics will also depend on variability. Sampling and analysis are required most frequently for microbial and less often for chemical constituents. This is because even brief episodes of microbial contamination can lead directly to illness in consumers, whereas episodes of chemical contamination that would constitute an acute health concern, in the absence of a specific event are rare. Sampling frequencies for water leaving treatment depend on the quality of the water source and the type of treatment".(WHO, 2011)

3.6 Samples collection:

After obtaining sterilized bottles from MOH water quality laboratory of the Blue Nile state, samples were collected from all drinking water sources in Ganes-shareg area.

The collections of samples were completed by successive steps as follows:

Bacteriology samples

- **Hand pumps:**

1- The Hand pump outlet piston cleaned to remove any attachments that may cause splashing by using clean cloth.
2- The Hand pump moved at maximum flow and let the water run for 1-2 minutes.
3- The outlet piston Sterilized for a minute with flame using cotton and alcohol.
4- The Hand pump moved before sampling to allow the water to flow for 1-2 minutes at medium flow rate.
5- Sterilized bottle opened and the bottle took out carefully and the tap unscrew.
6- The bottle filled and immediately and small air space leaved to shaking before analysis.
7- The bottle Caped carefully and kept in the ice box before Transportation to laboratory.

- **Surface sources**

1- Sterilized gloves Used.
2- Proper position in the surface intake Chosen .
3- The bottle nozzle Sterilized using flame from lighter.
4- The bottle Gently dropped in the water opposite the stream.
5- Wait until the bottle is filled and leave a vacuum of air to breathe the bacteria.
6- The bottle Removed and sealed and placed it in the cooling box

- **Treatment plant and the deep borehole with mechanic pump:**

1- Tap ware Cleaned to remove any attachments that may cause splashing by usingclean cloth.
2- Tap opened at maximum flow and let the water run for 1-2 minutes.
3- Sterilize the tap for a minute with flam.
4- Tap opened before sampling , the water allowed to flow for 1-2 minutes at Medium flow rate.
5- Sterilized bottle opened and took out , bottle carefully unscrewed the tap.
6- the bottle Filled and immediately holding the bottle under the water jet and fill it andleave small air space to shaking before analysis.
7- The bottle Caped carefully and kept it in the ice box before Transportation tolaboratory.

Chemical and physical sampling

1- Sterilized plastic container with size 1 letter used.
2- Container was filled with water from the targeted source and emptied 3 times.
3- Bottles filled up to the mark of 1 letter and sealed.
4- The sample Marked.

Sanitary inspection: carried out using standardized checklists for observations and interviews with a scoring system to quantify overall risk.

1- Standard checklist used for each source .
2- Actual visit to the source site conducted.
3- Actual inspection conducted.
4- The checklist questions filled.
5- Calculated the (Yes) answers to get the sanitary inspection score.

3.7 Samples analysis:

All sample analyzed in the MOH water quality laboratory in Dmazen – Blue Nile State except pH, temperature and turbidity which were checked in the source location.

3.7.1 Bacteriological examination: indicator Bacteria (E.coli)

I. The filtration membrane (MF) method is used to detect the (E.coli) as indicator bacteria for faecal contamination

II. 100-ml of water is filtered through a cellulose membrane with a pore size of 0.45 microns, which screens out all coliform bacteria.

The membrane is then incubated in a growth medium (Membrane Lauryl Sulphate Broth) at a particular temperature (44).

Bacteria that are favored by the growth medium will grow into colonies that can be counted after 24 to 48 hours. Results are reported as colony-forming units(CFU) per 100 mL. As with the MTF method, positive test results should be considered as presumptive, and confirmed with subsequent inoculations into more selective growth-media.

3.7.2- Chemical testing:

Photometer 7500 has been used

I- Fluoride:

Reagents and equipment :

1- palintest fluoride NO 1 tablets,
2- palintestNO 2 tablets ,
3- palintest automatic wavelength selection photometer
4- round test tubes 10 ml glass (PT 595).

Test and Procedures:

1- The test tube filled with sample to the 10 ml mark as a blank.

2- Other test tube filled with sample to 10 ml mark and add one fluoride NO (1) tablet then crush and mix to dissolve.

3-One fluoride NO 2 tablet Added then crushed and mixed to dissolve.

4- Waiting for five minutes to allow full color development.

5- Fluoride choice Selected on photometer7500 .

6- Photometer reading Taken in usual manner after using the blank sample.

7- The fluoride result is displayed as mg/l F.

II- Hardness

Reagents and equipment:

palintesthardicol NO 1 tablets,

Palintesthardicol NO 2 tablets ,

palintest automatic wavelength selection photometer

Round test tubes 10 ml glass.

Test and Procedures:

Test completed according to standard methods for examinations of water as fallowing steps:

1- The test tube filled with sample to the 10 ml mark as a blank.
2- Other test tube filled with sample to 10 ml mark and hardicol NO 1 tablet added then crushed & mixed to dissolve.
3- One hardicol NO 2 tablet added then crushed and mixed to dissolve and ensure all particles are completely dissolved.
4- Waiting for two minutes to allow full color development.
5- Hardness choice Selected on photometer 7500.
6- Photometer reading Take in usual manner after using the blank sample.
7- 7- The total hardness result is displayed as mg/l $CaCO_3$.

III- Total iron (Fe):

Reagents and equipment:

Palintest iron LR tablets,

Palintestautomatic wavelength selection photometer

Round test tubes 10 ml glass.

Test and Procedures:

Test is completed according to standard methods for examinations of water as fallowing steps:

1- The test tube filled with sample to the 10 ml mark as a blank.
2- Other test tube filled with sample to the 10 ml mark and one HR tablet added then crushed and mixed to dissolve.
3- Waiting for one minute to allow full color development.
4- Fe choice Selected on photometer.
5- Photometer reading Taken in usual manner after using the blank sample.
6- The result is displayed as mg /l Fe.

IV- **Nitrate (NO3):**

Reagents and equipment:

Palintestnitricol tablets,

Palintestautomatic wavelength selection photometer

Round test tubes 10 ml glass.

Test and Procedures:

Test is completed according to standard methods for examinationsof water as fallowing steps:

1- The test tube filled with sample to the 10 ml mark as a blank.
2- Other test tube filled with sample to 20 ml mark
3- One spoonful of Nitratest Powder and one Nitratest tablet Added and screw cap replaced and the tube shaken well for minute

4- Waiting for one minutes then gently invert three times to aid flocculation and waiting for two minute to ensure complete settlement.
5- The screw cap Removed and wiped around the top the tube with a clean tissue decant the clear solution into a round test tube filling the 10 ml mark.
6- Nitricol tablet Added, crushed and mixed to dissolve.
7- Waiting for 10 minutes to allow full colour development.
8- No3 choice Selected in photometer 7500.
9- Photometer reading Taken in usual manner after using the blank sample.
10- The Nitrate result is displayed as mg/l No3

3.7.3- Physical testing

I- Turbidity:

Equipment: palintest Turbimeter

Test and Procedures: it was measured according to standard methods for examination of water by the following steps

1- The test tube filled to the mark 10ml.
2- All marks and fingerprints Removed from the sample tube before measuring.
3- The sample tube Caped.
4- the silicone oil Dropped onto the tube and wiped using the lint free polishing cloth to reduce the effect of scratches on the glass.
5- the capped tube Holden at an angle and rotate to remove the bubbles from sample tube wall.
6- The sample tube Placed in the instrument.
7- The read mode Selected to measure turbidity.

8- Turbimeter reading Taken in usual manner after using the blank sample.
9- The result is displayed as NTU.

II- Temperature

Equipment: thermometer

Test and Procedures: it was measured according to standard methods for examination of water by the following steps

1- Sample Taken using a flask.
2- The metal part of the thermometer Inserted in the sample container.
3- Waited until the word HOLD appears in the screen.
4- The thermometer reading Taken.
5- The result is displayed as centigrade.

III- <u>Total Dissolved Solids (TDS):</u>

Equipment: Micro 800 MULTI

Test and Procedures: it was measured according to standard methods for examination of water by the following steps:

1- Calibration conducted using standard solution attached to the testing kits.
2- After calibration the instrument for water sample was put in the glass beaker.
3- The device (Micro 800 MULTI) sensorwas immersed into this water sample.
4- TDS were selected in the device Micro 800 MULTI.
5- Then it was allowed to stand until it achieves stable reading.
6- The reading was noted in ppm.

IV- Electrical Conductivity (EC)

Equipment: Micro 800 MULTI

Test and Procedures: it was measured according to standard methods for examination of water by the following steps

1- Calibration conducted using standard solution attached to the testing kits.
2- After calibration the instrument for water sample was put in the glass beaker.
3- The device (Micro 800 MULTI) sensor was immersed into this water sample.
4- EC were selected in the device Micro 800 MULTI.
5- Then it was allowed to stand until it achieves stable reading.
6- The reading was noted in μs.

V- **pH**:

Equipment: Micro 800 MULTI

Test and Procedures: it was measured according to standard methods for examination of water by the following steps

1- Calibration conducted using standard solution attached to the testing kits.
2- After calibration the instrument for water sample was put in the glass beaker.
3- The device (Micro 800 MULTI) sensor was immersed into this water sample.
4- PH were selected in the device Micro 800 MULTI.
5- Then it was allowed to stand until it achieves stable reading.
6- The reading was noted.

3.8 Data collection

The data were collected by the following methods:

1- **Sanitary inspection**: carried out using standardized checklists for observations and interviews with a scoring system to quantify overall risk.

2-**interview**: a numerous of interviews were implemented with a number of persons such as manager of health office , manager of Civil Water Corporation (CWC), workers at treatment plant. In Ganesshareg area and alrosairis locality obtain the required information.

3-**observation**: with regard the distribution system and facilities of storage at household.

4-**records**:searched in records at locality office, and rural water corporation.

5-**laboratory**: samples were collected from the identified sites of drinking water supply (Sources) at Ganesshareg area were analysed at MOH water quality laboratory in AldmazinTown to determine physical , chemical and bacteriological quality of drinking water. Some of the parameters checked in the field directly after taking the samples using the portable kits.

3.9 Data analysis

Data were analyzed by computer using both Microsoft Excel, and the results are presented in percentage tables and other statistical graphs.

3.10 Ethical consideration

The ethical considerations of this study as the following:

- Permission had been taken from Civil Water Corporation represented by manager of corporation in Alrosiris locality to permit for take water samples from water sources for purposes of study.
- Agreement had been taken from manager of environmental health unit and manager of distance in Blue Nile state to obtain on certain required information for study.
- Agreement had been taken from Ministry of Health Blue Nile State , represented by manager of water safety and quality laboratory to use laboratory and it's facilities for analyzed the water samples.

- Permission had been taken from health services coordinator in alrosairis locality to allow intervention in Ganes shareg area and facilitate the sampling and sanitary inspection .

