Shendi University

Faculty of Graduate Studies and scientific research

Study on the effect of seasonal changes on drinking water quality and the prevalence of water-borne diseases in Shendi Town, River Nile State, Sudan 2012- 2015.

A thesis submitted in fulfillment of the requirements for Ph. D degree in Public and Environmental Health (PEH)

By

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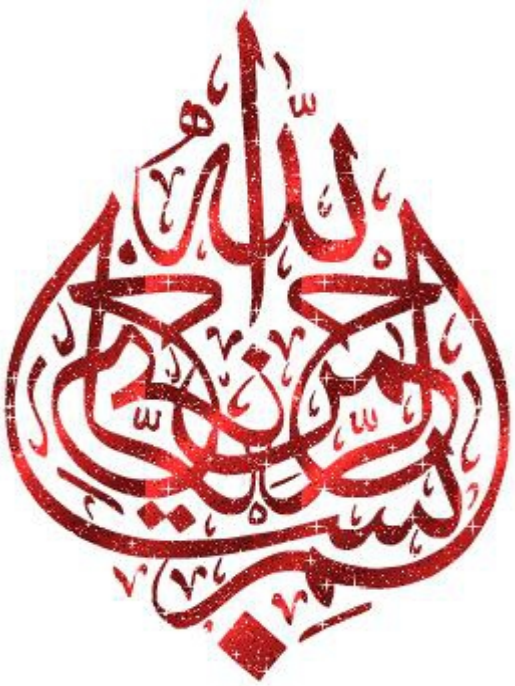
الآية الكريمة

يَقُول الله تَعَالَى فى محكم تنزيله :-



(أَوَلَمْ يَرَ الَّذِينَ كَفَرُوا أَنَّ السَّمَاوَاتِ وَالْأَرْضَ كَانَتَا رَتْقًا فَفَتَقْنَاهُمَا وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ أَفَلَا يُؤْمِنُونَ) (30) *صدق الله العظيم*

الآية (30) من سورة الأنبياء

Dedication

To my parents (Fatima and Ahmed).

To partner of my life……..

To both my small and big family (brothers, sisters and relatives).

To young researchers in health field in Sudan.

To all of those, I dedicate this thesis (very simple work).

Researcher

Contents

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Finally Also I send many thanks for all those who supported, contributed, and helped me in this thesis.

Researcher

Acronyms & abbreviations used in the research

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 Nerve 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
JTU	Jackson Turbidity Unit
L	Liter (s)
MF	Membrane Filtration
MF	Micro Filtration
Mg	Milligram (s)
ML	Milliliter (s)
MPN	Most Probable Number
MWR	Ministry of Water Resources
NF	Nano Filtration
NIEHS	National Institute Environmental Health Sciences
NTU	Nephelometric Turbidity Unit
OD	Oxygen Demand
OPV	Oral Polio Vaccine
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 FCCC	United Nation Framework Convention on Climate Change
UNHCR	United Nations High Commission for Refugees

UNICE	United Nation's International Children's mergencies Fund
USCFCCC	University of Southern California Foundation for Caresses Connection Control
USEPA	United State Environmental Production Agency
UV	Ultra Violet
R N A	Ribo Nucleic Acid
RO	Reverse Osmosis
RSF	Rapid Sand Filter (s)
SG	Specific Gravity
SS	Suspended Solids
SSF	Slow Sand Filtration
SSMO	Sudanese Standards Metrology Organization
TCU	True Color Unit
TDS	Total Dissolved Salts
VDH	Virginia Department of health
VS+FS	Volatile and Fixed Solids
WEDC	Water Engineering for developing countries
WEF	Water Environmental Federation
WHO	World Health Organization
WHO-GL	World Health Organization Guide Lines
WQI	Water Quality Index
WRF	Water research foundation
WSP_s	Water Safety Plans

Abstract

Background: The most common widespread health risk associated with drinking water is microbial contamination. Microbial contamination of major urban systems has potential to cause large outbreaks of water borne diseases. Nevertheless, the majority (around 80%) of the global population without access to improved drinking-water supplies resides in rural areas.

Study Design: descriptive cross sectional study.

Objectives: This study intends to identify drinking water supply system, and the effects of seasonal changes on drinking water quality and to know/and document seasonal prevalence of water- borne diseases in the study area- Shendi Town.

Methods: This study was conducted during the period from October 2012 till May 2015, after determined sample size and questionnaire designed, 80 samples were collected seasonally. After collection of Water samples from different blocks of Shendi Town according to steps that set by WHO, many methods were use such as: use of turbi meter for turbidity, use conduct meter for TDS and conductivity, use photometer for pH, Fe^{+2} ,hardness, SO_4^{-2},NO_3^{-1} , and F^{-1}. However presence and Absence method was use to assess presence of coli form and E. coli bacteria. Some of these tests were conducted immediately at field and others were completed in laboratory in Shendi and Atbara Towns. In this study different types of data collection were use like: questionnaire, observation, interviews, records and laboratory analysis. After collection of data these were analyzed using (SPSS), and computer programmes (excel sheet and chi square) after that, results were organized and expressed in tables and figures.

Results: the study revealed many findings the most important are : Distribution system of water is looped and network where very old, 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, Contents of Fe^{+2}, NO_3^{-1} , SO_4^{-2} in drinking water were below permissible limits of WHO / SSMO, Hardness of drinking water varied from season to another, There are relationship between family size and consumption of water, also correlation between storage of water and period of water supply is found, No relationship was found between educational level and knowledge of seasonal changes and its effects on water quality, in addition to its health risks, Typhoid disease is the more spread than other 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.

Conclusion: according to results of this study, seasonal variation had effects on drinking water quality, prevalence of water- borne diseases was different from season to another, distribution system of water supply is very old and un safe, present drinking water is unfit for drinking. Thus the study recommended the followings: Improvement quality of present drinking water by subjecting it to treatment process, maintenance of distribution system and used branch type if possible**,** Establish surface water treatment plant as soon as possible to serve the whole Town**,** Follow up the water supply system periodically by health authorities according to WHO guide lines for drinking water and Raise awareness of residents to practice good behaviors such as safe storage of drinking water, and correct method of hand washing to avoid risk of water- borne diseases.

المستخلص

الخلفية : أكثر الأخطار الصحية المرتبطة بمياة الشرب هو التلوث الميكروبى ، لذلك يجب متابعته و مراقبته بصورة منتظمة وان يعطى دائمآ اهمية قصوى وهذ ا لا يتأتى الا بالمسوحات والدراسات العلمية. التلوث الميكروبى فى معظم شبكات المياه بالمدن و الريف يلعب دور كبير جدآ فى إحتمالية و إمكانية حدوث وتفشى الأوبئة المتولدة من المياه ، مع ذلك معظم سكان العالم حوالى 80% ليس لديهم مصادر مياه شرب نقية متاحة خصوصآ المناطق الريفية.

نوعية الدراسة: دراسة وصفية مستعرضة .

الأهداف: تهدف هذه الدراسة إلى التعرف على نظام الإمداد بمياه الشرب ، دراسة آثار التغيرات الموسمية على نوعية مياه الشرب ومعرفة معدل انتشار الأمراض المتولدة من المياه بالمواسم في مدينة شندي .

طرق إجراء الدراسة: أجريت هذه الدراسة خلال الفترة من أكتوبر 2012 حتى مايو 2015، وبعد تحديد حجم العينة وتصميم الإستبيان ، قد تم جمع عينات المياه من مختلف مربعات مدينة شندي وفقا للخطوات التي وضعتها منظمة الصحة العالمية حيث استخدمت العديد من الطرق مثل: أستخدم جهاز العكارة لقياس درجة العكارة ، أستخدم جهاز قياس الموصلية الكهربائية لقياس TDS والموصلية الكهربائية، وأستخدم الجهاز الضوئى لتحديد الأس الهيدروجينى ، الحديد ، العسر ، الكبريتات (SO_4^{-2})، النترات (NO_3^{-1}) و الفلورايد (F^-[1]) . بينما أستخدمت طريقة غياب أو وجود التلوث لتقييم وجود البكتريا القولونية والبكتريا الإشريكية القولونية. وقد أجريت بعض هذه الاختبارات على الفور في الحقل و البعض الآخر تمت في المختبر في مدينتى شندي وعطبرة . في هذه الدراسة تم جمع البيانات بطرق مختلفة مثل: الاستبيان، المراقبة، والمقابلات، والسجلات و التحليل المختبرى . بعد الحصول على البيانات تم تحليلها بواسطة الحزمة الاجتماعية للتحليل الإحصائى (SPSS)، حيث أستخدمت بعض برامج الكمبيوتر مثل ميكروسوفت إكزيل و إختبار كاى المربع). بعد ذلك نظمت وتم عرضها في جداول وأشكال.

النتائج: توصلت الدراسة للعديد من النتائج من أهمها : نظام توزيع المياه شبكى و هى شبكة قديمة ، والجودة البكتريولوجية لمياه الشرب فقيرة جدآ، ومؤشرات التلوث تجاوزت الحدود المسموح بها من قبل منظمة الصحة العالمية والمعايير السودانية لمياه الشرب في جميع المواسم ، محتويات الحديد ، NO3، SO4 في مياه الشرب مقبولة تقع ضمن الحدود المسموح بها من منظمة الصحة العالمية والهيئة السودانية للمواصفات والمقاييس (SSMO)، درجة العسرفى مياه الشرب تختلف من موسم إلى آخر، وهناك علاقة بين حجم الأسرة واستهلاك المياه، كما تم العثور على علاقة بين تخزين المياه وفترة إمدادات المياه، لا توجد علاقة بين المستوى التعليمي ومعرفة التغيرات الموسمية وآثارها على نوعية المياه، بالإضافة إلى المخاطر الصحية والأمراض, مرض

التيفوئيد هو أكثر انتشارا من بين الأمراض المتولدة من المياه ، ومعدل انتشار الأمراض المتولدة من المياه في الخريف هو أعلى من الفصول الأخرى وهناك ضعف فى المعرفة وقلة وعى بين مجتمع الدراسة حول جودة مياه الشرب وعلاقتها بالأمراض التى ترتبط بها.

الخلاصة : وفقا لنتائج هذه الدراسة، التغيرات الموسمية لها أثر على جودة مياه الشرب، وانتشار الأمراض المنقولة بالمياه يختلف من موسم لآخر، ونظام توزيع المياه قديم جدا وهوغير آمن، ومياه الشرب الحالية لا تصلح للشرب وفقآ لمعايير منظمة الصحة العالمية والهيئة السودانية للمواصفات. وبالتالي الدراسة توصى بالآتى : تحسين جودة مياه الشرب الحالية بإخضاعها لعمليات المعالجة، صيانة نظام التوزيع مع إستخدم النوع الفرعى ما أمكن ، إنشاء محطة تنقية مياه سطحية في أقرب وقت ممكن لخدمة جميع مربعات مدينة شندى ، ومتابعة إمدادات المياه بنظام دوري من قبل السلطات الصحية وفقا لمعايير منظمة الصحة العالمية لجودة مياه الشرب ورفع الوعي الصحى للسكان من أجل المشاركة فى حماية المياه من التلوث والإسهام فى عمليات التنقية وكذلك ممارسة السلوكيات الجيدة مثل التخزين الآمن لمياه الشرب ، والطريقة الصحيحة لغسل اليدين لتجنب خطر الإصابة بالأمراض المتولدة من المياه.

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1 General:

Water covers 75% of our planet, yet only a tiny fraction of this abundant water is available to us as fresh water. The majority of water (97%) is found in the ocean and is too salty for drinking. The remaining water (3%) is fresh. Ninety nine point nine per cent of this water is locked up in the poles, is buried so deep underground that it is too costly to extract. Only one tenth of one per cent (0, 1%) of the earth's total volume of water is available to us in rivers, lakes, soil moisture, water vapor, or exploitable ground water. This amount, however is generous supply that it is continuously collected, purified and distribution in the water cycle (WHO, 2002). Fresh water comes from two sources: Surface water and ground water, the global system that supply and removes water from the earth's surface is known as hydrological cycle.

The most common and widespread health risk associated with drinking water is microbial contamination which has the potential to cause large outbreaks of waterborne diseases like dysentery, cholera, typhoid, skin infections etc . The chemical contaminations do not cause immediate acute health problems unless they are present in massive quantities through some accident and use of chemical fertilizers and pesticides in crop near the drinking water sources.

The impact of water on health derives principally from the consumption of water containing pathogenic organisms or toxic chemicals and the use of inadequate volumes of water that lead to poor personal and domestic hygiene, The risk of acquiring a waterborne infection increases with the level of contamination by pathogenic micro-organisms. However, the relationship is not simple and depends on factors such as infectious dose and host susceptibility.

Climate change may affect our water supplies in terms of quality, quantity and availability. Evaporation is likely to reduce fresh water resources, with the additional influence of salt water incursion due to higher mean sea levels. Reduction in ground water will affect aquifer water resources and force greater dependence on surface waters, which have higher levels of contamination.

1.2 Problem statement

Water is essential for life. Unfortunately, few people in developing countries have access to clean water and around 2.4 billion people still have no access drinking water. The failure to provide safe drinking water to all people is perhaps the greatest development failure of the 21th century. The most egregious consequence of this failure is the high rate of mortality among young children from preventable water-related diseases.