Chapter (4)

(Results)

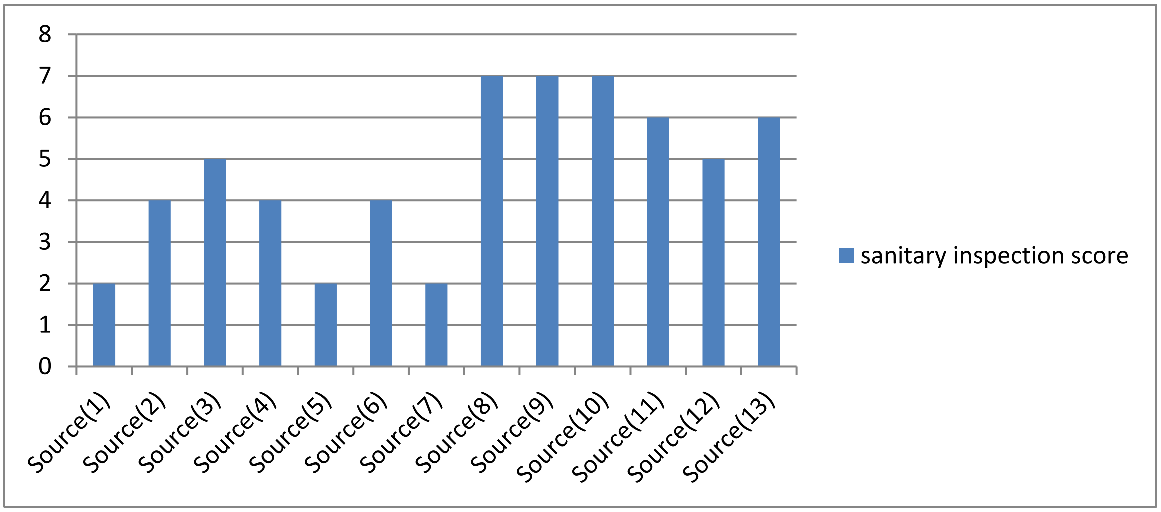
Sanitary inspection

Table (4-5) shows the locations and the sanitary inspection score for all sources in the study area

Source	Name of source	Location		Type	Sanitary inspection score
		Latitude	Longitude		
Source (1)	Tahaalshaeeb basic school	١١,٨٣٣١٠٤	٣٤,٣٩٥٦٧٩	Ground water	2
Source (2)	Khouraldao	١١,٨٢٩٩١٧	٣٤,٣٩٥٠٤٧	Ground water	4
Source (3)	Hai Giessan	١١,٨٢٤٦٩٩	٣٤,٣٩١١٩٥	Ground water	5
Source (4)	Hai Bakory	١١,٨٢٢٩٥٨	٣٤,٣٩١٧٥٢	Ground water	4
Source (5)	Alburhania	١١,٨١٨٥٩٠	٣٤,٤٠٤٣١٦	Ground water	2
Source (6)	Hai Alsafa	١١,٨٢٠٨٠٤	٣٤,٤٠٩٥٩٦	Ground water	4
Source (7)	Masgedabubakral sedeeg	١١,٨٢٨٧٧٢	٣٤,٣٩٩٤١٢	Ground water	2
Source (8)	alhamair	١١,٨٠٧٧٩٩	٣٤,٣٨٧٠١٨	Surface	7
Source (9)	altomsah	١١,٨٠٨٣٢٩	٣٤,٣٨٦٦٨١	Surface	7
Source (10)	almashtal	١١,٨١٢٩٧٨	٣٤,٣٨٥١٤٦	Surface	7
Source (11)	almahgar	١١,٨٢٢٢٧٠	٣٤,٣٨٢٣١٦	Surface	6
Source (12)	treatment plant	١١,٨١٠٨٠١	٣٤,٣٨٧٠٠	Surface	5
Source (13)	Deep borehole with mechanic pump	١١,٨١٦٦١٣	٣٤,٤٠٠٢٩٠	Ground water	6

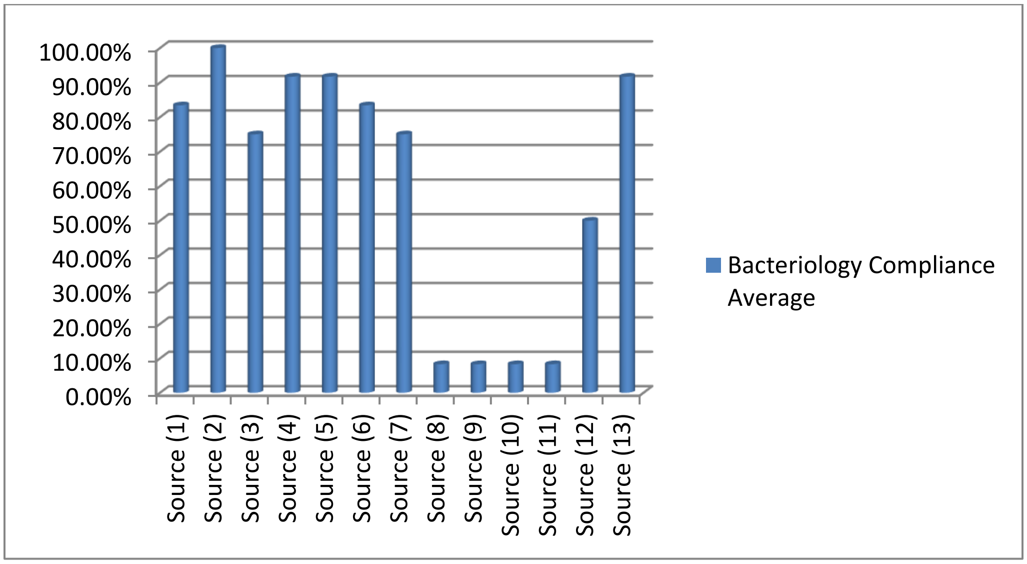
The Table show that the highest score of sanitary inspection among all sources is 7 and the lowest score is 2

Figure (4-1):sanitary inspection score for all sources



The figure show that the highest sanitary inspection score is 7 points appear in sources 8 , 9 and 10 and the lowest score is 2points appear in sources 1 ,5 and 7

Figure (4-2): Bacteriology Compliance Average



The figure show that source No2 is fully comply with SSMO & WHO bacteriology standard and 3 of sources comply with average 91.7% and 2 sources 83.40 , 2 sources 75% , one source 50% and four sources comply with average 8.30%

Bacteriology results

Table (4-6) Bacteriology analysis results for source No (1)

Source Name		TahaAlshaeeb basic school HP	
Source Type		Ground Water	
Location		HaiAltaloba	
Beneficiaries		768	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	-VE	0
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	-VE	0
8	Sample 8	+VE	6
9	Sample 9	-VE	0
10	Sample 10	+VE	2
11	Sample 11	-VE	0
12	Sample 12	-VE	0

The table shows that E.coli presence in 2 samples out of 12 and the highest Number of colonis is 6 , and it absence in 10 of the samples.

Table (4-7) Bacteriology analysis results for source No (2)

Source Name		Khouraldao	
Source Type		Ground Water	
Location		HaiAltaloba	
Beneficiaries		850	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	-VE	0
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	-VE	0
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	-VE	0
12	Sample 12	-VE	0

The table show that E.coli Not presence in any samples , and it absence in all the 12 samples.

Table (4-8) Bacteriology analysis results for source No (3)

Source Name		HaiGiessan	
Source Type		Ground Water	
Location		HaiGiessan	
Beneficiaries		4580	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	-VE	0
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	+VE	5
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	+VE	3
12	Sample 12	+VE	1

The table shows that E.coli presence in 3 samples out of 12 and the highest Number of colonis is 5 , and it absence in 9 of the samples.

Table (4-9) Bacteriology analysis results for source No (4)

Source Name		HaiBakory	
Source Type		Ground Water	
Location		HaiBakory	
Beneficiaries		2543	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	1
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	-VE	0
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	-VE	0
12	Sample 12	-VE	0

The table show that E.coli presence in 1 sample out of 12 and the highest Number of colonis is 1 , and it absence in 11 of the samples.

Table (4-10) Bacteriology analysis results for source No (5)

Source Name		ALBURHANIA	
Source Type		Ground Water	
Location		Haialengaz	
Beneficiaries		710	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	4
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	-VE	0
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	-VE	0
12	Sample 12	-VE	0

The Table show that E.coli presence in 1 sample out of 12 and the highest Number of colonis is 1 , and it absence in 11 of the samples.

Table (4-11) bacteriology analysis results for source No (6)

Source Name		Hai ALSAFA	
Source Type		Ground Water	
Location		Hai ALSAFA	
Beneficiaries		895	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	16
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	+VE	32
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	-VE	0
12	Sample 12	-VE	0

The table show that E.coli presence in 2 samples out of 12 and the highest Number of colonis is 32 , and it absence in 10 of the samples.

Table (4-12) bacteriology analysis results for source No (7)

Source Name		MasgedAbuBakralsedeeg	
Source Type		Ground Water	
Location		Hai ALTALOBA	
Beneficiaries		716	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	-VE	0
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	-VE	0
5	Sample 5	+VE	1
6	Sample 6	-VE	0
7	Sample 7	+VE	9
8	Sample 8	+VE	1
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	-VE	0
12	Sample 12	-VE	0

The Table show that E.coli presence in 3 samples out of 12 and the highest Number of colonis is 9 , and it absence in 9 of the samples.

Table (4-13) bacteriology analysis results for source No (8)

Source Name		ALHAMAIR	
Source Type		Surface Water	
Location		HaiAlshatee	
Beneficiaries		3104	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	45
2	Sample 2	+VE	82
3	Sample 3	-VE	0
4	Sample 4	+VE	105
5	Sample 5	+VE	54
6	Sample 6	+VE	195
7	Sample 7	+VE	95
8	Sample 8	+VE	112
9	Sample 9	+VE	95
10	Sample 10	+VE	73
11	Sample 11	+VE	1
12	Sample 12	+VE	15

The table show that E.coli presence in 11 samples out of 12 and the highest Number of colonis is 195 , and it absence only in one sample

Table (4-14) bacteriology analysis results for source No (9)

Source Name		ALTOMSAH	
Source Type		Surface Water	
Location		HaiAlshatee	
Beneficiaries		3002	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	5
2	Sample 2	+VE	14
3	Sample 3	-VE	0
4	Sample 4	+VE	99
5	Sample 5	+VE	73
6	Sample 6	+VE	145
7	Sample 7	+VE	196
8	Sample 8	+VE	1
9	Sample 9	+VE	7
10	Sample 10	+VE	145
11	Sample 11	+VE	136
12	Sample 12	+VE	26

The table show that E.coli presence in 11 samples out of 12 and the highest Number of colonis is 195 , and it absence only in one sample.