A wide range of water problems faces nations and individuals around the world. These problems include international and regional disputes over water, water scarcity and Contamination, unsustainable use of groundwater, ecological degradation, and the threat of climate change. At the heart of the world's water problems, however, is the failure to provide even the most basic water services for billions of people and the devastating human health problems associated with that failure. At the same time, despite problems with the data, it is evident that while progress has been made in providing water services to specific regions and areas, limited resources and rapidly growing populations have made it difficult to provide comprehensive and complete water coverage for all. The most serious consequence of this failure is widespread water-related disease and death. Although water-related diseases have largely been eliminated in wealthier nations, they remain a major concern in much of the developing world. While data are incomplete, the World Health Organization estimated in the 2000 assessment that there are four billion cases of diarrhea each year

in addition to millions of other cases of illness associated with the lack of access to clean water. Since many illnesses are undiagnosed and unreported, the true extent of these diseases is unknown. If no action is taken to address unmet basic human needs for water, as many as 135 million people will die from these diseases by 2020. Even if the explicit Millennium Goals announced by the United Nations in 2000 are achieved – unlikely given current international commitments – between 34 and 76 million people will perish from water related Diseases by 2020. This problem is one of the most serious public health crisis facing us, and deserves far more attention and resources than it has received so far.

1.3 Rationale:

Water-borne diseases are responsible for more than 80% of all illnesses and deaths in developing countries, WHO reported that every year more than 5 million human being die from illnesses linked to unsafe drinking water and 1-2 million deaths caused by diarrheal diseases. The rationale of this study was divided into different reasons. Firstly no work was done in (Shendi Town) therefore this study aims to know nature of drinking water supply and investigating about water-borne diseases. Secondly no surveillance system for drinking water in Shendi Town thus the study aims to detect sites of weakness of water supply system and design closed surveillance system for monitoring of drinking water quality for intervention at suitable time in case of appearance of any problem in drinking water. Thirdly water-borne diseases can be prevented by improving the quality of drinking water at source, at distribution system and in storage. The study intends to know places or sources of pollution for control and continuous monitoring. 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 seasonal variations have effects on drinking water quality and quantity, also may be leads to decrease or increase in prevalence of water-borne diseases.

1.5 Objectives

1.5.1 General objective:-

To study the effect of seasonal changes on drinking water quality and the prevalence of water-borne diseases in Shendi Town- River Nile State , sudan.

1.5.2 Specific objectives are to:-

1. Assess the supply system of drinking water in Shendi Town.
2. Examine bacteriological quality of drinking water in Shendi Town.
3. Determine levels of turbidity, PH, total dissolved solids, conductivity and hardness of drinking water.
4. Measure concentrations of fluoride, iron, sulphate and nitrate in drinking water.
5. Estimate the seasonal prevalence of water-borne diseases.

2. Literature Review

2.1 Definitions

2.1.1 Water definition

Water is a binary compound that occurs at ambient temperature as clean, colorless, tasteless, liquid, freezes into ice at 0 deg. C and boils at 100 deg. C; it is of vital importance for human life (SSMO, 2003).

2.1.2 Drinking water definition

Drinking water means water treated and/or untreated from any source and will be supplied through distribution system or directly from the source to consumption (SSMO, 2003).

2.1.3 Safe drinking water definition

This is defined by the guide lines as water that does not represent any significant risk to health over a life time of consumption, including different sensitivities that may occur between life stages (WHO, 2006).

2.2 Water sources

There are basically three categories of naturally occurring water sources they are ground water, rain water, and surface water (UNICEF, 1999).

2.2.1 Ground water

Ground water occurs under most of the world land surface but there are great variation in the depths at which it is found ,its mineral quality ,the quantities present and the rate of infiltration and the nature of the ground above it (thus accessibility). Ground water is the primary source of drinking water because usually it is bacteriologic ally safe, so disinfection is not necessary .However ground water aquifers can become bacteriologic ally polluted from sources of contamination such as

latrines, garbage , dumps, corrals, and cemeteries. Ground water may also be chemically contaminated, making it unfit for consumption without treatment, and common contaminants include iron, excessive dissolved salts and fluorides (UNICEF, 1999). Ground water is water that occupies the pores of crevices in sand, sand stone, limestone and other rocks, The crucial role which ground water plays as decentralized sources of drinking water for millions of rular and urban families cannot be overstated. Pollution of groundwater comes from many sources. Discharge of waste disposal from agriculture, industries and municipalities are main source of groundwater pollution. Sometimes surface run-off also brings mud, leaves, and human and animal wastes into surface water bodies. These pollutants may enter directly into the groundwater and contaminate it. Ground water was considered to be very clear and safe in past but nowadays it is getting polluted with rapid growth of urban and industrial activities, particularly in the developing countries where proper waste disposal measures are not followed Since the quality of public health depends to a greater extend on the quality of drinking water, it is incumbent that detailed information about the quality of water be systematically collected and monitored During last decade, it is observed that the ground water gets polluted drastically because of the increased human activities Consequently number of cases of water borne diseases has been seen which a cause of health hazards Therefore the pollution of water resources need a serious and immediate attention through periodical checkup of water quality (WHO, 2011).

2.2.2 Rain water

Rain water collection from roofs or larger catchment areas, can be utilized as source of drinking water particularly where there are no other safe water sources available (for example where ground water is polluted or to deep). Rain water may be collected (harvested) from surfaces by roof catchment and ground catchment after passing through a screen and or filter the water is conducted through gutters to cisterns. These cisterns can be large enough to serve a community or an institution (UNICEF, 1999).

2.2.3 Surface water

Surface water in stream, rivers, lakes and ponds is readily available in many populated areas, but it is almost always polluted often grossly so it should be only used where there are no other safe sources of water available, where no other sources are readily available. Surface water can be contained, collected and used after some form of filtration (UNICEF, 1999). It is important to Identify on source of water supplier in the area or to share the finding with the water supplier, this is important not only when problems are found but also when water quality is good (Howard,2002).

2.3 Water requirement

Water is the most important provision for any population; people can survive much longer without food than they can without water (Andrew, 1994). The basic physiological requirements for drinking water have been estimated at about 2 liters per head per day, this is just for survival. But from the stand point of the public health and improvement of the quality of life, water should be provided in adequate volume. A daily supply of 150-200 liters per capita is considered as adequate. The consumption of water depends upon climatic conditions, standard of living and habits of the people (Park, 2005).

2.4 Uses of water

Water is absolutely essential to life. From 50-65 per cent of human body is composed of water and variations of as little as 1-2 per cent will cause thirst or pain. The loss of 5 per cent of body water can cause hallucination; loss 10-15 per cent can be fatal. Although human can live several months without food but they can survive only a day or two without water (Moeller, 2005). The uses of water in a community are many and the requirement in quantity and quality are varied. Conventionally it has been convenient and economical to provide a single water supply sufficient in quantity to serve all uses and suitable in quality to meet drinking water requirement. The uses of water include:

*Domestic use (drinking, cooking, washing, bathing, flushing of toilet, gardening, etc).

*public purposes (cleaning streets, recreation purpose, fire protection, and public parks).

*Industrial purposes (for processing and cooling).

*Agricultural purposes such as irrigation of crops.

*Power production from hydro power and steam power.

*Carrying away waste from all types of establishments and institutions (Park, 2005). Water may be required for a variety of purposes, but many water supply projects focus on its provision for domestic use only (WEDC, 2002).

2.5 Drinking water quality

The quest for pure water dates back to antiquity. In modern times it has led to the formulation of specific standards to provide a basis for judging the quality of water. These standards are exposure limits for physical, chemical, viral and bacteriological agents that have been adopted by governments or appropriate authorities and therefore have legal force. The purpose of standards is to minimize all the known health hazards, since it is impossible to prevent all pollution (Park, 2005). The primary concern with health problems caused by water supply is infectious diarrheal diseases transmitted by the fecal – oral route, these are caused by disease-causing micro –organisms, or pathogens. Therefore the principal concern in the water quality is the microbiological quality of the water that is being consumed. Microbiological quality may change very rapidly over time and short distance and therefore requires frequent testing (Howard, 2002).

2.5.1 Physical quality

The ordinary consumer judges the water quality by its physical parameters. The provision of drinking water that is not only safe but also pleasing in appearance, taste and odor is a matter of high priority. The acceptability of drinking water is influenced by many different constituents (Park, 2005). The

most important physical parameters are temperature, taste, odor, color, conductivity, salinity, solids contents, density, and turbidity (Abd el-magid, 1995).

2.5.1.1 Temperature

Cool water is generally more potable. Low water temperature tends to decrease the efficiency of treatment process, including disinfection, and may thus have a deterious effects on drinking water quality. However high water temperature enhances the growth of microorganisms, taste, odor, color and corrosion problem may be increased. No guide line value is recommended for water since its control is usually impracticable (Park, 2005). Design and construction of water systems should provide for purying or convening of cool and also prevent freezing in cold climate (Salvato, 1982).

2.5.1.2 Taste

Usually drinking water must be almost tasteless to consumer. Taste is a subjective property that is rather difficult to measure. Presence of taste may be due to some dissolved impurities that have found their way into water. These substances may be organic or inorganic, organic as examples (phenols, chlorophenols, oil, fats, grease and unsaturated hydro carbons). Inorganic substances include dissolved salts, iron, manganese, chloride, and gaseous substances such as hydrogen sulfide (H2S) that is produced by decomposition of organic matter by microorganisms (Abd el magid, 1995). Taste refers only to gustatory sensations called bitter, salty, sour, and sweet that result from chemical stimulation of sensory nerve of the tongue and soft palate (APHA, AWWA &WEF, 1992).

2.5.1.3 Odor

Odor should be absent or very faint for water to be acceptable, not greater than three threshold odor numbers (Salvato, 1982). Existence of odors in water may be due to number of reasons such as:

*Biodegradation of organic and inorganic compounds of nitrogen, phosphorus and sulfur.

*Decomposition of algae and other microorganisms

* Generation of substances such as ammonia, sulphides and hydrogen sulphides (Abd el-magid, 1995). Odor is recognized as a quality factor affecting acceptability of drinking water (APHA, AWWA & WEF, 1992).

2.5.1.4 Color

Pure water is colorless; color in water may result from the presence of natural metallic ions such as iron oxides (cause red color) and manganese oxides (cause brown or black color). Other sources are humus and peat material, plankton, weeds, and industrial wastes. Color is classified as:

*True color (true color units, TCUs). Due to substances in solution

*Apparent color (due to suspended matter).

Water from which turbidity has been removed by methods such as filtration or centrifugation where the color was due to vegetable or organic extracts that are colloidal (Abd el-magid, 1995). Drinking water should be free from color which due to the presence of colored organic matter (primary humus substances) and metals such as iron and manganese. The guide line value is up to 15 true color units (TCUs), although level of color 15 TCU can be detected in a glass of water (Park, 2005).

2.5.1.5 Conductivity

Conductivity may be defined as electrical conductance of a conductor of unit length and unit cross –section area, and commonly expressed in micro mhos / cm. Pure water is normally not a good conductor of electricity, the increase of dissolved salts in water increase its conductivity. As such the conductivity of water sometimes used for indicating the degree of its purification or pollution. The conductivity value is proportional to the concentration of dissolved salts or solids A.EC =TDS (Abd el magid, 1995). Electrical conductivity (EC) of a substance is defined as its ability to

conduct or transmit electricity. The presence of chemicals (such as calcium and magnesium ions) gives water the ability to conduct electricity. Testing for EC does not give specific information about the chemicals present in water, but it gives an estimation of TDS. Thus, the EC of water is an indirect measure of dissolved chemicals, TDS (mg/L or ppm) = EC (μS/cm) x 0.67(CAWST, 2009).

Change in conductivity may indicate change in the mineral composition of raw water or seasonal variation in reservoirs, though it also indicates sewage industrial or agricultural pollution or intrusion of saline water. WHO guide lines give a maximum value for TDS of 1000 mg/L. Although in some areas of the world higher values are acceptable (Oxfam, 2001). Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25 degrees Celsius (25 C)(EPA, 2012). EC is measured in microsiemens/cm (μS /cm) and is a measure of salt content of water in the form of ions (Navneet Kumar, 2010).

Conductivity, or specific conductance, is a measure of the ability of water to carry an electric current, This ability depends on the concentration, mobility, and valence of ions in the water as well as on water temperature. In general, water containing substantial concentrations of inorganic compounds has higher conductivity. Water containing organic molecules that do not dissociate well will have lower Conductivity (APHA, 1995). Conductivity, the ability of water to carry an electric charge, can be considered a proxy indicator of dissolved solids (conductivity of 1400 μS/cm being equivalent to a total dissolved solids value of ~1000 mg/l) and is, therefore, an indicator of the taste/salinity of the water. Whilst there is little direct health risk associated with this parameter, high values are associated with poor taste and hence

customer dissatisfaction and complaints. Changes in conductivity with time and also high conductivity values can indicate contamination of the water (e.g. saline intrusion, faecal pollution or nitrate pollution) and can cause corrosion in rising mains and pipes. In this situation, further analysis of the water is recommended (UNICEF, 1995; WHO, 1997).

Conductivity will remain fairly constant throughout a distribution system as long as the water is in equilibrium with the pipe material. Conductivity may vary more if there are corrosion problems (USEPA, 2003). Thus changes in conductivity may indicate corrosion problems (EPA, 2006).

Conductivity is one of the water quality parameters that EPA recommends water systems consider for establishing a baseline for their distribution systems' water quality for security purposes, By doing so, systems will then know what is typical for their water, and any excursions outside the normal range of measurements can serve as an indicator of a potential contamination threat, Conductivity measurements can be made frequently at low cost. Measurements can be made using continuous on-line meters, or with portable instruments. If the system possesses the necessary instruments, conductivity results can be obtained Immediately (USEPA, 2006).

Electrical conductivity of water is a direct function of its total dissolved salts , Hence it is an index to represent the total concentration of soluble salts in water ,The permissible total dissolved salts for drinking water is 500mg/L. In the absence of potable water source the permissible limit is upto 2000 mg/L. High values of TDS in groundwater are generally not harmful to human beings but high concentration of these effect persons, who are suffering from kidney and heart disease (Dave et al., 2011).

2.5.1.6 Salinity

Salinity is the total dissolved solids in water after all carbonate have been converted to oxide, all bromide and iodide have been replaced by chloride and all organic matter has been oxidized (Abdel-magid, 1995). The amount of TDS is a measure of salinity of the water, WHO guide lines give a maximum value for TDS of 1000 mg/L where the salinity of the water exceed either consumer acceptability or WHO guide lines, then an alternative source may be needed (Oxfam, 2001).

2.5.1.7 Solids contents

Solids content is defined as the matter that remains as residue upon evaporation and drying at 103 to 105 deg. C. Solids can be classified as:

*Dissolved solids (DS): In potable water these consist mainly of inorganic salts and small concentrations of organic matter.

*Suspended solids (SS): In water, these solids may of inorganic particles such as plant fibers or biological solids like algae, bacteria, etc. These are the solids that can be filtered our by a fine filter paper.

*Volatile and fixed solids (VS+ FS): they give a measure of the amount of organic matter present in sample. The test carried out by burning organic matter to convert it to carbon dioxide and water at controlled temperature of 550 deg. C. to prevent the decomposition and volatilization of inorganic substances.

*Settleable solids: These are solids in suspension that can settle in quiescent conditions under the influence of gravitational attraction (Abdel- magid, 1995). Total dissolved solids (TDS) can have an important effects on taste of drinking water, the palatability of water with a TDS level of less than 600mg/L is generally considered to be good. Drinking water becomes increasingly unpalatable at TDS levels greater than 1200mg/L. Water with extremely low concentration of TDS may be unacceptable because of it filet (Park, 2005). Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and

potassium cations and carbonate, hydrogencarbonate, chloride, sulfate, and nitrate anions(WHO, 2003). TDS in drinking water comes from natural sources, sewage, urban runoff and industrial wastewater. Brackish or saline aquifers can exist naturally or develop overtime in coastal regions with sea water infiltration due to lowering of a quifer depths.

Drinking water with high concentrations of total dissolved solids will not make people sick. Although there are no direct health concerns, TDS concentrations greater than 1,200 mg/L (e.g. brackish or saline water) cause a bitter or salty taste. Some people can taste salt in drinking water at levels around 500 mg/L, and it may cause them to not use it and choose another, possibly contaminated, water source instead(CAWST, 2009). The total dissolved solids test is a measure of the amount of dissolved and suspended material in the water. "Mineral water" typically has a high total dissolved solids level. The maximum recommended level for total dissolved solids is 500 milligrams per liter (mg/1)(DHEC, 2009). The quality of groundwater for drinking purpose can be expressed in terms of total dissolved solids. Groundwater with a TDS values less than 500 mg/L can be considered as excellent for drinking purpose(Navneet Kumar, 2010). The presence of dissolved solids in water may affect its taste , The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre , Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste(WHO, 2003). The major determinant of the TDS level in water is the geochemical characteristics of the ground it comes in contact with, for example granite and silicons sands, and well leached soils have TDS less than 360 mg/l, the WHO (1984) gave the palatability of drinking water according to its TDS level with rating given by Bruvold as less than 500 mg/l s excellent level and greater than 1700 mg/l as unacceptable , TDS is related to other water quality parameters like hardness, which may occur if the high TDS content is due to the presence of carbonates.

Elevated levels of dissolved solids and chlorides increase the ability of the water to conduct an electrical current. The increase in conductivity accelerates corrosion by making it easier for the chemical reactions involved in corrosion to occur. Total dissolved solids can also be responsible for scaling in water heaters, spotting on dishes, particles forming in ice, rings on cooking utensils, and particles forming in food during cooking, The most noticeable effect of excessive TDS is the taste it gives to water. If a large part of the TDS are chlorides, the water will have a salty taste.
Sulfates will produce a bitter taste; while bicarbonates give the water a medicinal taste. (DHEC, 2009)..

With TDS, the treatment process must deal with a number of different mineral compounds or "salts." The available treatment processes for TDS while effective, are relatively more expensive than treatment for other water quality problems, such as iron removal.

Of the available treatment processes for TDS, reverse osmosis (RO) and deionization (DI) units are the only ones capable of treating the entire household supply. Because deionized water is also corrosive, DI units are not recommended for whole-house use. Where only the taste of the water is of concern, point of- use devices are another means for treating TDS. These are small treatment units which use distillation, deionization, reverse osmosis, or ultra-filtration to treat only enough water for use in drinking and cooking. They are limited to a production of from 10 to 15 gallons of water per day (DHEC, 2009).

2.5.1.8 Density

The density of the fluid is defined its mass per unit volume. For water at standards pressure 760mmHg, and at 4 deg. C. the density is 1000Kg /m^3. The reciprocal of density (1/p) is termed the specific volume; it is defined as the volume of the fluid occupied by unit mass of it. The ratio of the weight or density of substance to the weight or density of water an equal volume of water at standards condition is denoted as specific gravity (s.g) (Abdel-magid, 1995).

2.5.1.9 Turbidity

Turbidity in water is caused by suspended matter such as clay, silt, finely organic and inorganic matter, soluble colored organic compounds, plankton and other microscopic organisms. Turbidity is an expression of the optical property that causes light to be scattered and absorbed than being transmitted in straight lines through the sample (APHA, AWWA &WEF, 1992). Turbidity measurements are made in terms of nephelometric turbidity unit (NTU), formazin turbidity unit (FTU) and Jackson turbidity unit (JTU). The result are interchangeable, its calibrations has been based on the formazin scale. NTU is the standard measure of turbidity, is a good measure of sedimentation, filtration and storage efficiency, particularly when supplemented by the total microbes count (Salvato, 1982). Historically the standard method for determination of turbidity has been based on the Jackson candle turbid meter. Turbidity of treated water usually falls within 0-1 unit (APHA, AWWA & WEF, 1992). WHO recommends that if water is more than 5 NTU then some form of treatment to remove turbidity is necessary before water can be effectively disinfected by chlorine. The NTU should be measured and if found to be higher than 5, then the next stage is to undertake a simple sedimentation test to establish it and how long it takes for the suspended solids to settle out (Oxfam, 2001). Turbidity is important because bacteria are often found attached to suspended particles in the water. In chlorination supplies raised turbidity may reduce the efficiency of disinfection (Howard, 2002). Turbidity is important because its effects, both on the acceptability of water to consumers and the selection of efficiency of treatment processes, particularly the efficiency of disinfection with chlorine (WHO, 1997). Turbidity is a principal physical characteristic of water and is an expression of the optical property that causes light to be scattered and absorbed by particles and molecules rather than transmitted in straight lines through a water sample. It is caused by suspended matter

or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms (EPA, 1999). Excessive turbidity, or cloudiness, in drinking water is aesthetically unappealing, and may also represent a health concern. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis throughout the world. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa (EPA, 1999).

Turbidity also has different implications for water quality and treatment depending on the nature of the particles involved and the location of the turbidity within the drinking water system. High turbidity measurements or measurement fluctuations can indicate a decline in source water quality, inadequate water treatment or disturbances in the distribution system (CDW, 2012). Turbidity is also a useful indicator of groundwater quality changes. Groundwater, especially if under a more or less direct influence of surface water, will experience rapid movements during recharge periods or after rain events. This will displace sediment and turbidity can be an indicator of such changes. Turbidity in groundwater does not indicate pathogen presence but provides information on general water quality and is an indicator of surface influence on groundwater quality (Martin, Allen, et al., 2008). For systems that use groundwater that is not under the direct influence of surface water, thus is considered less vulnerable to faecal contamination, turbidity should generally be below 1.0 NTU. Best practice for these systems includes appropriate well sitting, construction and maintenance, as well as monitoring source water turbidity and ensuring that turbidity levels do not interfere with the disinfection and distribution of the water supply (CDW, 2012).

All drinking water systems should monitor and control turbidity in the distribution system including at the consumer's tap. For effective operation of the distribution system, turbidity levels should be approximately 1.0 NTU or less entering the distribution system. Increases in distribution system turbidity can be indicative of deteriorating water quality and it is good practice to minimize turbidity fluctuations. Increases in turbidity can be sudden or can gradually increase over time. Although some variation in turbidity is normal, increases above typical turbidity levels measured during routine monitoring can provide an indication of potential contamination or stagnation. If an unusual, rapid, or unexpected increase in turbidity levels does occur, the system should be inspected and the cause determined (CDW, 2012).

Turbidity can serve to signal potential contamination problems or difficulties within a distribution system. Increased distribution system turbidity can be indicative of microbiological problems such as intrusion, detachment of biofilm, release of corrosion products or disturbance of deposits. Turbidity should be included in routine monitoring of the distribution system so that deviations from normal conditions can be detected. Turbidity within the distribution system can be monitored in conjunction with other parameters, such as pH, disinfectant residual and pressure to obtain a better understanding of the source of turbidity and thus, the appropriate corrective actions to take when turbidity increases are observed (CDW, 2012). Turbidity can be used as an indicator for identifying contamination entry, hydraulic problems or finished water reservoir rehabilitation frequencies in the distribution system. Sudden increases in turbidity can indicate main breaks, backflow, fire fighting or hydrant opening, flushing, scheduled maintenance or repairs, valve failures, and treatment failures in the distribution system, Particles in treated drinking water may also be introduced during new construction. Microorganisms can adhere to particles that protect them from disinfection, provide a source of nutrients, and facilitate their movement within the distribution system , Furthermore, an increase in turbidity in the distribution system will exert a greater chlorine demand which could lead to inadequate

disinfection of the distributed, Thus turbidity can be an indicator that conditions permit potential microbiological growth in the distribution system.(EPA, 2006).

Measurement of turbidity:

High levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria. The turbidity must always be low e.g below 5 NTU/ JTU and ideally below 1NTU for effective disinfection. Measurement of turbidities lower than 5 NTU will generally require electronic meter, however turbidities of 5 NTU upwards can be measured by simple extinction methods as following steps:

*Add water slowly to the turbidity tube taking care not to form bubbles, fill until the mark at the bottom of the tube just disappears.

*Read the turbidity from the scale marked on the side of the tube. The value is that corresponding to line nearest the level of the water in the tube. The scale is not linear and extrapolation of values between the lines is therefore not recommended. Turbidity may change during sample transmits and storage, therefore should be measured on site at the time of sampling if possible (WHO, 1997). Increased chlorine residual and bacteriological sampling of distribution system in indicated when the maximum contaminant level for turbidity is exceeded in the distribution system (Salvato, 1982). When chlorinated water supply contain more than 0.2mg/L free chlorine and give a turbidity reading of less than 5 NTU it is unlikely to contain fecal coli form, thus there is no need to perform bacteriological analysis (i.e.) E. coli count (Robert, 2004).

2.5.1.10 Radioactivity

Trace elements of radon, radium, uranium and other radionuclide's have been discovered in some water systems all are suspected to increase risk. Radioactivity is emitted from radionuclides in the of form alpha particles, beta particles and finally gamma rays. In drinking water the presence of alpha particles and beta particles and proton emitters is regulated as well as radium

and uranium (Robert, 2004). Radioactivity in drinking water should not only be kept within safe limits, it also within those limits, be kept a low as is reasonably possible. The guide line values recommended take a count of both naturally occurring radioactivity and any radioactivity that may reach water sources as result of human's activities (Park, 2005).

2.5.2 Chemical quality

The health risk due to toxic chemicals in drinking water differ from that caused by microbiological contaminants, there are few chemical constituents of water that can lead to acute health problems except through massive accidental contamination of supply (Park, 2005). Although chemically contaminated water supplies are less wide spread and more localized than bacteriological contaminated water, specific contaminants can greatly affect the quality of water in different areas, the most common contaminants found in water sources are iron and dissolved salts (UNICEF, 1999). The chemical parameters of drinking water quality include PH, alkalinity, acidity, hardness, dissolved oxygen, oxygen demand, dissolved gases, inorganic substances, and organic substances, etc (Abdel- magid, 1995).

2.5.2.1 Hydrogen ion concentration (pH)

The PH is a measure of the acid or alkaline nature of solution, and affects the quality of water. The PH ranges from 0-14 with 7 as neutrality, below 7 being acidic and above 7 being alkaline. One of the best controls of biological growth is PH. At low PH hydrogen ion causes denaturation of the key enzyme proteins. Most microorganisms cannot survive below PH 4. PH can be adjusted by addition of acid or alkaline compounds to water (Abdel-magid, 1995). WHO guide lines recommend drinking water be in the range PH 6.5 – 8.5. Ideally the water will be fairly neutral with PH around 7. Knowing the PH value is also important, as PH value alter the effectiveness of two of the chemicals commonly used in water treatment. Chlorination is considerably slow down when PH is higher than 8 and the effectiveness of

aluminum sulphate commonly used as coagulant, is severely affected by low or high PH, with a range of about PH 6.5 – 7.5 being optimum (Oxfam, 2001). Monitoring for pH is one of the most common tests conducted for water (Addy et al. 2004). In its Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents (USEPA, 2003).