Table (4-15) Bacteriology analysis results for source No (10)

Source Name		MoshraaALMASHTAL	
Source Type		Surface Water	
Location		HaiAlshatee	
Beneficiaries		3750	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	26
2	Sample 2	+VE	19
3	Sample 3	-VE	0
4	Sample 4	+VE	84
5	Sample 5	+VE	93
6	Sample 6	+VE	152
7	Sample 7	+VE	32
8	Sample 8	+VE	7
9	Sample 9	+VE	8
10	Sample 10	+VE	177
11	Sample 11	+VE	73
12	Sample 12	+VE	67

The Table show that E.coli presence in 11 samples out of 12 and the highest Number of colonis is 195 , and it absence only in one sample.

Table (4-16) Bacteriology analysis results for source No (11)

Source Name		MoshraaALMAHGAR	
Source Type		Surface Water	
Location		HaiAlshatee	
Beneficiaries		3603	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	+VE	10
2	Sample 2	+VE	6
3	Sample 3	-VE	0
4	Sample 4	+VE	85
5	Sample 5	+VE	132
6	Sample 6	+VE	8
7	Sample 7	+VE	53
8	Sample 8	+VE	10
9	Sample 9	+VE	2
10	Sample 10	+VE	17
11	Sample 11	+VE	65
12	Sample 12	+VE	7

The Table show that E.coli presence in 11 samples out of 12 and the highest Number of colonis is 195 , and it absence only in one sample.

Table (17) Bacteriology analysis results for source No (12)

Source Name		GanesssharegTreatment plant	
Source Type		Surface Water	
Location		HaiAlshatee	
Beneficiaries		4989	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	-VE	0
2	Sample 2	-VE	0
3	Sample 3	+VE	5
4	Sample 4	+VE	3
5	Sample 5	+VE	4
6	Sample 6	-VE	0
7	Sample 7	+VE	5
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	+VE	175
11	Sample 11	+VE	65
12	Sample 12	-VE	0

The Table show that E.coli presence in 6 samples out of 12 and the highest Number of colonis is 175 , and it absence in 6 of samples.

Table (4-18) bacteriology analysis results for source No (13)

Source Name		DEEP BORHOLE WITH MECHANIC PUMP	
Source Type		Ground Water	
Location		Hai Alemtedad	
Beneficiaries		4991	
#	**Sample**	**E.coli**	**No of Colonies**
1	Sample 1	-VE	0
2	Sample 2	-VE	0
3	Sample 3	-VE	0
4	Sample 4	+VE	12
5	Sample 5	-VE	0
6	Sample 6	-VE	0
7	Sample 7	-VE	0
8	Sample 8	-VE	0
9	Sample 9	-VE	0
10	Sample 10	-VE	0
11	Sample 11	-VE	0
12	Sample 12	-VE	0

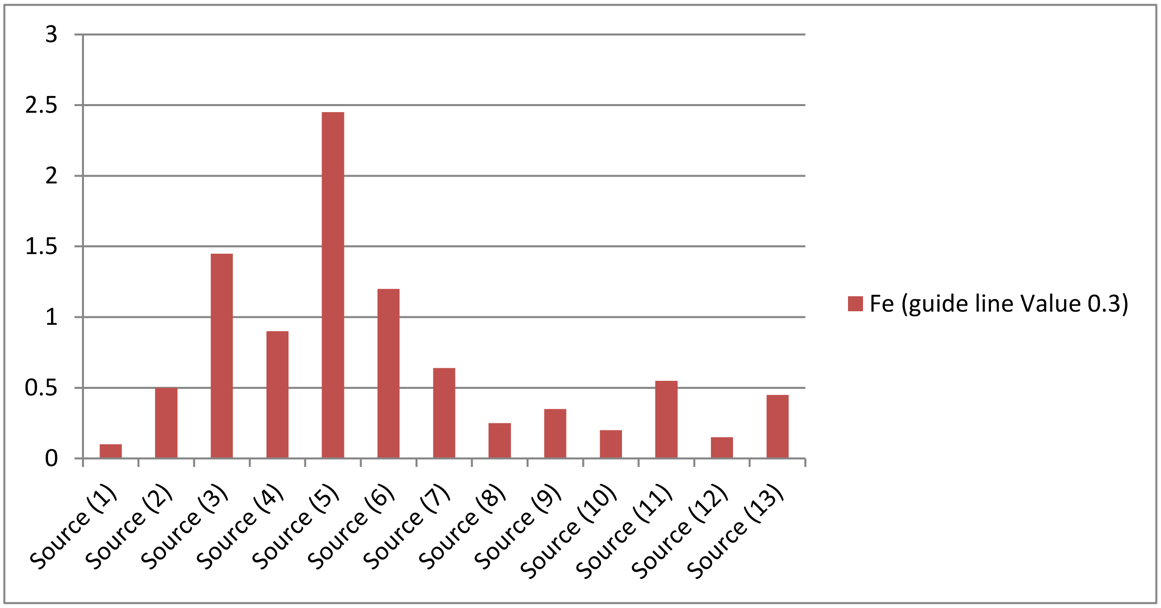
The table show that E.coli presence in 1 sample out of 12 and the highest Number of colonis is 12 , and it absence in 11 of samples.

Table (4-19) Results of chemical analysis

Source	Area	Type	Fe	F	No3	Hardness	PH
Source (1)	HaiAltaloba	ground water	0.1	1.1	0.52	245	8.97
Source (2)	Khouraldao	ground water	0.5	1.16	0.50	240	8.3
Source (3)	HaiGiessan	ground water	1.45	1.11	3.20	350	8.1
Source (4)	Haibakory	ground water	0.9	1.15	0.44	400	7.7
Source (5)	Haialengaz near	ground water	2.45	0.77	0.56	265	7.99
Source (6)	Hai ALSAFA	ground water	1.2	1.09	0.26	280	8
Source (7)	Hai ALTALOBA	ground water	0.64	1.46	2.40	285	7.54
Source (8)	HaiAlshatee	Surface	0.25	0.79	0.02	80	8.03
Source (9)	HaiAlshatee	Surface	0.35	0.93	0.10	90	8.21
Source (10)	HaiAlshatee	Surface	0.20	0.86	0.14	65	8.44
Source (11)	HaiAlshatee	Surface	0.55	0.57	0.26	45	8.2
Source (12)	HaiAlshatee	Surface	0.15	0.90	0.48	70	8.5
Source (13)	Hai alemtedad	ground water	0.45	0.45	0.08	210	7.6

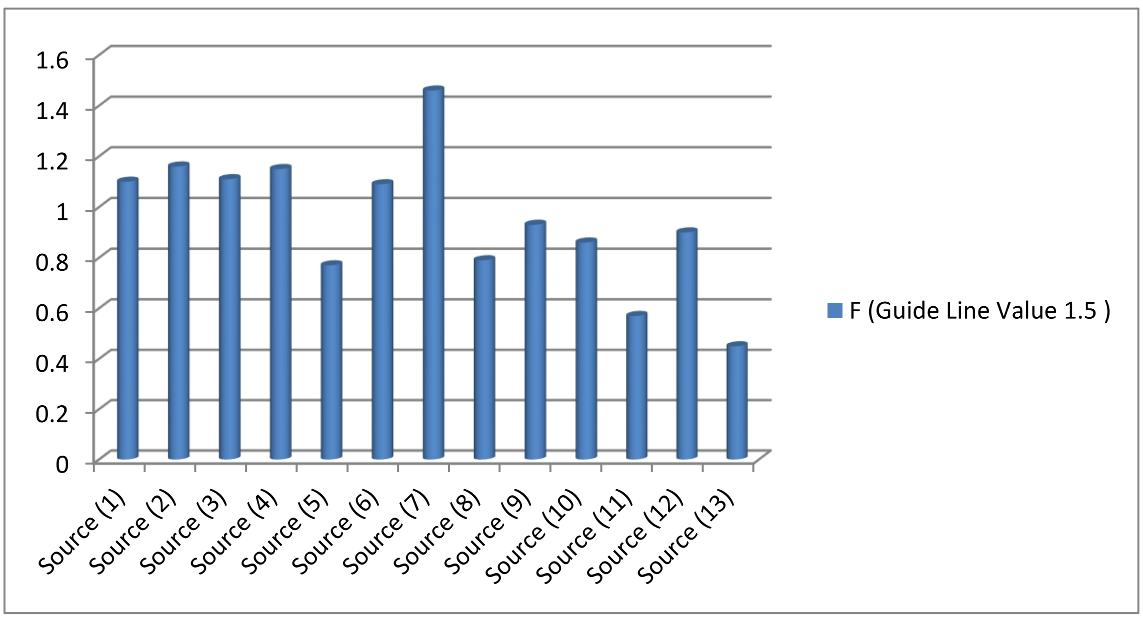
The table show the result of chemical analysis , the lowest values of Fe , F , No3 , Hardness and PH are 0.1 in source(1) , 0.45 in source(13), 0.02 in source(8) , 7.6 in source (13)and the Highest values are 2.45 in source(5) , 1.46 in source(7) and , 3.20 in source(3) and 400 in source(4) , 8.97 in source(1)

Figure (4-3): Fe concentration and complying Average



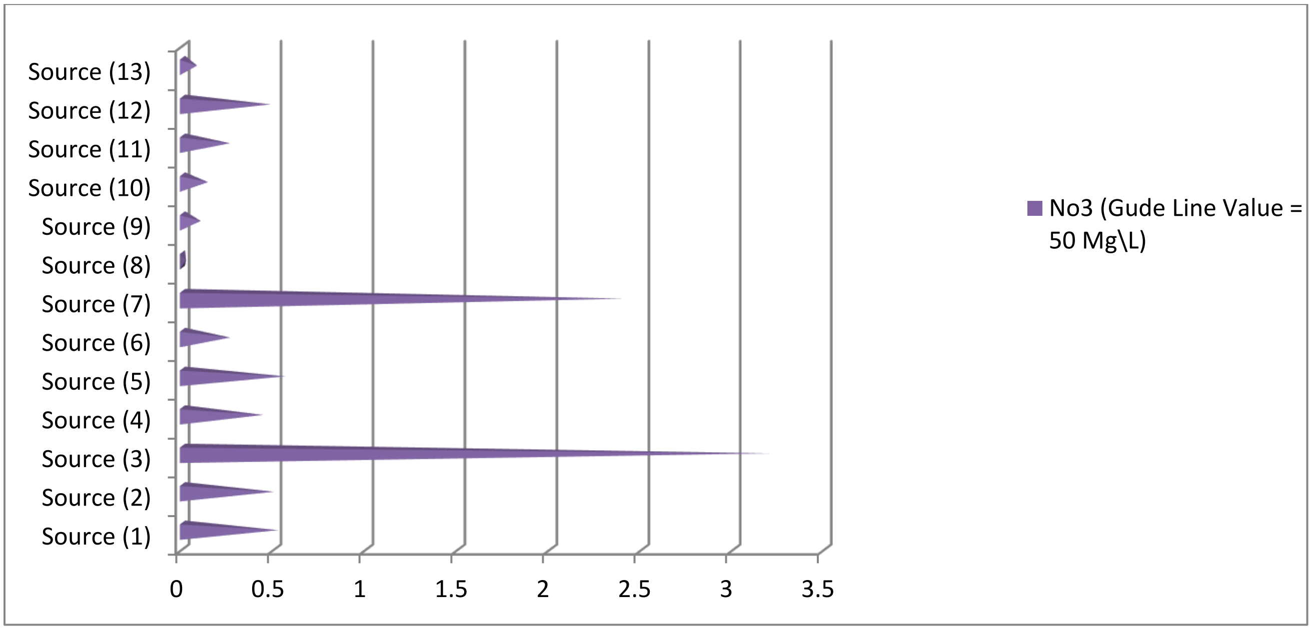
The Figure show that only sources 1 , 8 , 10 , 12 are comply with SSMO and WHO **Fe** standard , and the highest value 2.45 found in source(5)