EPA recommends pH monitoring to establish baseline water quality in the distribution system. In well-buffered waters, pH should remain fairly constant throughout the distribution system, as long as the water has come into equilibrium with the pipes and there are no significant corrosion problems (AWWA, 1999a). A reduction in pH can be an indication of problematic biofilm growth. For example, a decrease in pH can result from growth of sulfur-reducing bacteria such as *Thiobacillus*. These bacteria generate hydrogen ions which lowers the pH (AWWA, 1995). A growth in nitrifying bacteria may also decrease the pH by oxidizing ammonium to nitrate and other nitrogen compounds (Schock, 1999).

pH is a commonly-monitored parameter, although monitoring is not necessarily required under all circumstances. The concept of pH is understood by most operators of distribution systems, and equipment is often already available. The pH can be monitored using on-line monitoring equipment, by doing grab samples in the field, and in a water treatment plant laboratory, allowing for almost immediate results (EPA, 2006). PH is an artificial scale used to measure acidity. A pH of 7 is neutral, neither acidic nor basic. As the scale decreases from 7 to 0, the water becomes more acidic. As the pH increases from 7 to 14, the water becomes more basic. Most well water has a pH between5 and 9. The recommended range for drinking water is from 6.5 to 8.5(DHEC, 2009). The pH of natural waters is often found slightly acidic (5.0-7.5). This way be due to the presence of dissolved carbon dioxide and organic acids (fulvic and humic acids), which are derived from the decay and subsequent leaching of plant materials, A low pH can cause corrosion of water carrying metals pipes, thereby releasing toxic metals such as zinc, lead, cadmium, copper etc (Navneet Kumar,

2010). Acidic water can also cause problems for human consumption. While slightly acidic water is not dangerous, on its own, it can be quite dangerous when combined with other compounds. Water with a pH that is less than 6.5 can leach metal ions, including iron, manganese, copper, lead and zinc from plumbing fixtures and pipes. This, in return, can be quite dangerous. On the other end of the pH scale, water that has a pH greater than 8.0 can be difficult to disinfect. The World Health Organization recommends that the pH of the water be less than 8.0, because basic water does not allow for effective chlorination (Health Canada, 2007).

2.5.2.2 Alkalinity

Alkalinity is a measure of buffering capacity of water. Alkalinity is caused primary by chemical compounds dissolved from rock and soil and mainly due to the presence of hydroxyl (OH), carbonate (CO3) and bicarbonate (HCO3) ions. These compounds are mostly the carbonates and bicarbonates of sodium (Na), potassium (K) magnesium (Mg), and calcium (Ca), other ions may be contribute to alkalinity but are generally found at low concentration such as H2Po4, Po4, HSIO3, and HS. Alkalinity in water is determined by titrating a sample of water with 0.02N, H2SO4 solution (Abdel- magid, 1995).

2.5.2.3 Acidity

Acidity is usually attributed to samples with PH below the value of seven. In unpolluted water, acidity comes from dissolved CO_2 or organic acids leached from soil. Atmospheric pollution also may cause acidity. The acidity of water is determined by titrating a water sample with 0.02N NaOH to PH 8.3 (Abdel-magid, 1995).

2.5.2.4 Hardness

Hardness may be defined as the soap destroying power of the water. The consumer considers water hard if large amount of soap are required to produce lather. The hardness in water is caused mainly by four dissolved compounds these are: Calcium bicarbonate, magnesium bicarbonate, calcium sulphate, and

magnesium sulphate. The presence of any one of these compounds produces hardness.

There are others which are less importance chloride and nitrate of calcium and magnesium can also cause hardness, also iron, manganese and aluminum compounds cause hardness but generally are present in such small amount (Park, 2005). The hardness of water is removed by boiling, by adding lime (28mg per 454 liters of water), adding sodium carbonate, use of permutite water soften and use of soda lime (lime plus caustic soda) such as NaOH (Jaypee, 2000). Water hardness is the major amount of calcium and magnesium cations in water. Hardness is mostly expressed as milligram of calcium carbonate ($CaCO_3$) equivalent per liter and also can be mentioned in term of carbonate (temporary) and noncarbonated (permanent) hardness. The hardness in water is naturally occurring in groundwater which weathering of limestone, sedimentary rock and calcium bearing minerals. They are also present locally from industrial effluent such as chemical and mining industry or the excessive use of lime to the soil in agriculture field. Water hardness is a measure of the cations (cations = ions which bear positive electron charges) dissolved in the water and is therefore, related to dissolved solids. The more cations dissolved in the water the "harder" the water. The most common cations of this type are calcium and magnesium. Iron, strontium, and manganese may also contribute, but they are seldom present in appreciable amounts. Hardness is usually reported as an equivalent amount of calcium carbonate ($CaCO_3$) , Water's hardness is determined by the concentration of multivalent cations in the water. Multivalent cations are cations (positively charged metal complexes) with a charge greater than 1+. Usually, the cations have the charge of 2+. Common cations found in hard water include Ca^{2+} and Mg^{2+}. These ions enter a water supply by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium). Rainwater and distilled water are soft, because they also contain few ions.

The following equilibrium reaction describes the dissolving/formation of scales calcium carbonate $- CaCO_3 + CO_2 + H_2O \leftrightharpoons Ca^{+2}\ \ 2HCO^{-3}$.

Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard (McGowan, 2000). Although hardness is caused by cations, it may also be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness (WHO, 2011). Hardness water is mainly an aesthetic concern because of the unpleasant taste and reduces the ability of soap to produce lather. It is also cause scale formations in pipes and on distribution system (BCC, 2007).

Due to the high levels of hardness in water, people may become unacceptable with unaccomplished taste. Therefore, the most common method to remove hardness in household level for drinking and ground water utilization is boiling. However, there are various others methods for calcium and magnesium hardness removal from groundwater such as reverse osmosis, ion exchange, and chemical treatment with lime-soda ash method , The ion exchange process is extensively used and also the most effective methods to remove hardness in groundwater. It is contained with resin that calcium and magnesium ion can be exchanged for sodium and potassium ions. The commercials resins are presently used in individual home and industrials purposes to remove the ionic impurity in water. Hardness is an important water quality parameter because excess hardness is not suitable for drinking and other purpose. Hard water produces serious health problems like- urolithosis, cardiovascular disorder, kidney problems, anencephaly and cancer. According to past studies, an inverse relationship between the hardness of drinking water and cardiovascular disease has been reported by Smith and Crombie and other some diseases like anencephaly and cancer also caused by hardness of water.,(Meena KL, et al., 2011). Some studies have shown a weak inverse relationship between water hardness and cardiovascular disease in men, up to a level of 170 mg calcium carbonate per litre of water. The World Health Organization has reviewed the evidence and concluded the data were inadequate to

allow for a recommendation for a level of hardness, Recommendations have been made for the maximum and minimum levels of calcium (40–80 ppm) and magnesium (20–30 ppm) in drinking water, and a total hardness expressed as the sum of the calcium and magnesium concentrations of 2–4 mmol/L.

Some studies correlate domestic hard water usage with increased eczema in children (Mc Nally., et al., 1998; Arnedo Pena , et al., 2007) . Groundwater is often harder than surface water and may have levels up to several thousand mg/l because of it high solubilizing potentials, particularly for rocks containing gypsum, calcite and dolomite. Source of hardness include sewage and run-off from soils particularly limestone formations, building materials containing calcium oxide and textile and paper materials containing magnesium.

The minerals that cause water hardness can be removed by a water softener. Water softeners use an ion exchange process to replace the calcium and magnesium that cause hardness with an equivalent amount of sodium, which does not contribute to water hardness, With use, all of the sodium in a softener will eventually be replaced by calcium and magnesium. When this occurs, the softener must be regenerated to maintain its softening ability. In regeneration, the softener is filled with a concentrated salt solution. The sodium in the salt solution replaces the calcium and magnesium in the softener, restoring it to its original condition. Most manufacturers offer either a manual or an automatic regeneration cycle in their softeners, Ion exchange softeners produce a water with near zero hardness. Because a moderate amount of hardness is desirable, some individuals choose to soften a portion of the water and blend it with unsoftened water to produce a final hardness of 50 to 100 mg/1. In cases where the water hardness exceeds 200 mg/1 or where elevated levels of chlorides are present, softening may produce a salty taste in the water. In these instances, a by-pass line can be installed from before the softener to a kitchen faucet; or a point-of use,

If excessive iron and manganese are present, it may be necessary to remove these metals prior to softening. While water softeners will remove small

amounts of iron and manganese, excessive amounts will foul the water softener. As a rule of thumb, the total amount of iron and manganese should not exceed 1.0 mg/l for every 140 mg 1 (8 gpg) of hardness (DHEC, 2009).

2.5.2.5 Dissolved oxygen (DO)

Dissolved oxygen in water needed for the maintance of aerobic condition, but solubility of oxygen in water is low. Drinking water saturated with oxygen has a pleasant taste, while water lacking dissolved oxygen has an insipid taste (Abdel-magid, 1995). Depletion of dissolved oxygen in water supplies can encourage microbial reduction nitrate to nitrite and sulphate to sulphite, giving rise in odor problems, it can also cause an increase in the concentration ferrous iron in solution, no health- based guide line value has been recommended (Park, 2005).

2.5.2.6 Oxygen demand (OD)

Oxygen demand is the amount of O2 needed to stabilize organic matter, there are three types of it as below:

*Biochemical oxygen demand (BOD) is a measure of the mount of pollution by organic substances in water.

*Permanganate value (PV) is the chemical oxidation of water sample using a potassium permanganate solution (KMnO4).

*Chemical oxygen demand (COD) is the chemical oxidation of water sample using a mixture of concentrated H2SO4 and potassium dichromate (K2Cr2O7) (Abdel-magid, 1995).

2.5.2.7 Dissolved gases

Natural water contain dissolved gases with varying concentrations depending upon their solubility in water, when water is an aerobic and there is microbial activity, free ammonia, hydrogen sulphide and methane may exist. In latter case, the water needed to be oxygenated before use. From the point of view of water purity, the most important gases are oxygen and carbon dioxide (Abdel- magid, 1995).

2.5.2.8 Inorganic substances

Many of the chemicals that reach water are poisons and dangerous. Among the inorganic chemicals that can be found in water supplies are arsenic, cadmium, cyanide, lead, selenium, mercury, copper, chromium, zinc, and etc. WHO has developed guide lines value for chemical constituents that reach drinking water, these guide line values must be reviewed and updated periodically (WHO, 2002). The effect of metal in drinking water ranges from beneficial through troublesome to dangerously toxic. Some metals are essential, other may adversely affect water consumers, and some metal may be either beneficial or toxic depending on concentration (APHA, AWWA & WEF, 1992). The most important inorganic minor chemical constituents for consideration in drinking water are fluorides and nitrates concentration as they cause anthropogenic pollution and natural contamination, this value cause dental flourosis and above 3mg/L cause skeletal flourosis (MWR, 2006). WHO-GL for nitrate is 10mg/L concentrations above this value is concern to health because it cause methaemoglobinaemia (blue-baby syndrome)among children less than six months (Howard, 2002).

2.5.2.8.1 Fluoride:-

Fluoride can occur in drinking water naturally as a result of the geological composition of soils and bedrock. Some areas of the country have high levels of naturally occurring fluoride which can dissolve easily into ground water as it moves through gaps and pore spaces between rocks.

Fluoride can also be added to public drinking water supplies as a public health measure for reducing cavities among the treated population. Fluoridation is not required by EPA, which is prohibited by the Safe Drinking Water Act from requiring the addition of any substance to drinking water for preventive health care purposes (EPA, 2011). Fluoride is found in all natural waters at some concentration. Seawater typically contains about 1mg l–1 while rivers and lakes generally exhibit

concentrations of less than 0.5 mg l–1. In groundwaters, however, low or high concentrations of fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride-bearing minerals. Concentrations in water are limited by fluorite solubility(WHO, 2006). Some fluoride compounds, such as sodium fluoride and fluorosilicates, dissolve easily into ground water as it moves through gaps and pore spaces between rocks. Most water supplies contain some naturally occurring fluoride. Fluoride also enters drinking water in discharge from fertilizer or aluminum factories. Also, many communities add fluoride to their drinking water to promote dental health (EPA, 2012). Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in ground water in small amounts. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between rock and the circulating ground water. Presence of other ions, particularly bicarbonate and calcium ions also affects the concentration of fluoride in ground water (Jha BM, 2010). Fluoride is a naturally occurring substance and is present in virtually all water, usually at very low levels. Higher concentrations of naturally occurring fluoride often are associated with well water, where fluoride has dissolved from the rock formations into the groundwater.1 Community water fluoridation began in 1945, after scientists discovered that higher natural levels of fluoride in a community water supply were associated with fewer dental caries (cavities) among the residents (CRS, 2011).