Figure (4-4): Fluorideconcentration and complying Average



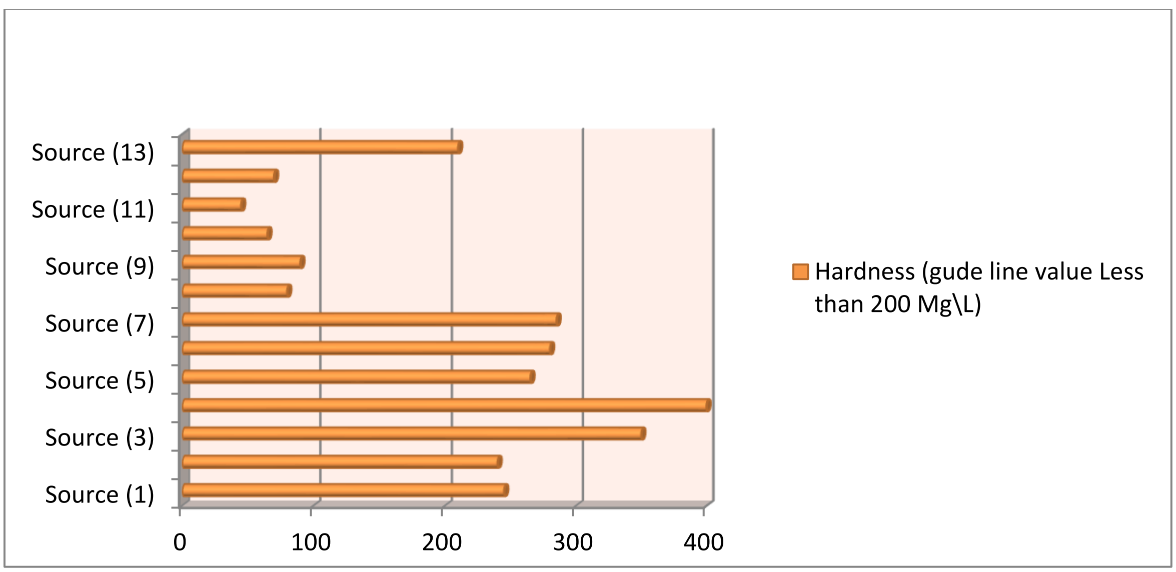
The Figure show that all the sources are comply with SSMO & WHO Fluoride Standards and in safe range.

Figure (4-5): Nitrate (No3) concentration and complying Average



The Figure show that all the sources are comply with SSMO & WHO nitrates Standards and in safe range.

Figure (4-6): Hardness concentration and complying Average



The Figure show that just 5 of sources comply with SSMO & WHO Hardness Standard and other sources are poor and not in safe range, the highest result in source(4) 400Mg\L

Physicochemical

Table (4-20) Physicochemical results for source (1)

Source Name		Hand pump (TahaAlshaeeb basic school)			
Source type		Ground water			
Location		HaiAltaloba			
SN	**Sample**	**Turbidity (NTU)**	**Temperature (Cº)**	**TDS(PPM)**	**E.cμs/cm**
1	**Sample 1**	2.68	29	476	925
2	**Sample 2**	3.8	32	259	490
3	**Sample 3**	1.2	28	306	613.3
4	**Sample 4**	1.22	27.7	581	1162
5	**Sample 5**	0.9	29.1	579	1058
6	**Sample 6**	4.3	29.2	581	1162
7	**Sample 7**	1.8	29.1	568.4	1135
8	**Sample 8**	2	30.1	585.5	1171
9	**Sample 9**	3.4	30.1	597.2	1194
10	**Sample 10**	3.2	29.4	594.1	1188
11	**Sample 11**	3.1	25.3	584.6	1169
12	**Sample 12**	1.2	25.9	592.2	1084

The Table show that lowest values of Turbidity ,Temperature , TDS and E.c are 0.9 , 25.3 , 259 , 490 and 6.6 and the highest values for, are 4.3 , 32 , 592.2 , 1194

Table (4-21) Physicochemical result for source (2)

Source name		Hand pump (Khouraldao)			
Source type		Ground water			
Location		HaiAltaloba			
#	**Sample**	**Turbidity (NTU)**	**Temperature (Cº)**	**TDS(PPM)**	**E.cμs/cm**
1	**Sample 1**	0.98	27	503	1007
2	**Sample 2**	2.81	31	227	455
3	**Sample 3**	3.3	28	287.6	575.1
4	**Sample 4**	1.12	27.6	539.7	1079
5	**Sample 5**	1.27	29.3	536.6	1072
6	**Sample 6**	1.98	29.2	538.3	1077
7	**Sample 7**	3.1	29.2	535.1	1071
8	**Sample 8**	2.3	30.3	538.3	1076
9	**Sample 9**	3.1	30.1	528.8	1059
10	**Sample 10**	2.1	29.9	529.1	1056
11	**Sample 11**	1.4	24	538.5	1075
12	**Sample 12**	2.4	25	525	1053

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 0.98 , 24 , 227 , 455 and the highest values for, are 3.3 , 31 , 539.7 , 1079

Table (4-22) Physicochemical result for source (3)

Source Name		HaiGiessan			
Source type		Ground water			
Location		HaiGiessan			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	1.75	29	400	995
2	**Sample 2**	2.7	31	468	933
3	**Sample 3**	2.3	28	304.2	602.7
4	**Sample 4**	3.4	27.7	529	1058
5	**Sample 5**	1.2	28.4	564.5	1211
6	**Sample 6**	2.15	29.2	530.9	1063
7	**Sample 7**	1.11	29.1	535.3	1070
8	**Sample 8**	3.2	29.1	528.7	1029
9	**Sample 9**	2.1	30.2	541	1079
10	**Sample 10**	3.2	29	628.8	1257
11	**Sample 11**	4	30.5	544.8	1089
12	**Sample 12**	2.2	29.7	537.5	1076

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 1.11 , 27.7 , 304.2 , 602.7 and the highest values, are 4 , 30.5 , 628.8 , 1257

Table (4-23) Physicochemical result for source (4)

Source Name		Haibakory			
Source type		Ground Water			
Location		west of alhelalalahmar			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	1.78	28	582	1165
2	**Sample 2**	1.41	32	218	438
3	**Sample 3**	1.7	28.1	313.7	627
4	**Sample 4**	3.1	27.4	584.9	1170
5	**Sample 5**	1.87	29.3	595.8	1191
6	**Sample 6**	1.22	29.2	602	1203
7	**Sample 7**	2.1	30.3	630.9	1261
8	**Sample 8**	1.9	29.6	626	1273
9	**Sample 9**	2.5	29.6	628.1	1256
10	**Sample 10**	2.3	29.4	629.1	1258
11	**Sample 11**	3.3	29.5	631	1262
12	**Sample 12**	2.49	28	610	1218

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 1.22 , 27.4 , 218 , 438 and the highest values, are 3.3 , 32 , 631 , 1262

Table (4-24) physicochemical result for source (5)

Source Name		ALBURHANIA Hand pump			
Source Type		Ground water			
Location		Haialengaz			
#	**Sample**	**Turbidity (NTU)**	**Temperature (C^{o})**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	3.69	30	434	868
2	**Sample 2**	5.48	32	290	582
3	**Sample 3**	2	27.8	241.4	482.6
4	**Sample 4**	2.1	27.4	468	936.4
5	**Sample 5**	2.43	29.1	445.6	891.4
6	**Sample 6**	2.3	25.6	506	1011
7	**Sample 7**	2	25	500	1000
8	**Sample 8**	2.5	27.2	502	1004
9	**Sample 9**	1.3	25	503.4	1006
10	**Sample 10**	3.1	25.7	500.8	1001
11	**Sample 11**	1.4	24	495.2	977.1
12	**Sample 12**	1.58	26	498	997

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 1.4 , 24 ,241.4 482.6 and the highest values, are 5.48 , 32 , 506 , 1011

Table (4-25) Physicochemical result for source (6)

Source Name		Hai ALSAFA			
Source Type		Ground water			
Location		Hai ALSAFA			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	2.19	28	462	937
2	**Sample 2**	3.94	31	269	538
3	**Sample 3**	1.2	27	264.6	529
4	**Sample 4**	2.2	27.5	502.3	1004
5	**Sample 5**	1.22	29.2	506.8	1013
6	**Sample 6**	1.15	29.1	504.1	1011
7	**Sample 7**	2	25	511.3	1026
8	**Sample 8**	3.5	25.7	505.8	1007
9	**Sample 9**	3.1	26	501.2	1004
10	**Sample 10**	1.3	24	503.8	1008
11	**Sample 11**	4.2	24.9	494	992
12	**Sample 12**	2.1	27	501.1	1002

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 1.2 , 24 ,264.6, 529 and the highest values, are 4.2 , 31 , 511.3 , 1026

Table (4-26) Physicochemical result for source (7)

Source Name		MasgedAbuBakralsedeeg Hand pump			
Source Type		Ground water			
Location		Hai ALTALOBA			
#	**Sample**	**Turbidity (NTU)**	**Temperature(Cº)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	4.33	26.1	285	567
2	**Sample 2**	2.78	31.6	297	594
3	**Sample 3**	1.3	27.9	311	622
4	**Sample 4**	2.6	27.6	506	1182
5	**Sample 5**	3.3	29.3	590	1183
6	**Sample 6**	3.98	29.2	587.5	1175
7	**Sample 7**	2.6	29.1	588.4	1177
8	**Sample 8**	1.2	25.6	530.4	1069
9	**Sample 9**	3	24	535	1073
10	**Sample 10**	2.4	28	534.4	1068
11	**Sample 11**	0.9	26	538.9	1077
12	**Sample 12**	2	27	539.5	1077

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 1.2 , 24 ,285, 567 and the highest values, are 4.33 , 31.6 , 590 , 1183

Table (4-27) Physicochemical result for source (8)

Source Name		MoshraaALHAMAIR			
Source Type		Surface Water (Blue Nile)			
Location		HaiAlshatee			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C^o)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	16	28.6	95	154
2	**Sample 2**	28.6	29.5	108	217
3	**Sample 3**	799	28.3	62.25	124.6
4	**Sample 4**	800	28.4	127.7	254.3
5	**Sample 5**	713	27.6	126.5	251.5
6	**Sample 6**	670	28.6	133	265.9
7	**Sample 7**	789	29.4	136.7	273.1
8	**Sample 8**	712	29.3	135.3	270.7
9	**Sample 9**	765	28.9	138	278.2
10	**Sample 10**	769	29	132	264.9
11	**Sample 11**	794	29.2	77.62	155.3
12	**Sample 12**	794	29.1	140	279.9

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c 16 , 27.6 ,95, 154 , and the highest values, are 799 , 29.5 , 140 , 279.9

Table (4-28) Physicochemical result for source (9)

Source Name		Moshraa ALTOMSAH			
Source Type		Surface Water (Blue Nile)			
Location		HaiAlshatee			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	16.7	27.7	53.7	107
2	**Sample 2**	10.9	28.9	94	190
3	**Sample 3**	799	28.1	51.75	103.5
4	**Sample 4**	734	28.8	107.2	214.8
5	**Sample 5**	722	27.3	107.6	215
6	**Sample 6**	765	29.1	150.9	301
7	**Sample 7**	774	29.4	133.8	276.6
8	**Sample 8**	779	28.3	131.5	263
9	**Sample 9**	729	29.2	130	259.9
10	**Sample 10**	735	28.8	131.8	264.4
11	**Sample 11**	783	29.4	133.3	266.2
12	**Sample 12**	789	29.9	131.8	263.5

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 16.7 , 27.3 , 51.75, 103.5 and the highest values, are 799 , 29.9 , 150.9, 301

Table (4-29) Physicochemical result for source (10)

Source Name		Moshraa ALMASHTAL			
Source Type		Surface Water (Blue Nile)			
Location		HaiAlshate			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cμs/cm**
1	**Sample 1**	17.4	26.7	81.1	162
2	**Sample 2**	12.9	28.4	95	188
3	**Sample 3**	800	27.8	52.65	105.2
4	**Sample 4**	714	28.4	94.85	188.2
5	**Sample 5**	795	27.2	89.7	213.9
6	**Sample 6**	733	29.1	135.7	271.3
7	**Sample 7**	745	29	145.7	291
8	**Sample 8**	714	28.9	134.7	269.9
9	**Sample 9**	786	28.9	133.4	266.7
10	**Sample 10**	745	28.9	133.7	276.2
11	**Sample 11**	729	29	135.4	271
12	**Sample 12**	720	29	139.3	270

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 12.9 , 26.7 , 52.65, 105.2 and the highest values, are 800 , 29.1 , 145.7, 291

Table (4-30) Physicochemical result for source (11)

Source Name		Moshraa ALMAHGAR			
Source Type		Surface Water (Blue Nile)			
location		HaiAlshatee			
#	**Sample**	**Turbidity (NTU)**	**Temperature (Cº)**	**TDS(PPM)**	**E.cμs/cm**
1	**Sample 1**	13.7	26.9	71.3	148.8
2	**Sample 2**	11.1	28.2	93	186
3	**Sample 3**	795	27.9	52.3	104.6
4	**Sample 4**	744	28.5	112.9	255.7
5	**Sample 5**	798	27.4	106.6	213.2
6	**Sample 6**	687	28.6	139	269.8
7	**Sample 7**	766	29.2	134.3	269.4
8	**Sample 8**	753	29.2	133.3	267.4
9	**Sample 9**	799	29	134.2	269.1
10	**Sample 10**	781	29	133.8	166.1
11	**Sample 11**	790	29.9	135.6	271.2
12	**Sample 12**	788	29.2	123.4	264.5

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 11.1 , 26.9 , 52.3, 104.2 and the highest values, are 798 , 29.9 , 135.6, 271.2

Table (4-31) Physicochemical result for source (12)

Source Name		GanessSharege Treatment plant			
Source Type		Surface water treatment plant			
Location		HaiAlshatee			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	17.6	27.4	54.4	109
2	**Sample 2**	16.8	27.2	53.8	107.4
3	**Sample 3**	6.69	28.9	103	202
4	**Sample 4**	14.8	28.7	94	188
5	**Sample 5**	14.9	28.5	93	186
6	**Sample 6**	15.6	24.4	94	188
7	**Sample 7**	15.9	28.3	49	99
8	**Sample 8**	713	28.1	95.26	190.5
9	**Sample 9**	743	27.7	50.84	101.6
10	**Sample 10**	784	28.5	104.4	208.9
11	**Sample 11**	789	28.4	57	114.3
12	**Sample 12**	790	27.5	157	314

The Table show that the lowest values of Turbidity ,Temperature , TDS and E.c are 6.69 , 24.4 , 49 , 99 and the highest values, are 790 , 28.9 , 157, 314

Table (32) Physicochemical result for source (13)

Source Name		DEEP BORHOLE WITH MECHANIC PUMP			
Source Type		Ground Water			
Location		HaiAlemtedad			
#	**Sample**	**Turbidity (NTU)**	**Temperature(C°)**	**TDS(PPM)**	**E.cµs/cm**
1	**Sample 1**	1.12	29.2	265	595
2	**Sample 2**	2.3	28.1	270.3	593.9
3	**Sample 3**	24	27.6	460.7	921.8
4	**Sample 4**	3.1	29.3	463	925.9
5	**Sample 5**	2.1	29.1	451.3	951
6	**Sample 6**	2.7	29.2	465.1	930.1
7	**Sample 7**	2.4	30	476.5	934.2
8	**Sample 8**	1.23	29.9	466.3	932.6
9	**Sample 9**	1.23	30.4	450.3	900.4
10	**Sample 10**	3.5	30	452	903.9
11	**Sample 11**	2.1	29.5	426.1	843.7
12	**Sample 12**	2.8	26.4	470	930

The Table show that the lowest values of Turbidity, Temperature, TDS and E.c are 1.12 ,26.4 , 265, 593.9and the highest values, are 3.5 , 26.4 , 476.7, 951

Table (4-33) the Compliance of physicochemical for all sources

Source	Number of samples	Turbidity (NTU)		Temperature (Cº)		TDS (PPM)		E.c (µs/cm)	
		comply	Not Comply	Comply	Not Comply	Comply	Not Comply	Comply	Not Comply
Source (1)	12	12	0	12	0	12	0	12	0
Source (2)	12	12	0	12	0	12	0	12	0
Source (3)	12	12	0	12	0	12	0	12	0
Source (4)	12	12	0	12	0	12	0	12	0
Source (5)	12	11	1	12	0	12	0	12	0
Source (6)	12	12	0	12	0	12	0	12	0
Source (7)	12	12	0	12	0	12	0	12	0
Source (8)	12	0	12	12	0	12	0	12	0
Source (9)	12	0	12	12	0	12	0	12	0
Source (10)	12	0	12	12	0	12	0	12	0
Source (11)	12	0	12	12	0	12	0	12	0
Source (12)	12	0	12	12	0	12	0	12	0
Source (13)	12	12	0	12	0	12	0	12	0
Total	156	95	61	156	0	156	0	156	0

The Table show the compliance average for physicochemical parameters for all sources, and it shows the sources that comply to the Standards is Turbidity , TDS and E.c are 7 , 12 , 12 , 12 , 10 , and the sources that not comply is 5, 0 ,0 , 0 , 2 , in source 5 that all samples comply with turbidity standards expect 1 sample

Chapter (5)

Discussion , Conclusion and Recommendations

5.1 Discussion:

Water is a fundamental human need. Each person on Earth requires at least 20 to 50 liters of clean, safe water per day for drinking, cooking, and simply keeping themselves clean. Polluted water isn't just dirty—it's deadly .So this study aimed to assess the water quality in Ganes shareg Area by Appling the first level of water quality monitoring and its find out the below points.

This study found that there are many types of water sources in Ganes shareg area (ground and surface). The ground water utilized as Hand pumps and deep borehole with mechanic pump, and the surface water used as traditional surface intake (MOSHRAA) in the bank of Blue Nile and small water treatment plant.

After conducting comprehensive sanitary inspection for all sources, The study found that the hand pumps registered the lowest risk score among all sources and the surface sources registered high risk score, and these points shows in table (4-4) , figure (4-2), the source (13) inspite of it is aground water but it registered a high risk score and this refer to the bad sanitary situation around the site

The current study found that only one source out of 12 sources is free of indicator for fecal contamination (E.coli) in all 12 samples per source , the result shows that the ground water is less contaminated than surface water , in sources 4, 5, 13 E.coli appear only in one sample among 12 samples from sources , and this result comply with previous studies conducted by Belal (2015) at shendi town , and Adam (2013) in south kordofan , they found that the microbial quality is much better in ground sources than surface , and we observe that microbial quality of water is very poor , this because of bad hygiene behaviors and absence of sanitation system in the area.

The present study showed that sources 1, 8, 10, 12 are safe for Fe**,** the result within range of SSMO and WHO and 9 other sources are out of 13 are not comply with standards rate, also this study found that all sources in the area are complying with the standards for Nitrate No3 and all sources are below the standard range of Fluoride (F). High level of Fe in the water may affect the aesthetic aspect and may lead to rejection of water by consumers

The current study shows that only sources 8, 9, 10, 11, 12 are safe and complying with the SSMO and WHO standards for Hardness and the other sources 8 out of 13 are higher than the standards and considered as a very hard water. and the surface water registered the lowest rang and very soft water, according to WHO and Cambridge Water Department's Website Hard water is not a health hazard the amount of hardness minerals in water affects the amount of soap and detergent necessary for cleaning

The study found that sources 1, 2, 3, 4, 6, 7, 13 has turbidity less than 5NTU for all 12 samples per source, and this comply with SSMO and WHO standard and it within the result of previous studies that shown the turbidity of ground water always safe and within the standards and the source no(5) has 11 samples out of 12 are less than 5 NTU and this safe and within the SSMO and WHO standards and the other source are above 5 NTU and this above the standards , High level of turbidity can affect the water treatment processes , specially chlorine 0.33 that added as homes

This study revealed that all sources are safe and complying with standards for Temperature, E.c and TDS , 0 samples out of 12 .

The study shows that all sources are complying with pH standards in all 12 samples from source except source 1, 5, 8, 13 are not complying for 1,1,1,3 samples.

In General the study was very useful in understanding the water quality situation in the area and in selecting the parameters that need regular monitoring. Water quality was assessed by conducting chemical tests covering selected parameters and bacteriological tests at different points of community water sources.

5.2- Conclusion

Based on the findings of this study the following conclusions are drawing:-

- No sewerage system in Ganes shareg area and the vast majority of the population use pit latrines as sanitation system.
- There is no drinking water monitoring and surveillance system applied in the study area and there no water safety plan.
- All sources need sanitary intervention (fencing for hand pumps, clean the environment around the sources, fix the concert cover …etc)
- Bacteriological quality of drinking water is poor in surface water sources.
- pH of drinking water is acceptable and within the guidelines of WHO and SSMO with average 98 %.
- Contents of NO3 in drinking water are below the permissible limit of WHO / SSMO guidelines.
- Fluoride concentration in drinking water, is lack according to the SSMO guideline.
- Hardness is high in all ground water sources in the study area.
- Content of Fe is safe and within range of guideline only in 4 water sources 30.8% of the sources.
- All sources are comply with standards for TDS and Conductivity.
- Turbidity is high in the majority of the surface water in the study area.
- Temperature is acceptable in all the sources.