Health Effects

Fluoride in drinking water is beneficial at low concentrations, but can pose health concerns at higher concentrations. There are many sources of fluoride in the diet. Dentists apply fluoride to teeth; some municipal water systems add fluoride to their water supply's; many tooth pastes have

fluoride as an additive; and some foods also have elevated fluoride such as fish and tea. The Centers for Disease Control (CDC) have recommended 1.0 to 1.2 milligrams

per liter (mg/L) of fluoride as the optimum beneficial concentration in drinking water for dental protection for the state of New Hampshire(DES, 2007). Fluoride is beneficial when present in small concentrations (0.8 to 1.0 mg/L) in drinking water for calcification of dental enamel. However, it causes dental and skeletal fluorosis if high. Higher concentration of fluoride in drinking water is also linked with cancer (Navneet Kumar, 2010). Exposure to excessive consumption of fluoride over a lifetime may lead to increased likelihood of bone fractures in adults, and may result in effects on bone leading to pain and tenderness. Children aged 8 years and younger exposed to excessive amounts of fluoride have an increased chance of developing pits in the tooth enamel, along with a range of cosmetic effects to teeth(EPA, 2012). Researchers continue to study the potential health effects associated with exposure to fluoride in drinking water. Many of the studies have focused on ingestion of higher, naturally occurring levels of fluoride rather than on artificial fluoridation levels. The studies generally have shown that fluoride ingestion at elevated levels primarily produces effects on skeletal tissues (skeletal fluorosis) and that these effects are more severe as exposure to fluoride increases above a threshold. Very mild, skeletal fluorosis is characterized by slight increases in bone mass. The most severe form of this condition, "crippling skeletal fluorosis," involves bone deformities, calcification of ligaments, pain, and immobility(CRS, 2011). A small amount of fluoride in water is generally good for strengthening people's teeth and preventing decay. Fluoride is added to some city water systems and certain consumer

products to protect teeth such as toothpastes and mouthwashes. Small amounts of fluoride are generally good for people's teeth. But at higher amounts over time, it can cause dental fluorosis and damage people's teeth by staining and pitting. Over many years, fluoride can build up in people's bones, leading to skeletal fluorosis characterized by stiffness and joint pain. In severe cases, it can cause changes to the bone structure and crippling effects. Infants and young children are most at risk from high amounts of fluoride since their bodies are still growing and developing.

There is currently no effective cure for fluorosis – the only prevention is to drink water that has safe levels of fluoride (CAWST, 2009).

Fluoride removal:-

Fluoride is only required to be removed from drinking water if the levels are higher than 4.0 mg/L MCL set by the EPA. Fluoride removal methods can be divided in two alternatives: membrane and adsorption techniques. Membrane techniques include reverse osmosis, nanofiltration, dialysis, and electrodialysis, while adsorption techniques include alumina/aluminium based materials, clays and soils, calcium based minerals, synthetic compounds, and carbon based materials. Each one of these approaches has advantages and disadvantages. A recent paper published by Mohapatra et al. (2009), Review of Fluoride Removal from Drinking Water, summarizes the current state of knowledge on this topic.

EPA recommends distillation or reverse osmosis as effective approaches for removing fluoride to below 4.0 mg/L (WRF, 2011).

2.5.2.8.2 Nitrate and nitrite:-

Nitrate and nitrite are naturally occurring inorganic chemicals that make up part of the nitrogen cycle. The nitrogen cycle is the movement of nitrogen, in different chemical forms, from the environment to organisms and then back to the environment. As part of the nitrogen cycle, bacteria convert nitrogen gas from the atmosphere into nitrate and nitrite and then back again as the cycle continues. Nitrate is the more stable of the two chemicals and is therefore more abundant in soils (DHEC, 2009). Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved Nitrogen in the form of Nitrate is the most common contaminant of ground water. Nitrate in ground water generally originates from non point sources such as leaching of chemical fertilizers & animal manure, ground water pollution from septic

and sewage discharges etc. It is difficult to identify the natural and man made sources of nitrogen contamination of ground water. Some chemical and micro-biological processes such as nitrification and denitrification also influence the nitrate concentration in ground water (Jha BM, 2010). Common sources of nitrate include application of fertilizers, use of septic systems, concentration of animal waste, and decomposition of plant residues. Since nitrate and nitrite occur naturally in the environment, small amounts might be present in water. Nevertheless, human activities can significantly influence these levels. Municipal and industrial wastewater and animal feed lots are major point sources for nitrate and nitrite in water. Concentrated use of septic tanks along with runoff or leachate from the use of fertilizer are some of the main nonpoint sources. Once in the soil, nitrate/nitrite is very mobile. It is water soluble and moves easily through the soil at virtually the same speed as water(DHEC, 2009).

The WHO suggests that drinking water should have less than 50 mg/L of nitrate to protect against methaemoglobinaemia in bottle-fed infants (short term exposure). In most countries, nitrate levels in surface water are not more than 10 mg/L, although nitrate levels in well water often exceed 50 mg/L (WHO, 2006). Nitrite levels should be less than 3 mg/litre to protect infants from methaemoglobinaemia short-term exposure). There is a provisional guideline for long term nitrite exposure set at less than 0.3 mg/L. The guideline value is considered provisional because of the uncertainty of the chronic health effects and our susceptibility to it, Concentrations greater than 44.3 mg/L nitrate causes 97% of reported illness. High nitrate levels are often associated with higher levels of microbiological contamination since the nitrates may have come from manure or sewage. (CAWST, 2009). High levels of nitrate in drinking water are a health concern primarily because of the potential for the nitrate to be converted to nitrite. Nitrite interferes with the ability of your blood to carry oxygen. It does this by converting blood hemoglobin into methemoglobin. Unlike hemoglobin, methemoglobin does not function as an oxygen carrier to the tissue. The resulting condition is known as methemoglobinemia and causes severe oxygen deficiency and

can lead to death. The sensitive populations are infants, individuals with reduced gastric acidity, individuals with a hereditary lack of methemoglobin reductase, and women who are pregnant. Methemoglobinemia is usually found in infants rather than adults, especially infants less than six months of age. It is characterized by shortness of breath and blueness of skin. As a result, it is often called the "blue baby syndrome(DHEC, 2009). When ingested, both nitrate and nitrite can oxidize blood haemoglobin (Hb) to methaemoglobin (metHb); nitrite is approximately ten times as potent as nitrate. MetHb cannot transport oxygen, and the oxygen-poor blood causes development of a blue colour in tissues (cyanosis). The abnormal colour is usually first noticed in the lips, followed by the fingers and toes, the face, and then the whole body. Infants below 6-12 months of age are particularly susceptible: their stomachs are less acidic than those of older children or adults, favoring the reduction of nitrate to nitrite. In addition, the haemoglobin of infants is more vulnerable to oxidation. Methaemoglobinaemia arises from short-term rather than chronic exposure to nitrate and nitrite. WHO GVs for nitrate and nitrite are set at 50 and 3 mg/L, respectively, to protect against methaemoglobinaemia in bottle-fed infants. In addition, the sum of the ratios of the concentrations of each to its guideline value should not exceed 1. For example, drinking

water containing 30 mg/L nitrate and 1.5 mg/L nitrite would exceed the guideline value. There is some evidence that nitrite can react with amines or amides in the body to form nitrosamine, a known carcinogen. Chronic exposure to nitrite has produced changes in the adrenals, heart and lungs in laboratory animal studies. Accordingly, WHO provisionally recommends a GV of 0.2 mg/L nitrite for long-term exposure (UNICEF, 2008) . The toxicity of nitrate to humans is thought to be solely the consequence of its reduction to nitrite. Nitrate has been implicated in methaemoglobinaemia and also a number of currently inconclusive health outcomes. These include proposed effects such as cancer (via the bacterial production of *N*-nitroso compounds), hypertension, increased infant mortality, central nervous system birth defects, diabetes, spontaneous abortions, respiratory tract infections, and changes

to the immune system (CDC, 1996; Gupta et al., 2000). Nitrate is easily dissolved in water, which means that it is difficult to remove. The technology for removal of nitrate from drinking water does exist. Three water treatment systems that remove nitrate are distillation, reverse osmosis, and ion exchange. Distillation boils water, then catches and condenses the steam while nitrate and other minerals remain in the boiling tank. Reverse osmosis forces water under pressure through a membrane to filter out contaminants. Ion exchange introduces another substance, normally chloride, to "trade places" with nitrate in water (Napacho, Manyele , 2010).

2.5.2.9 Organic substances

Many organic chemicals can also pollute water, example for these are chlorinated pesticides such as DDT and hydrocarbons such as benzene that are carcinogenic and host of chemical that causes genetic change and birth defects. Certain organic chemical like phenols, impart a bad taste to water. WHO has developed guideline values for a number of organic constituents of drinking water including certain commonly used pesticides. In local situation, it may be necessary to control the concentration in order to protect public health (Howard, 2002).

2.5.3 Microbiological quality

The primary concern with health problems caused by water supply is infectious diarrheal diseases transmitted by the fecal- oral route, there for the principal concern in water quality is the microbiological quality of the water. Microbiological quality may change very rapidly over time and short distances, there for requires frequent testing (Howard, 2002). Water for drinking and cooking purposes must be made free from disease-producing organisms (pathogens), these organisms include viruses, protozoa, helminthes (worms), and bacteria. Some organisms, which cause diseases in people, originate with fecal discharge of infected individuals. Other are from the fecal discharge of animals (Davis & cornwell , 1998). Other organisms naturally present in the environment and not regarded as pathogens in drinking water may also cause

occasional opportunist disease such as organisms in drinking water may cause infection predominantly among people whose local or general natural defense mechanisms are impaired, this is most likely to be the case in very old and young children, those organisms such as pseudomonas, flavor bacteria, acineto bacteria, klebsiella, and serratia (WHO, 1984).

Waterborne diseases are caused by a wide variety of pathogenic microorganisms, biotoxins, and toxic contaminants found in the water we drink, clean with, play in, and are exposed to through other less direct pathways such as cooling systems. Waterborne microorganisms include protozoa that cause cryptosporidiosis, parasites that cause schistosomiasis, bacteria that cause cholera and legionellosis, viruses that cause viral gastroenteritis, amoebas that cause amoebic meningoencephalitis, and algae that cause neurotoxicity (Barterman, et al., 2009). The following groups of microorganisms have been linked with the occurrence of waterborne disease. As each pathogen is isolated and identified as a threat to water quality:

2.5.3.1 Viruses

Drinking water should be free from any viruses infectious to man. Disinfection with 0.5 mg/L of free chlorine residual after contact period of at least 30 minutes at PH of 8 is sufficient to in activate viruses. Ozone has been shown to be effective viral disinfectant, preferably for clean water, if residual of 0.2-0.4 mg/L are maintained for 4 minutes, it is not possible to maintain ozone residual in distribution system (Park, 2005). Viruses are inactive when outside of a living host cell. Viruses linked to waterborne disease have protein coats that provide protection from environmental hazards and range in size from 0.02 to 0.09□m. Unlike bacteria and protozoa, they contain only one type of nucleic acid (RNA or DNA). Key pathogens include hepatitis A and Norwalk virus(EPA, 1993).

2.5.3.2 Protozoa

Drinking water should not contain any pathogenic intestinal protozoa. Species of protozoa known to have been transmitted by ingestion of

contaminated drinking water include Entamoeba histolytica, Guardia ssp, and rarely blantidium coli. Rapid or slow sand filtrations have been shown effective in removing a high proportion of pathogenic protozoa (Park, 2005).

Protozoa, common in bodies of water, are much larger than bacteria and viruses. To survive harsh environmental conditions, some species can secrete a protective covering and form a resting stage called a "cyst." Encystment can protect protozoa from drinking water disinfection efforts and facilitate the spread of disease. Key protozoa being studied as agents of waterborne disease include *Giardia* and *Cryptosporidium (*EPA, 1993).

2.5.3.3 Helminthes

The infective stages of many parasitic round worms and flat worms can be transmitted to man through drinking water. A single mature larva or fertilized eggs can cause infection and such infective stages should be absent from drinking water. However the water rout is relatively unimportant except in case of darcunculus medinesis (guinea worm) and the human schistosomiasis which are primarily hazards of unpiped water supplies. The methods for detection of these parasites are unsuited for routine monitoring (Park, 2005). Lack of safe drinking water contributes to intestinal helminth infections, which cause malnutrition and anaemia in children). Both early childhood malnutrition and anaemia can cause permanent effects in brain development, malnourished and anaemic children grow up to be less intelligent and do less well in school (Stephenson et al., 2000).

2.5.3.4 Free living organisms

Free living organisms that may occur in drinking water supplies include fungi, algae, and etc. The most common problems with these are their interference in operation of water treatment process, color, turbidity, taste, and odor of finished water, thus drinking water must be free from these free-living organisms (Park, 2005).

2.5.3.5 Bacteria

The word bacteria (singular bacterium) come from the Greek word meaning (rod) or (staff). Bacteria are single celled microscopic organisms that multiply by spitting in to binary fission. In order to multiply they need carbon obtained from carbon dioxide (CO2), if they are autotrophic or from organic compounds (dead vegetation and meat) if they are heterotrophy. Their energy comes either from sunlight if they photosynthetic or from chemical reaction if they are chemosynthetic. Bacteria are present in air, water, earth, rotting vegetation, and the intestines of human and animals. Under ideal conditions bacteria may be divided (generation time) every 20 minutes. Never the less they are taking up food quickly that they are likely to be limited by shortage food, oxygen, or water (Abdel- magid, 1995). Bacteria are the most widely distributed life forms. Pathogenic bacteria range in length from approximately 0.4 to 14 □m (a □m or "micrometer" equals one one-thousandth of a millimeter) and 0.2 to1.2 □m in width. Key bacterial pathogens responsible for waterborne disease include *Legionella, Salmonella typhi*, *Shigella*, and *Vibrio cholera*(EPA, 1993).

2.5.3.5.1 Coli form group bacteria

The coli form of organisms includes all the aerobic and facultative an aerobic, gram-negative, non- spores- forming, rod-shaped bacteria that ferment lactose with acid and gas formation within 24-48 hours at 35-37 deg. C (Salvato, 1982). Coli form bacteria defined here are as facultative an aerobic, gram negative, non-spore-forming rods that ferment lactose with gas formation within 48 hours at 35 deg. C or as applied to the membrane filter method a dark red colony with metallic sheen within 24 hours on an endo-type medium contain lactose. However an acrogenic (non gas producing) lactose fermenting strains of E. coli and coli forms that do not produce metallic sheen on endo medium may be encountered. These organisms as well as typical coli forms can

consider indicator organisms (APHA, AWWA & WEF, 1998). Fecal coli form bacteria more than 99% of which are E. coli are an indicator of the level of human /animal waste contamination in water and the possibility of presence of harmful pathogen i.e. microbiological contamination. It is worth noting that sometimes the presence of coli form organisms (total coli form) is used as an indicator. However coli form organism may not always be directly related to the presence of fecal contamination or pathogens in drinking water, but still the coli form test used for monitoring the microbial quality of the treated piped water supplies (Oxfam, 2001). The indicator bacteria that most surveillance bodies use in routine assessment of risk of fecal contamination is Escherichia coli (E. coli) or as an alternative thermo tolerant coli form. E. coli provides the closest match to 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. Basic characteristics of the ideal indicator are:

*Present wherever pathogens are present.

*Present in the same of higher numbers than pathogens.

*Specific for fecal or sewage pollution.

*At least as resistant as pathogens to conditions in natural water environments and water purification and disinfection process.

*Nonpathogenic.

*And detected by simple, rapid and inexpensive methods (Howard, 2002).

The second edition of the WHO guide lines for drinking water quality published in 1993 strongly recommended the use of E. coli as the preferred fecal indicator because its provides the closest match to the criteria for an ideal indicator (WHO, 2002).

2.5.3.5.2 Escherichia coli pathogenic strains

Escherichia coli is present in large numbers in normal intestinal flora of humans and animals, where it's generally causes no harm. However in other parts of the body E. coli can cause serious diseases such as urinary tract

infections, bacteraemia and meningitis. A limited number of entero pathogenic strains can cause acute diarrhea. Several classes of entero pathogenic E. coli have been identified on the basis of different virulence factors, including entero hemorrhagic E. coli (EHEC), entero toxinogenic E. coli (ETEC), entero pathogenic E. coli (EPEC), entero invasive E. coli (EIEC), entero aggregative E. coli (EAEC),and diffusely adherent E. coli (DAEC).EHEC organisms can cause infections, ETEC produces heat labile or heat stable E. coli entero toxin, or both toxin simultaneously and is an important cause of diarrhea in developing countries specially in young children, infection with EPEC has associated severe, chronic, non bloody diarrhea, vomiting and fever in infants, this occur commonly in developing countries and rare in developed counties. EIEC causes watery and occasionally bloody diarrhea. Entero pathogenic E. coli are I enteric organisms and humans are the major reservoir, particularly of EPEC, ETEC, and EIEC strains. Lives stock such as cattle, sheep, goats, pigs, and chickens are major source of EHEC strains (WHO, 2004).

2.5.3.5.3 Thermo tolerant bacteria

Thermo tolerant coli form bacteria are coli form organisms that are able to ferment lactose at 44-45 deg. C., the group include the genus E. coli and some species of klebsiella, Entero bacter and citro bacter. Because thermo tolerant coli form organisms are readily detected they have an important secondary role as indicators of the efficiency of water treatment process in removing fecal bacteria (WHO, 1997).

2.5.3.6 Water associated diseases

The most common and widespread health risk associated with drinking water is microbial contamination which has the potential to cause large outbreaks of waterborne diseases like dysentery, cholera, typhoid, skin infections etc . The chemical contaminations do not cause immediate acute health problems unless they are present in massive quantities through some accident and use of chemical fertilizers

and pesticides in crop near the drinking water sources. It therefore becomes essential to regularly control the quality of groundwater and to device ways and means to protect it. Water has a profound effect on human health both as a means to reduce disease and as a media through which disease-causing agents may be transmitted. The impact of water on health derives principally from the consumption of water containing pathogenic organisms or toxic chemicals and the use of inadequate volumes of water that lead to poor personal and domestic hygiene, The risk of acquiring a waterborne infection increases with the level of contamination by pathogenic micro-organisms. However, the relationship is not simple and depends on factors such as infectious dose and host susceptibility. Drinking-water is only one way for the transmission of such pathogens, some agents may be transmitted from person to person, or through the contamination of food. In many cases, poor personal hygiene may lead to the transmission of pathogenic organisms through contamination of water stored within the home or by preparation of food. Poor hygiene practices often result from the use of inadequate volumes of water and therefore water quantity is also important in controlling infectious diarrhoeal diseases. In general terms, it is better to provide larger volumes of reasonable quality water than to provide very limited quantities of excellent quality (UNICEF, 1995; WHO, 1997).

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. Despite continuing efforts by governments, civil society and the international community, over a billion people still do not have access to improved water sources (UNISEF, 2008). Water-associated diseases are classified into five main groups (according to Bradley, 1974):

2.5.3.6.1 Water-washed (water-hygiene) diseases

occur due to the lack of adequate water supply for washing, bathing and cleaning. Pathogens are transmitted from person to person or by contact with contaminated

surfaces. Eye and skin infections as well as diarrhoeal illnesses occur under these circumstances. Waterborne pathogens include bacteria, viruses, protozoa and helminths. A short list of the most important pathogens and their significance in water supplies (WHO,2011). Control of water-washed diseases depends more on the quantity of water than the quality. Most of the diarrhoeal diseases should be considered to be water-washed as well as water-borne, helminths; acute respiratory infections (ARI); skin and eye diseases; and diseases caused by fleas, lice, mites or ticks. For all of these, washing and improved personal hygiene play an important role in preventing disease transmission(UNICEF, 2008).

2.5.3.6.2 Water-scarce diseases occur due to the lack of water available for washing, bathing and cleaning. Hence, pathogens are transmitted from person to person or from contaminated surfaces to a person and are spread by the faecal–oral route. In particular, eye (trachoma) and skin infections (scabies), as well as diarrhoeal diseases occur under those conditions.

2.5.3.6.3 Water-based diseases

are caused by organisms, in particular by different species of worms that spend parts of their life-cycle in different habitats. They have spent one development cycle in aquatic molluscs, and another as fully grown parasites in other Technical guidance on water-related disease surveillance, animal or human hosts. Because stagnating surface waters, such as reservoirs, are the preferred habitat of parasitic worms, the occurrence of water-based diseases such as dracunculiasis and schistosomiasis can be heavily influenced by anthropogenic activities.

2.5.3.6.4 Vector-borne diseases

are caused by bites from insects that breed in water. Insect vectors such as mosquitoes transmit diseases such as malaria, Chikungunya and other diseases (WHO,2011). These diseases are not directly related to drinking-water quality. However, consideration of vector control during the design, construction and operation of surface water reservoirs and canals (for drinking water or irrigation purposes) can

reduce the potential for water related disease transmission. The most common vector insects are mosquitoes and flies (UNICEF, 2008).

2.5.3.6.5 Waterborne diseases

are caused by the ingestion of faecally contaminated water. Cholera and typhoid fever are classical examples of waterborne diseases, where only a few highly infectious pathogens are needed to cause severe diarrhoea. Shigellosis, hepatitis A, amoebic dysentery and other gastrointestinal diseases can also be waterborne (WHO,2011). Most water-borne pathogens infect the gastrointestinal tract and cause diarrhoeal disease. In most cases, the specific pathogen responsible for infection is not identified, and case identification and treatment is fairly generic. Two very serious forms of diarrhoeal disease, cholera and shigellosis, should be considered separately because of their severity and tendency to create epidemics (UNICEF, 2008).

2.5.3.6.5.1 Amebiasis

Amebiasis is a result of infection with *Entamoeba histolytica*, a protozoan parasite which is found in two forms. The trophozoite is the active form of the parasite which causes symptoms. Cysts are the infectious form which sometimes develops in the lower intestine but does not cause symptoms. Infected persons may shed both trophozoites and cysts in stool(Kansas,2009). Amoebiasis, or Amebiasis, refers to infection caused by the amoeba Entamoeba histolytica , The term Entamoebiasis is occasionally seen but is no longer in use it refers to the same infection (WHO,1969;WHO,1997). *Entamoeba histolytica* is a protozoan parasite that should not be confused with *Entamoeba hartmanni*, *Entamoeba coli*, or other intestinal protozoa that do not cause amebiasis. The trophozoite is the metabolically active form (which causes symptoms), but it is not as infectious as the cyst form because it cannot survive in the environment or transit through the acidic stomach. Under some conditions, these environmentally resistant cysts form in the lower intestine and are infectious. Thus, infected persons can shed both trophozoites and cysts in stool (Utah,2010).

There are a number of other amebae capable of causing human disease, including dysentery. The term "amebiasis" should only be applied to *E. histolytica*. Other amebae that can cause dysentery-like illness include:

- Dientamoeba fragilis (causes Dientamoebiasis)
- Entamoeba hartmanni
- Entamoeba coli
- Endolimax nana
- Iodamoeba butschlii(William,2012).

The disease, known as amebiasis, amoebiasis (British spelling) or amebic dysentery, can exhibit symptoms ranging from no apparent symptoms through mild to severe dysentery with a great deal of blood and mucus
in the stool. Annually, approximately 70,000 persons die worldwide from this disease. In some persons, the disease can remain latent for many years.(William,2012).

amoebiasis is estimated to cause 70,000 deaths per year worldwide(WHO,1998). Symptoms can range from mild diarrhea to dysentery with blood and mucus in the stool. E. histolytica is usually a commensal organismSevere amoebiasis infections (known as invasive or fulminant amoebiasis) occur in two major forms. Invasion of the intestinal lining causes amoebic dysentery or amoebic colitis. If the parasite reaches the bloodstream it can spread through the body, most frequently ending up in the liver where it causes amoebic liver abscesses. Liver abscesses can occur without previous development of amoebic dysentery (Duggal P. et al.,2002).

Transmission:-

Amoebiasis is usually transmitted by the fecal-oral route, but it can also be transmitted indirectly through contact with dirty hands or objects as well as by anal-oral contact. Infection is spread through ingestion of the cyst form of the parasite, a semi-dormant and hardy structure found in feces. Any non-encysted amoebae, or trophozoites, die quickly after leaving the body but may also be present in stool: these are rarely the source of new infections. Since amoebiasis is transmitted through contaminated

water, it is often endemic in regions of the world with limited modern sanitation systems (Ryan K. J., Ray C. G.,2004).

Amebiasis has a worldwide distribution but is rare in children under the age of 5. Prevalence is higher in developing countries. In industrialized countries, risk groups include those living in institutions for the developmentally disabled, men who have sex with men, travelers and recent immigrants(Kansas,2009).

Diagnosis:

Testing for *Entamoeba histolytica* is available at large reference labs. The most common tests are microscopy (to identify cysts and trophozoites in a stool sample), serology, and histopathology in tissue samples. For best sensitivity, collect three separate stool samples. The clinician must distinguish *E. histolytica* from *E. dispar*, which is morphologically identical but does not cause disease. If a laboratory reports results as *E. histolytica*/*E. dispar*, the lab was unable to differentiate between the two species(Utah,2010).

Complications:-

In the majority of cases, amoebas remain in the gastrointestinal tract of the hosts. Severe ulceration of the gastrointestinal mucosal surfaces occurs in less than 16% of cases. In fewer cases, the parasite invades the soft tissues, most commonly the liver. Only rarely are masses formed (amoebomas) that lead to intestinal obstruction.(Mistaken for Ca caecum and appendicular mass) Other local complications include bloody diarrhea, pericolic and pericaecal abscess, Complications of hepatic amoebiasis includes subdiaphragmatic abscess, perforation of diaphgram to pericardium and pleural cavity, perforation to abdominal cavital (amoebic peritonitis) and perforation of skin (amoebic cutis Pulmonary) amoebiasis can occur from hepatic lesion by haemotagenous spread and also by perforation of pleural cavity and lung. It can cause lung abscess, pulmono pleural fistula, empyema lung and broncho pleural fistula. It can also reach brain through blood vessel and cause amoebic brain abscess and amoebic meningoencephalitis. Cutaneous amoebiasis

can also occur skin around site of colostomy wound, perianal region, region overlying visceral lesion and at the site of drainage of liver abscess, Urogenital tract amoebiasis derived from intestinal lesion can cause amoebic vulvovaginitis (May's disease), rectovesicle fistula and rectovaginal fistula, Entamoeba histolytica infection is associated with malnutrition and stunting of growth (Mondal D. et al.,2006). **Treatment**:-

The two drugs most frequently employed are oral metronidazole (Flagyl®) and tinidazole. The actual treatment regimens are dependent on the severity of the disease and the location (*i.e*. intestinal versus extra intestinal) (William, 2012).

Prevention:

To prevent future exposures, recommend that individuals:

- Always wash their hands thoroughly with soap and water before eating or preparing food, after using the toilet, and after changing diapers.
- Wash the child's hands as well as their own hands after changing a child's diapers.
- In a daycare setting, dispose of diapers in a closed-lid garbage can.
- Wash their hands thoroughly and frequently when ill with diarrhea or when caring for someone with diarrhea. Hands should be scrubbed for at least 15–20 seconds after cleaning the bathroom, after using the toilet or helping someone use the toilet, after changing diapers, before handling food, and before eating.