5.3- Recommendations

According to the finding of this study and conclusion, I recommended related authorities by the following: -

- State Ministry of health and water authority in alrosairis locality should be Activate the regular drinking water monitoring and surveillance program in the study area.
- Civil management of Water authority in Blue Nile State, should be Promote and improve the drinking water treatment processes in treatment plant to obtain safe drinking water and control the unofficial surface water intake.
- Department of water safety and hygiene in Alrosairis locality should Conduct the health and hygiene awareness programs in the Ganes shareg area about water safety to encourage community participation in WSP, surveillance programs and production of water sources from pollution
- Ministry of health and other stakeholder to Setup the water safety plan and coordinate with Line-ministries to ensure the community participation in WSP and surveillance program.
- MOH & Water authority must distribute chlorine (0.33) (house to house) in the study area to avoid infection from cross contamination.
- The community leaders in the study area should protect the water sources from animals and avoid discharge the waste in the water source.

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Appendixes

Appendix (I) Levels of Assessment

Level of assessment	Microbiological and Related	Inspections and risk assessments	Physical and chemical
Level 1	Thermotolerant coliforms (or E. coli) Turbidity (treated water) pH (treated water) Chlorine residual (treated water)	Sanitary inspection Pollution risk assessments Brief interviews at treatment works	Appearance (qualitative) Conductivity Priority inorganics (arsenic, fluoride, nitrate) unless known to be absent locally
Level 2	E. coli Faecal streptococci	Audit of treatment work records Catchment assessment Basic hydrogeological assessment	Alkalinity Copper (piped systems) Corrosivity Hardness Iron and manganese Odour (qualitative)
Level 3	Bacteriophages Clostridia perfringens Pathogen assessments Cyanobacterial toxins	Catchment assessment/EIA Full hydrogeological assessment Hazard analysis Microbial risk assessment Full chemical assessment	Inorganics: aluminium, ammonia, boron, cadmium, chromium, cyanide, lead, mercury, selenium Odour (quantitative) Organics: pesticides, disinfectant byproducts Radiation

Appendix (II) Naturally occurring chemicals for which guideline values have not been established

#	**Chemical**	**Reason for not establishing a guideline Value**	**Remarks**
1.	Bromide	Occurs in drinking-water at concentrations well below those of health concern	
2.	Chloride	Not of health concern at levels found in drinking-water	May affect acceptability of drinking water
3.	Hardness	Not of health concern at levels found in drinking-water	May affect acceptability of drinking water
4.	Hydrogen sulfide	Not of health concern at levels found in drinking-water	May affect acceptability of drinking water
5.	Iron	Not of health concern at levels causing acceptability problems in drinking-water	May affect acceptability of drinking water
6.	Manganese	Not of health concern at levels causing acceptability problems in drinking-water	May affect acceptability of drinking water
7.	Molybdenum	Occurs in drinking-water at concentrations well below those of health concern	
8.	pH	Not of health concern at levels found in drinking-water	An important operational water quality parameter
9.	Potassium	Occurs in drinking-water at concentrations well below those of health concern	
10.	Sodium	Not of health concern at levels found in drinking-water	May affect acceptability of drinking water
11.	Sulfate	Not of health concern at levels found in drinking-water	May affect acceptability of drinking water
12.	Total dissolved solids	Not of health concern at levels found in drinking-water	May affect acceptability

Appendix (III) Guideline values for naturally occurring chemicals that are of health significance in drinking-water

	Chemical		Guideline value mg/l	Remarks
1	Inorganic	Arsenic	0.01 (A, T)	
2		Barium	0.7	
3		Boron	2.4	
4		Chromium	0.05 (P)	For total chromium
5		Fluoride	1.5	Volume of water consumed and intake from other sources should be considered when setting national standards
6		Selenium	0.04 (P)	
7		Uranium	0.03 (P)	Only chemical aspects of uranium addressed
8	Organic	Microcystin-LR	0.001 (P)	For total microcystin-LR (free plus cell-bound

Appendix (IV) water-related diseases

Category	Example	Intervention
Water-borne	Diarrhoeal disease, cholera, dysentery, typhoid, infectious hepatitis	Improve drinking-water quality, prevent casual use of unprotected sources
Water-washed	Diarrhoeal disease, cholera, dysentery, trachoma, scabies, skin and eye infections, ARI (acute respiratory infections)	Increase water quantity used Improve hygiene
Water-based	Schistosomiasis, guinea worm	Reduce need for contact with contaminated water, reduce surface water contamination
Water-related (insect vector)	Malaria, onchocerciasis, dengue fever, Gambian sleeping sickness	Improve surface water management, destroy insect breeding sites, use mosquito netting

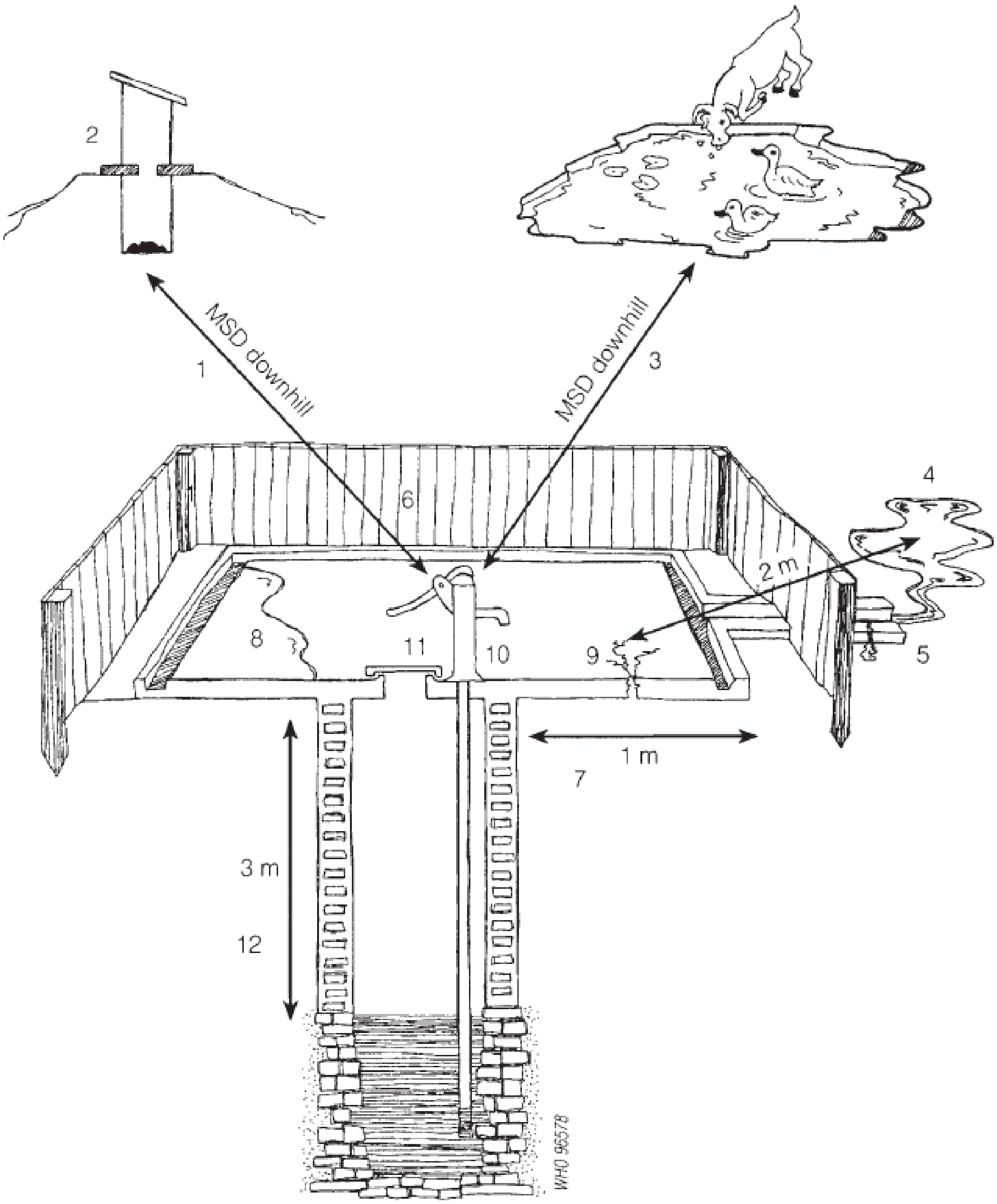
Appendix (V) pathogens that are of relevance for drinking-water supply management.

	Pathogen	Health significance	Persistence in water supplies	Resistance to chlorine	Relative infectivity	Important animal source
Bacteria	Burkholderiapseudomallei	High	May multiply	Low	Low	No
	Campylobacter jejuni, C. coli	High	Moderate	Low	Moderate	Yes
	Escherichia coliPathogenic	High	Moderate	Low	Low	Yes
	E. coli – Enterohaemorrhagic	High	Moderate	Low	High	Yes
	Francisellatularensis	High	Long	Moderate	High	Yes
	Legionella spp.	High	May multiply	Low	Moderate	No
	Leptospira	High	Long	Low	High	Yes
	Mycobacteria (nontuberculous)	Low	May multiply	High	Low	No
	Salmonella Typhi	High	Moderate	Low	Low	No
	Other salmonellae	High	May multiply	Low	Low	Yes
	Shigella spp.	High	Short	Low	High	No
	Vibrio cholerae	High	Short to long	Low	Low	No
Viruses	Adenoviruses	Moderate	Long	Moderate	High	No
	Astroviruses	High	Long	Moderate	High	No
	Enteroviruses	High	Long	Moderate	High	No
	Hepatitis A virus	High	Long	Moderate	High	No
	Hepatitis E virus	High	Long	Moderate	High	Potentially
	Noroviruses	High	Long	Moderate	High	Potentially
	Rotaviruses	High	Long	Moderate	High	No
	Sapoviruses	High	Long	Moderate	High	Potentially
Protozoa	Acanthamoeba spp.	High	May multiply	High	High	No
	Cryptosporidium hominis/ parvum	High	Long	High	High	Yes
	Cyclosporacayetanensis	High	Long	High	High	No
	Entamoebahistolytica	High	Moderate	High	High	No
	Giardia intestinalis	High	Moderate	High	High	Yes
	Naegleriafowleri	High	May multiply	Low	Moderate	No
Helminths	Dracunculusmedinensis	High	Moderate	Moderate	High	No
	Schistosoma spp.	High	Short	Moderate	High	Yes

Appendix (VI)- Use of indicator organisms in monitoring

Microorganism(s)	Validation of process	Operational	Verification and surveillance
E. coli (or thermotolerant coliforms)	Not applicable	Not applicable	Faecal indicator
Total coliforms	Not applicable	Indicator for cleanliness and Integrity of distribution systems	Not applicable
Heterotrophic plate counts	Indicator for effectiveness Of disinfection of bacteria	Indicator for effectiveness of disinfection processes and cleanliness and integrity of distribution systems	Not applicable
Clostridium perfringensa	Indicator for effectiveness of disinfection and physical removal processes for viruses and protozoa	Not applicable	Not applicable
Coliphages Bacteroidesfragilis phages Enteric viruses	Indicator for effectiveness of disinfection and physical removal processes for viruses	Not applicable	Not applicable

Appendix (VII) - Sanitary inspection form (Hazard analysis)for covered dug well with hand-pump



(WHO, 2000)

Appendix (VII)

I Type of facility COVERED DUG WELL WITH HAND-PUMP

1. General information: Health center ....
  Village...
2. Code no. — Address...
3. Water authority.........................
4. Date of visit.....................................
5. Water sample taken? .... Sample no. ....