If uncertain about the water supply the following procedures will purify drinking water from amebic cysts:

- Boil water for at least 1 minute (up to 10 minutes depending upon altitude)
- Add iodine (12.5 ml of a saturated aqueous solution of iodine crystals per liter/quart of water
- Use a portable filter with less than 1.0 micrometer pore size;
- Chlorination may not be effective and should not be used (Utah, 2010).

To help prevent the spread of Amoebiasis around the home :

- ❖ Wash hands thoroughly with soap and hot running water for at least 10 seconds after using the toilet or changing a baby's diaper, and before handling food.
- ❖ Clean bathrooms and toilets often; pay particular attention to toilet seats and taps.
- ❖ Avoid sharing towels or face washers(Madigan et al.,2003).

2.5.3.6.5.2 Shigellosis:-

Shigellosis or bacillary dysentery is an acute bacterial disease characterized by bloody diarrhoea. *Shigella* spp. are small Gram-negative bacteria that belong to the Enterobacteriaceae family. The genus *Shigella* comprises four species: *S. dysenteriae*, *S. flexneri*, *S. boydii* and *S. sonnei*. Bacillary dysentery is the most communicable of the bacterial enteritis. Symptoms are fever nausea, vomiting, cramps and tenesmus. Mild and asymptomatic cases occur. The illness is usually self-limited and lasts 4–7 days. The incubation time is 1–7 days for all *Shigella* spp. infectious diseases (WHO, 2011).

Shigellosis, commonly known as acute bacillary dysentery, is manifested by the passage of loose stools mixed with blood and mucous and accompanied by fever, abdominal cramps and tenesmus (a symptom characterized by incomplete sense of evacuation with rectal pain)(Sur et al, 2004). Shigellosis is an infection of the digestive system caused by Shigella bacteria. The bacteria are only found in humans. Anyone can be infected but children are particularly prone. The bacteria cannot survive for long outside the human body(CDC, 2008).

Shigellosis is a bacterial infection of the colon that causes diarrhoea and can lead to death. Dysentery (frequent mucoid or bloody stools) when caused by Shigella is called Shigella dysentery. Of the estimated 164.7 million Shigella diarrhoeal episodes occurring globally every year, most occur in developing countries (99%) and mainly in children (69%) (WHO 2006). Of the 1.1 million

deaths due to Shigella, 69%are in children aged less than five years (Kotloff 1999; WHO 2006).

Transimition :-

Shigellosis infection occurs when Shigella bacteria are ingested, which most commonly occurs by person-toperson spread. People with shigellosis may have no symptoms but can still carry the infection in their faeces. They can pass the infection to others if they do not wash their hands properly after going to the toilet or changing the nappy of an infected infant. They can then contaminate objects that are touched by others or food or drink that is consumed by others(CDC, 2008). People infected with this bacterium may experience mild to severe diarrhea (which can be watery, bloody or mucousy). There may also be vomiting, a fever, nausea and cramps. It can last for 4 to 7 days. After you come in contact with this bacterium, you will usually feel symptoms in 1 to 3 days, but may range from 12 hours to one week.(Heymann DL, 2004).

Shigella dysenteriae, *S. flexneri, S. sonnei*, and *S. boydii* are the four species of small, Gram-negative, non-motile bacilli that cause shigellosis, and all but *S. sonnei* havemore than one genetically distinct subtype (serotype) (von Seidlein 2006). The species distribution varies globally; for example, *S. flexneri*was reported to bemost prevalent in India (58%,Dutta 2002) andRwanda (68%,Bogaerts1983), while *S. sonnei* was the most frequently detected species in Thailand (85%, von Seidlein 2006), Israel (48.8%, Mates 2000).

Shigellae are transmitted by the faeco-oral route, via direct personto- person contact, and via food, water, and inanimate objects. Only a small number of ingested bacteria are required to produce illness. The disease is communicable as long as an infected person excretes the organism in the stool, which can extend up to four weeks fromthe onset of illness. Secondary attack rates, the number of exposed persons developing the disease within one to four days following exposure to the primary case Park 2005). Shigellosis occurs predominantly in developing countries and is most common where

overcrowding and poor sanitation exist. It occurs in densely populated areas and institutions where populations are in close contact with each other, such as day-care centres, cruise ships, institutions for people with mental or psychological problems, and military barracks (Sur, 2004).

Complications:-

Shigellosis may be associated with a large number of mild to severe life-threatening complications , particularly due to *S.dysenteriae* type 1. Children may have high fever, rectal prolapse and convulsions. Arthritis and arthralgia are complained by some patients. Intestinal perforation, haemorrhage, toxic megacolon and protein loosing enteropathy may complicate a shigellosis case. Leukemoid reaction(WBC count > 50,000/ cmm) and haemolytic uraemic

syndrome (a triad of microangiopathic haemolytic anaemia, thrombocytopaenia and renal failure) are seen in *S.dysenteriae* type 1 infection and may be fatal (Sur, 2004).

Diagnosis:-

Diagnosis of shigellosis is made clinically by the typical features of bacillary dysentery with blood and mucus in stool although some cases may present with mild to moderate watery diarrhea initially. Dehydration is usually not a conspicuous feature. Microscopic examination of faecal smear stained with iodine shows presence of plenty of faecal leucocytes (> 10/high power field). Confirmation is made by stool culture, serological and biochemical Tests(Sur et al, 2004). Diagnosis of shigellosis can only be made by stool

culture (WHO2005a).However, Shigella species die rapidly in unfavourable environments and stool culture should ideally be supplemented by attempts to identify Shigella DNA using polymerase chain reaction (PCR) (von Seidlein 2006).

Treatment:-

- Fluid and electrolyte replacement is important to prevent dehydration. Antibiotics are used in severe cases only because the bacteria are resistant to many drugs. It is better if you don't use anti-diarrhea medicine because these drugs make it harder for your body to eliminate the bacteria(CDC, 2005).

Prevention and control:-

Since the main route of transmission of shigellosis is through water, also person-to-person contact, the prevention and control strategies essentially include provision of safe water supply and adequate sanitation facilities, maintenance of good personal hygiene and food safety. Hand washing with plenty of water and soap is the most important single effective preventive strategy against shigellosis . It is emphasized that hands should be washed before eating, before feeding children, after defecation and after disposal of children's excreta (Sur et al, 2004).

2.5.3.6.5.3 Giardiasis:-

Giardia lamblia is a flagellated protozoan that infects several species including humans and is a major agent of waterborne outbreaks of diarrhea(Sara R, Davis Hyaman, Theodore E., 2002). *Giardia lamblia* is a flagellate protozoan that infects the biliary tract and upper small intestine. It exists in trophozoite (free living stage) and cyst forms. The cyst is the infective form and is sporadically excreted in feces. *Giardia* cysts survive well in the environment, particularly in cold water. Boiling for a minimum of one minute may inactivate them(Alberta & wellness, 2011).

Giardia lamblia is a flagellated protozoan parasite that colonizes and reproduces in the small intestine, causing giardiasis. The parasite attaches to the epithelium by a ventral adhesive disc, and reproduces via binary fission (Oxford, 2003). Giardiasis does not spread via the bloodstream, nor does it spread to other parts of the gastrointestinal tract, but remains confined to the lumen of the small intestine,Giardia trophozoites absorb their nutrients from the lumen of the small intestine, and are anaerobes. If the organism is split and stained, its characteristic pattern resembles the familiar "smiley

face" symbol. Chief pathways of human infection include ingestion of untreated sewage, a phenomenon particularly common in many developing countries; contamination of natural waters also occurs in watersheds where intensive grazing occurs (Michael Hogan C, 2010) .

Giardiasis is a parasitic intestinal disease that may result in asymptomatic infection; acute, self-limited diarrhea; or chronic intermittent symptoms. The disease is spread primarily from person to person through ingestion of infective cysts. A typical case of giardiasis presents with frequent loose stools with mucous but no blood, dull epigastric pain, and flatulence. Some individuals experience chronic intermittent diarrhea, weight loss, bloating, or stomach cramps. Infection is diagnosed by direct examination of stool or stool antigen detection. There are several antiparasitic agents available to treat giardiasis. Control measures include good hand hygiene practices and avoiding drinking of untreated surface water(CDC, 2009).

Giardia lamblia is a parasitic protozoan cell that infects thousands of people all over the world, causing Gillin et al., 1996a disease known as giardiasis. The trophozoite form of this protist lacks organelles found in higher eukaryotes, such as mitochondria and peroxisomes . Even structures such as the Golgi complex are absent (or controversial) in trophozoites (Lanfredi-Rangel et al., 1999; Lujan et al., 1995; Marti and Hehl, 2003; Reiner et al., 1990). The *Giardia* cell possesses cytoskeletal structures composed of microtubules (Brugerolle, 1991; Kulda and Nohýnková, 1995). In the interphase, these include the basal bodies and axonemes of the eight flagella, microtubules accompanying the caudal axonemes—the funis—made up of sheets of microtubules following the axonemes of the caudal flagella, (Erlandsen and Feely, 1984).

Transmission:-

Direct person-to-person (fecal-oral) transmission is probably the principal mode of spread. This may occur when cysts in feces of an infected person are passed hand to mouth to an uninfected person. This is probably the most common mode of spread among children, especially in toddlers in diapers. The prevalence

of infection is highest in areas of poor sanitation and in institutions (including child care centers). Fecal-oral transmission also occurs from the ingestion of *Giardia* cysts through the consumption of fecally contaminated food or water; this accounts for many cases reported in campers and hikers who drink untreated water. Community-wide outbreaks have occurred when municipal systems have become contaminated or when filtration systems have been bypassed or broken(CDC, 2009). Giardia infection can occur through ingestion of dormant microbial cysts in contaminated water, food, or by the faecal-oral route (through poor hygiene practices). The cyst can survive for weeks to months in cold water, so can be present in contaminated wells and water systems, especially stagnant water sources, such as naturally occurring ponds, storm water storage systems, and even clean-looking mountain streams. They may also occur in city reservoirs and persist after water treatment, as the cysts are resistant to conventional water treatment methods, such as chlorination and ozonolysis (Huang DB, White AC, 2006).

People infected with *Giardia* may have mild or severe diarrhea. Symptoms may appear from 1 to 4 weeks after exposure but usually within 10 days. Fever is rarely present. In some instances, infected persons will have no symptoms at all. Sometimes, infected persons will have chronic diarrhea over several weeks or months, with significant weight loss(CDC, 2008).

Treatment :-

All treatment decisions should be made in consultation with the patient's health care provider.

- Metronidazole, tinidazole or nitromidazole are the drugs of choice. Cure rates range from 80% to 100% depending on the drug used.
- If therapy fails, a course can be repeated with the same drug. Relapse is common in immunocompromised patients who may require prolonged treatment. Treatment of asymptomatic carriers is generally not recommended because the resulting benefits and risk have not been established (CDC,2009).

Preventive Measures :-

We can decrease the chance of coming in contact with *Giardia* with these practices:

• Wash hands frequently with water and soap, and especially after using the toilet, changing a diaper or before preparing and/or eating food. (Sanitizing gel may be substituted when hands are not visibly soiled.)

• Promptly clean contaminated surfaces with household chlorine bleach-based cleaners.

• Carefully dispose of sewage wastes so as not to contaminate surface or groundwater.

• Avoid food or water from sources that may be contaminated(CDC, 2008).

- Provide public education about personal hygiene, especially the sanitary disposal of feces and careful hand washing after defecation and sexual contact, and before preparing or eating food.
- Educate food handlers about proper food and equipment handling and hygiene, especially in avoiding cross-contamination from raw meat products, and thorough hand washing.
- Advise infected individuals to avoid food preparation.
- Educate about the risk of sexual practices that permit fecal-oral contact, Educate about condom use for safer sex.
- Test private water supplies for presence of contamination, if suspected.
- Advise individuals to avoid using public swimming pools when feces cannot be contained or when experiencing diarrhea. Water contained in public swimming areas can be a vehicle for the human to human transmission of enteric pathogens.
- Educate regarding good personal hygiene, especially hand washing for staff and children in institutions and daycares.
- Educate campers, backpackers, and others to avoid drinking water directly from streams. Water should be boiled for at least one minute before it is used for drinking, food preparation, and oral hygiene (Alberta and wellness, 2011).

2.5.3.6.5.4 Typhoid:-

The disease has received various names, such as gastric fever, abdominal typhus, infantile remittant fever, slow fever, nervous fever or pythogenic fever. The name "typhoid" means "resembling typhus" and comes from the neuropsychiatric symptoms common to typhoid and typhus(oxford, 2011). Despite this similarity of their names, typhoid fever and typhus are distinct diseases and are caused by different species of bacteria(Cunha BA, 2004).Typhoid fever or enteric fever is a major health burden in developing countries. It is caused by Salmonella typhi and Salmonella paratyphi. The faeco-oral route is the commonest mode of transmission and poor sanitation and reduced access to clean drinking water increases its prevalence and incidence(Ratnayake et al. , 2011).

Typhoid (typhoid fever) is a serious disease. It is caused by bacteria called *Salmonella* Typhi.

The causative agent of typhoid fever is *Salmonella typhi*, which is an enteropathogenic organism among other *Salmonella* spp. They belong to the family Enterobacteriaceae and are Gramnegative facultatively anaerobic bacteria. Today *Salmonella* spp. are classified by DNA serotyping into different serotypes. Common human *Salmonella* serotypes are *S. typhi*, *S. paratyphi*, *S. enteritidis* and *S. typhimurium* which cause enteric fever or gastroenteritis (WHO, 2011).