Thermo tolerant coliform grade.........

<u>II Specific diagnostic information for assessment Risk</u>

1. Is there a latrine within 10 m of the well and hand-pump? Y/N
2. Is the nearest latrine on higher ground than the hand-pump? Y/N
3. Is there any other source of pollution (e.g. animal excreta, rubbish) Y/N within 10m of the hand-pump?
4. Is the drainage poor, causing stagnant water within 2m of the cement Y/N floor of the hand-pump?
5. Is there a faulty drainage channel? Is it broken, permitting ponding? Y/N
6. Is the wall or fencing around the hand-pump inadequate, allowing Y/N animals in?
7. Is the concrete floor less than 1m wide all around the hand-pump? Y/N
8. Is there any ponding on the concrete floor around the hand-pump? Y/N
9. Are there any cracks in the concrete floor around the hand-pump Y/N which could permit water to enter the hand-pump?
10. Is the hand-pump loose at the point of attachment to the base Y/N so that water could enter the casing?
11. Is the cover of the well unsanitary? Y/N
12. Are the walls of the well inadequately sealed at any point Y/N for 3m below ground level?

Total score of risks .... /12

Contamination risk score: 9–12 5 very high; 6–8 5 high; 3–5 5 intermediate; 0–2 5 low

III Results and recommendations

The following important points of risk were noted: .... (list nos 1–12)

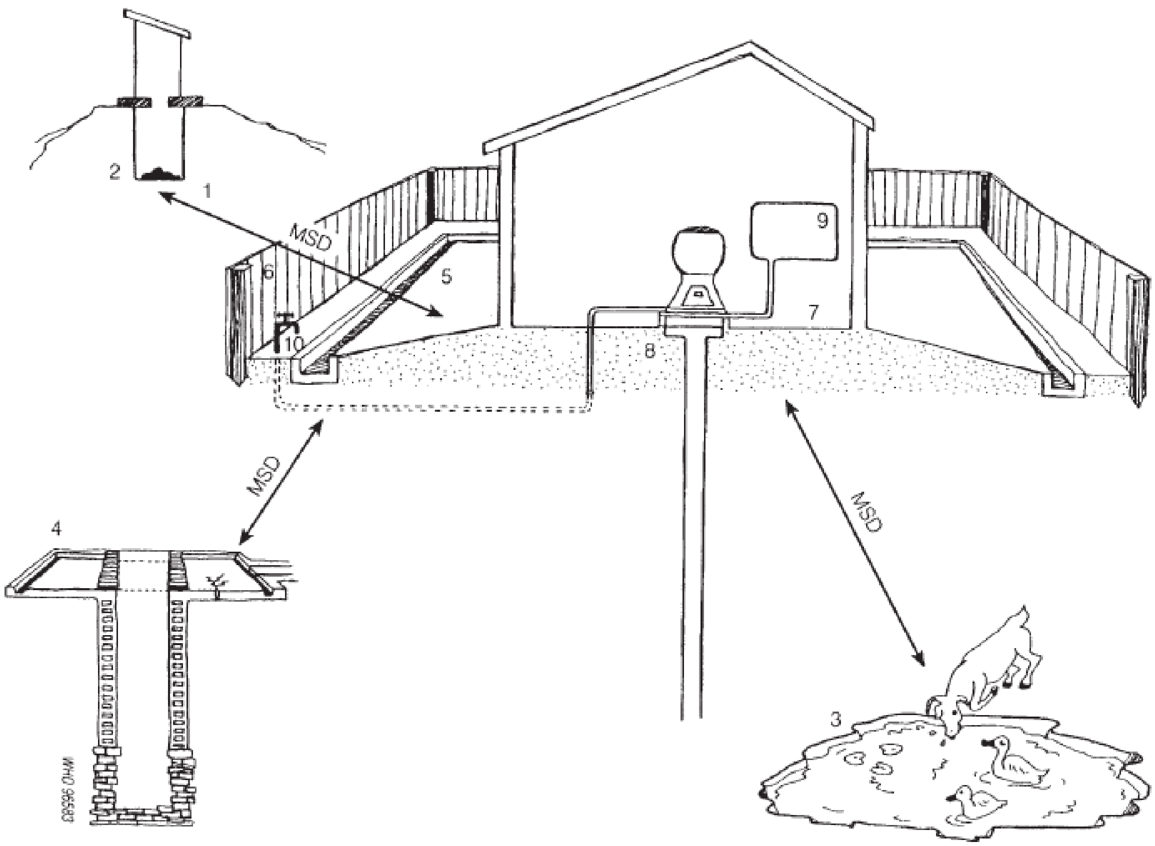
and the authority advised on remedial action.

Signature of sanitarian ....

Appendix (IX)

sanitary inspection form for deep borehole with mechanical pump

Note: MSD = minimum safe distance determined



(WHO, 2000)

Appendix (X) : Sanitary inspection form (Hazard analysis)

I Type of facility DEEP BOREHOLE WITH MECHANICAL PUMP

1. General information: Health centre ....
   Village ....
2. Code no.— Address ....
3. Water authority.........................
4. Date of visit ....
5. water sample taken? ...Sample no. ......
   Thermo tolerant coliform grade ....

<u>II Specific diagnostic information for assessment Risk</u>

1. Is there a latrine or sewer within 15–20 m of the pumphouse? Y/N
2. Is the nearest latrine a pit latrine that percolates to soil, i.e. unsewered? Y/N
3. Is there any other source of pollution (e.g. animal excreta, rubbish, surface Y/N
water) within 10 m of the borehole?
4. Is there an uncapped well within 15–20 m of the borehole? Y/N
5. Is the drainage area around the pumphouse faulty? Y/N
Is it broken, permitting ponding and/or leakage to ground?
6. Is the fencing around the installation damaged in any way which Y/N
would permit any unauthorized entry or allow animals access?
7. Is the floor of the pumphouse permeable to water? Y/N
8. Is the well seal unsanitary? Y/N
9. Is the chlorination functioning properly? Y/N
10. Is chlorine present at the sampling tap? Y/N

Total score of risks .... /10

Contamination risk score: 9–10 5 very high; 6–8 5 high; 3–5 5 intermediate; 0–2 5 low

III Results and recommendations

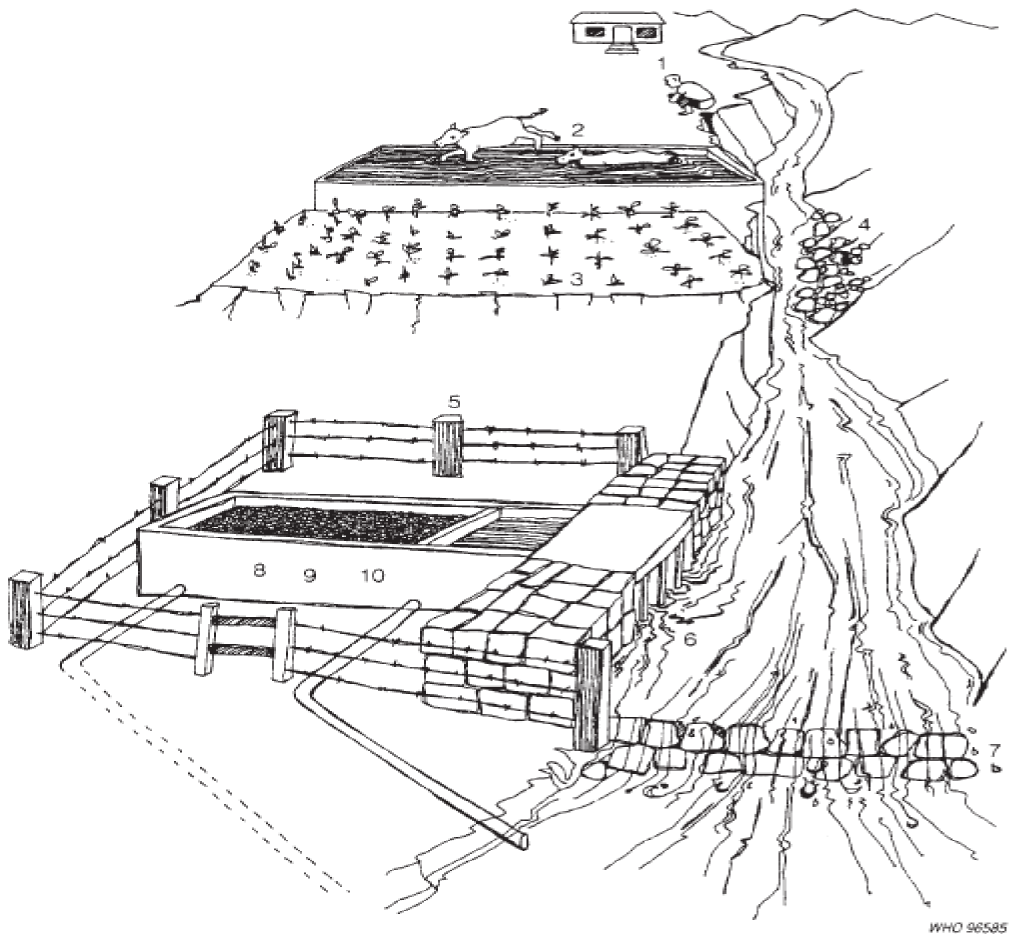
The following important points of risk were noted: .... (list nos 1–10)

and the authority advised on remedial action.

Signature of sanitarian ....

Appendix (XI)

Fig. A2.9 Example of sanitary inspection form for surface source and abstraction



(WHO, 2000)

Appendix (XII) : Sanitary inspection form (Hazard analysis)

I Type of facility SURFACE SOURCE AND ABSTRACTION

1. General information: Health centre ....
 Village ....
2. Code no.—Address ....
3. Water authority/community representative signature ....
4. Date of visit ....
5. Water sample taken? .... Sample no. ....

Thermotolerant coliform grade ....

II Specific diagnostic information for assessment Risk

1. Is there any human habitation upstream, polluting the source? Y/N
2. Are there any farm animals upstream, polluting the source? Y/N
3. Is there any crop production or industrial pollution upstream? Y/N
4. Is there a risk of landslide or mudflow (causing deforestation) Y/N in the catchment area?
5. Is the intake installation unfenced? Y/N
6. Is the intake unscreened? Y/N
7. Does the abstraction point lack a minimum-head device (weir Y/N or dam to ensure minimum head of water)?
8. Does the system require a sand or gravel filter? Y/N
9. If there is a filter, is it functioning badly? Y/N
10. Is the flow uncontrolled? Y/N

Total score of risks .... /10

Contamination risk score: 9–10 5 very high; 6–8 5 high; 3–5 5 intermediate; 0–2 5 low

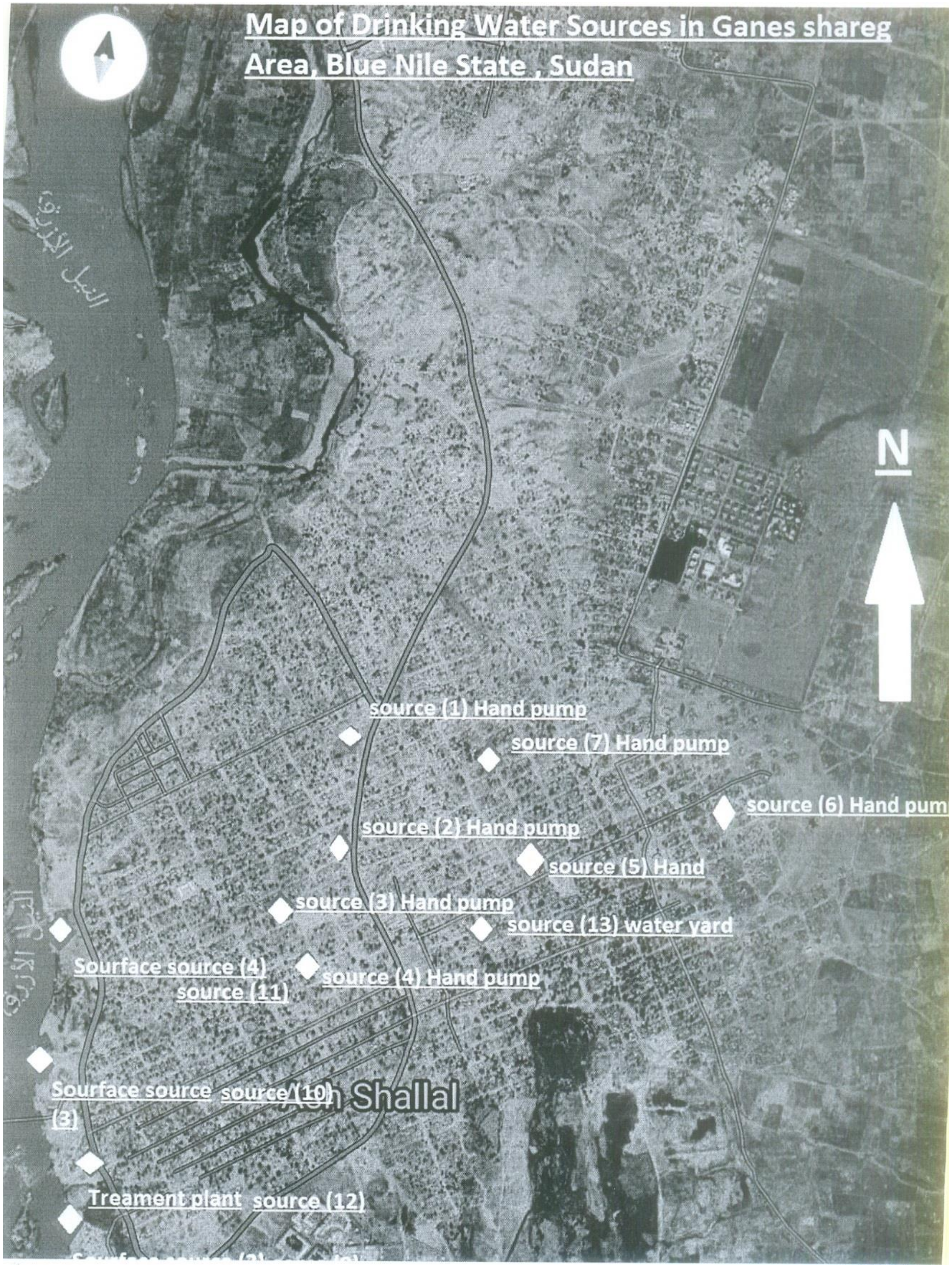
III Results and recommendations

The following important points of risk were noted: .... (list nos 1–10)

and the authority advised on remedial action.

Signature of sanitarian ....

Appendix (XII) Map of Drinking Water Sources in the Study Area



بسم الله الرحمن الرحيم

Shendi University

Faculty of postgraduate studies and scientific research

Samples collection form

Date …………………………………...time…………………………………

Location ……………………. Neighborhood ……………………

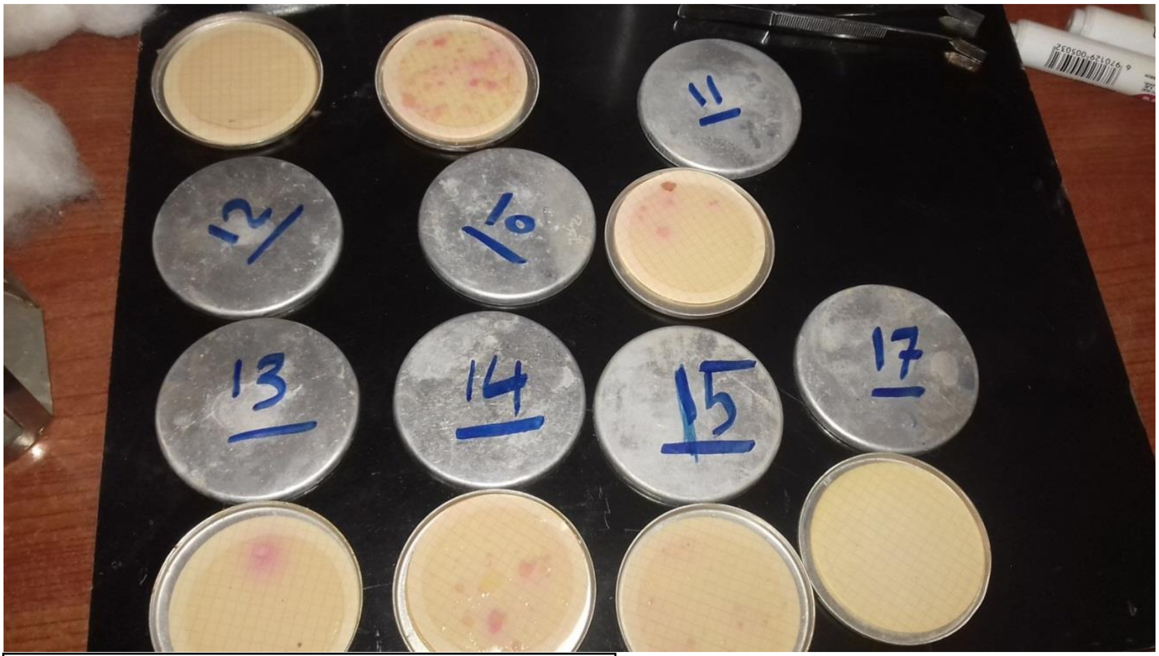
Type of source………………………. Site of sampling…………………….

Residual free chlorine…………….. Type of required analysis……………..

Taken By …………………………………………………………..

Date & time of receive sample at lab…………………………………………

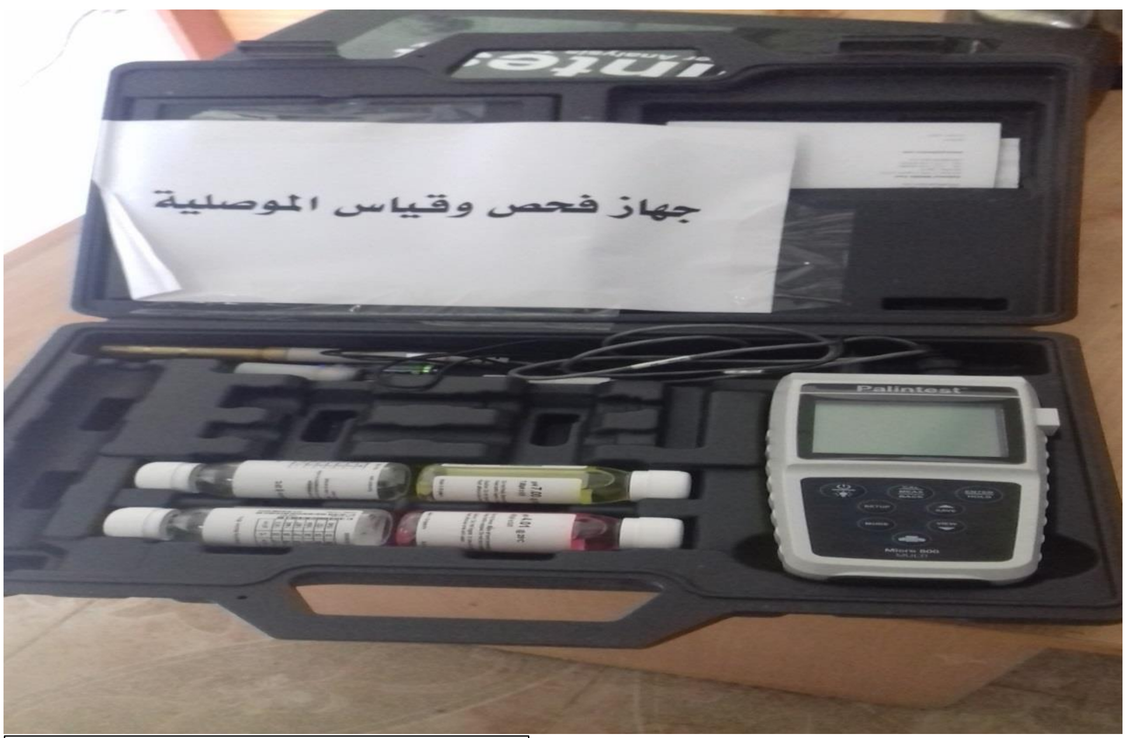
Name of receiver…………………………………………………………...



Bacteriological Test Result

Chemical Analysis using **Photometer 7500**

Recording The Bacteriological Results After the incubation



EC, TDS and PH Device

Sanitary inspection around the Surface sources

Sampling For Bacteriological Test at the Treatment Plant

Sampling tools Disinfection

Disinfection for Sampling from Han-Pump