Some people who are infected do not develop illness. Others may develop fever, headache, weakness, and loss of appetite. Constipation or diarrhea may occur; stomach cramps may mimic appendicitis. Some people get “rose spots” on the trunk of the body. Symptoms may be mild, but typhoid fever can be life-threatening, especially if untreated((VDH, 2009).

Typhoid causes a high fever, fatigue, weakness, stomach pains, headache, loss of appetite, and sometimes a rash. If it is not treated, it can kill up to 30% of people who get it(CDC, 2012). *S. typhi* has been isolated from water and sewage. The persistence in water supplies is moderate; the survival time of *Salmonella* spp. in drinking-water

ranges from a few days to over100 days. Resistance to chlorine is low. Faecal contamination of groundwater and surface water, and insufficient disinfection practices are the main cause of waterborne outbreaks (WHO, 2004).

Diagnosis:-

Diagnosis is made by any blood, bone marrow or stool cultures and with the Widal test (demonstration of salmonella antibodies against antigens O-somatic and H-flagellar). In epidemics and less wealthy countries, after excluding malaria, dysentery or pneumonia, a therapeutic trial time with chloramphenicol is generally undertaken while awaiting the results of The Widal test is time consuming and often, when a diagnosis is reached, it is too late to start an antibiotic regimen The term "enteric fever" is a collective term that refers to typhoid and paratyphoid(Parry CM, Beaching NJ, 2009).

Typhoid fever is a global health problem. Its real impact is difficult to estimate because the clinical picture is confused with those of many other febrile infections. Additionally, the disease is underestimated because there are no bacteriology laboratories in most areas of developing countries. These factors are believed to result in many cases going undiagnosed (WHO, 2003).

Treatment:-

The rediscovery of oral rehydration therapy in the 1960s provided a simple way to prevent many of the deaths of diarrheal diseases in general Where resistance is uncommon, the treatment of choice is a fluoroquinolone such as ciprofloxacin(Parry CM, Beaching NJ, 2009; Effa EE, et al., 2011).Otherwise, a third-generation cephalosporin such as ceftriaxone or cefotaxime is the first choice(Fraser A, et al., 2007; Wallace MR, et al.,1993; Dutta P et al., 2001). Cefixime is a suitable oral alternative(Bhutta ZA, Khan JA, Molla AM, 1994; Cao XT, 1999).

Prevention:

There are two vaccines licensed for use for the prevention of typhoid, the live, oral Ty21a vaccine (sold as Vivotif Berna) and the injectable Typhoid polysaccharide vaccine (sold as Typhim Vi by Sanofi Pasteur and Typherix by GlaxoSmithKline). Both are between 50% to 80% protective and are recommended for travellers to areas where typhoid is endemic. Boosters are recommended every five years for the oral vaccine and every two years for the injectable form. There exists an older killed whole-cell vaccine that is still used in countries where the newer preparations are not available, but this vaccine is no longer recommended for use, because it has a higher rate of side effects (mainly pain and inflammation at the site of the injection (Fraser A, et al., 2007). Spread of typhoid fever can be prevented by careful hand washing after each toilet visit and before preparing and/or eating food. Persons who live in the house or have other close contact with a person who has typhoid fever need to be tested for the disease and may not work in foodhandling until they have multiple negative tests. A vaccine is available that provides some protection for persons traveling to areas where the disease is common. However, even if they are vaccinated, persons traveling to these areas still need to be careful about what food and water are consumed (VDH, 2009).

2.5.3.6.5.5 Cholera:-

Cholera is an acute diarrheal illness that is caused by the bacterium *Vibrio cholerae*. It can be very mild, but in about one in 20 cases, it is severe. Severe cases are characterized by profuse watery diarrhea, vomiting, and leg cramps. In these cases, fl uid loss is rapid and can quickly lead to dehydration and shock. In severe cases, without treatment, cholera can be one of the most rapidly fatal infectious diseases: 50 percent of patients with severe cases die without treatment, and death can occur within hours(WHO,2009). Cholera was the first disease for which modern public health surveillance and reporting was carried out in an organized way. It is one of the three diseases currently reportable under the International Health Regulations (IHR) of

1969. According to those regulations, national health, administrations should report the first cases of cholera on their territory to WHO within24 hours of their being informed(WHO, 2000). Cholera is an acute bacterial infection of the intestine caused by ingestion of food or water containing *Vibrio cholerae*, serogroups O1 or O139. Symptoms include acute watery diarrhoea and vomiting which can result in severe dehydration or water loss. When left untreated, death can occur rapidly – sometimes within hours(WHO, 2000). Cholera is a diarrhoeal disease caused by infection of the intestine with the bacterium Vibrio cholerae, either type 01 or 0139. Both children and adults can be infected. About 20% of those who are infected develop acute, watery diarrhoea – 10–20% of these individuals develop severe watery diarrhoea with vomiting. If these patients are not promptly and adequately treated, the loss of such large amounts of fluid and salts can lead to severe dehydration and death within hours(WHO,2005). The primary symptoms of cholera are profuse, painless diarrhea and vomiting of clear fluid. These symptoms usually start suddenly, one to five days after ingestion of the bacteria. diarrhea is frequently described as "rice water" in nature and may have a fishy odor. An untreated person with cholera may produce 10 to 20 litres of diarrhea a day(Sack DA, Sack RB, Nair GB,2004).with fatal results. For every symptomatic person, 3 to 100 people get the infection but remain asymptomatic.(King AA, Ionides EL, Bouma MJ, 2008). Cholera has been nicknamed the "blue death" due to a patient's skin turning a bluish-gray hue from extreme loss of fluids (Patricia K, 2009).

Transmission:-

Cholera is typically transmitted by contaminated water. In the developed world, seafood is the usual cause, while in the developing world it is more often] water. Cholera has been found in only two other animal populations: shellfish and plankton ((Sack DA, Sack RB, Nair GB, 2004).

People infected with cholera often have diarrhea, and if this highly liquid stool, colloquially referred to as "rice-water", contaminates water used by others, disease

transmission may occur (Ryan KJ, Ray CG ,2004). The source of the contamination is typically other cholera sufferers when their untreated diarrheal discharge is allowed to get into waterways, groundwater or drinking water supplies. Drinking any infected water and eating any foods washed in the water, as well as shellfish living in the affected waterway, can cause a person to contract an infection. Cholera is rarely spread directly from person to person (Archivist, 1997).

Cholera is transmitted through contaminated food or drinking-water, as well as by person-toperson contact through the faecal-oral route. Sanitary conditions in the environment play an important role since the *V. cholerae* bacterium survives and multiplies outside the human body and can spread rapidly where living conditions are crowded and water sources unprotected and where there is no safe disposal of faeces (WHO, 2000). Anyone who ingests contaminated water can get cholera, regardless of their age or health status. Its incubation period is short—two hours to five days—and it can spread from place to place as people travel (WHO, 2008).

Diagnosis:-

A rapid dip-stick test is available to determine the presence of V. cholera , In those samples that test positive, further testing should be done to determine antibiotic resistance (Sack DA, Sack RB,2006). In epidemic situations, a clinical diagnosis may be made by taking a patient history and doing a brief examination. Treatment is usually started without or before confirmation by laboratory analysis, Stool and swab samples collected in the acute stage of the disease, before antibiotics have been administered, are the most useful specimens for laboratory diagnosis. If an epidemic of cholera is suspected, the most common causative agent is V. cholerae O1. If V. cholerae serogroup O1 is not isolated, the laboratory should test for V. cholerae O139. However, if neither of these organisms is isolated, it is necessary to send stool specimens to a reference laboratory. Infection with V. cholerae O139 should be reported and handled in the same manner as that caused by V. cholerae O1 (CDC, 2010).

Treatment:-

Cholera patient being treated by:

Fluids: In most cases, cholera can be successfully treated with oral rehydration therapy (ORT), which is highly effective, safe, and simple to administer, Rice-based solutions are preferred to glucose-based ones due to greater efficiency [5. In severe cases with significant dehydration, intravenous rehydration may be necessary. Ringer's lactate is the preferred solution, often with added potassium ((Sack DA, Sack RB, Nair GB, 2004; WHO, 2005). Large volumes and continued replacement until diarrhea has subsided may be needed , Ten percent of a person's body weight in fluid may need to be given in the first two to four hours , This method was first tried on a mass scale during the Bangladesh Liberation War, and was found to have much success(Molson, 2007). If commercially produced oral rehydration solutions are too expensive or difficult to obtain, solutions can be made. One such recipe calls for 1 litre of boiled water, 1/2 teaspoon of salt, (6 teaspoons of sugar, and added mashed banana for potassium and to improve taste.

Electrolytes:- As there frequently is initially acidosis, the potassium level may be normal, even though large losses have occurred ,As the dehydration is corrected, potassium levels may decrease rapidly, and thus need to be replaced(Sack DA, Sack RB, Nair GB, 2004).

Antibiotics:- Antibiotic treatments for one to three days shorten the course of the disease and reduce the severity of the symptoms, Use of antibiotics also reduces fluid requirements , People will recover without them, however, if sufficient hydration is maintained(Sack DA, Sack RB , 2006). Doxycycline is typically used first line, although some strains of V. cholerae have shown resistance , Testing for resistance during an outbreak can help determine appropriate future choices(Sack DA, Sack RB, Nair GB, 2004).Other antibiotics proven to be effective include cotrimoxazole, erythromycin,tetracycline, chloramphenicol, and furazolidone , .Fluoroquinolones,

such as norfloxacin, also may be used, but resistance has been reported (Krishna BV, Patil, Chandrasekhar, 2006).

Vaccination :-

A number of safe and effective oral vaccines for cholera are available , Dukoral, an orally administered, inactivated whole cell vaccine, has an overall efficacy of about 52% during the first year after being given and 62% in the second year, with minimal side effects(Sinclair D et al, 2011). It is available in over 60 countries. However, it is not currently recommended by the Centers for Disease Control and Prevention (CDC) for most people traveling from the United States to endemic countries (CDC, 2010). One injectable vaccine was found to be effective for two to three years. The protective efficacy was 28% lower in children less than 5 years old(Graves PM et al, 2010). However, as of 2010, it has limited availability, Work is under way to investigate the role of mass vaccination (WHO,2010). The World Health Organization (WHO) recommends immunization of high risk groups, such as children and people with HIV, in countries where this disease is endemic, If people are immunized broadly, herd immunity results, with a decrease in the amount of contaminant ion in the environment (Sack DA, Sack RB, 2006).

Prevention:-

Although cholera may be life-threatening, prevention of the disease is normally straightforward if proper sanitation practices are followed. In developed countries, due to nearly universal advanced water treatment and sanitation practices,. There are several points along the cholera transmission path at which its spread may be halted Sterilization: Proper disposal and treatment of infected fecal waste water produced by cholera victims and all contaminated materials (e.g. clothing, bedding, etc.) are essential. All materials that come in contact with cholera patients should be sanitized by washing in hot water, using chlorine bleach if possible. Hands that touch cholera patients or their clothing, bedding, etc., should be thoroughly cleaned and disinfected

with chlorinated water or other effective antimicrobial agents Sewage: antibacterial treatment of general sewage by chlorine, ozone, ultraviolet light or other effective treatment before it enters the waterways or underground water supplies helps prevent undiagnosed patients from inadvertently spreading the disease Sources: Warnings about possible cholera contamination should be posted around contaminated water sources with directions on how to decontaminate the water (boiling, chlorination etc.) for possible use Water purification: All water used for drinking, washing, or cooking should be sterilized by either boiling, chlorination, ozone water treatment, ultraviolet light sterilization (e.g. by solar water disinfection), or antimicrobial filtration in any area where cholera may be present(Alkinson W, et al., 2009).

2.5.3.6.5.6 Poliomyelitis:-

Poliomyelitis, often called polio or infantile paralysis, is an acute, viral, infectious disease spread from person to person, primarily via the fecal-oral route(Chen JI, 2004). The term derives from the Greek polios , meaning "grey", myelós (“marrow”), referring to the grey matter of the spinal cord, and the suffix -itis, which denotes inflammation., i.e., inflammation of the spinal cord’s grey matter, although a severe infection can extend into the brainstem and even higher structures, resulting in polioencephalitis, producing apnea that requires mechanical assistance such as an iron lung(Chamerlin SL, Narins B, 2005). Poliomyelitis, often called polio or infantile paralysis, is an infectious disease caused by a virus. This virus is a member of the enterovirus subgroup of the Picornaviridae family and has three serotypes: PV1, PV2 and PV3. Immunity to one serotype of the virus does not provide significant protection against the other serotypes (APHA, 2008; CDC, 2009). The term "poliomyelitis" is used to identify the disease caused by any of the three serotypes of poliovirus. Two basic patterns of polio infection are described: a minor illness which does not involve the central nervous system (CNS), sometimes called abortive poliomyelitis, and a major illness involving the CNS, which may be paralytic or nonparalytic(Falconer M, Bollentach E, 200). In most people with a normal immune system, a poliovirus

infection is asymptomatic. Rarely, the infection produces minor symptoms; these may include upper respiratory tract infection (sore throat and fever), gastrointestinal disturbances (nausea, vomiting, abdominal pain, constipation or, rarely, diarrhea), and influenza-like illness (Alkinson W, et al., 2009).

Transmissions:-

Poliomyelitis is highly contagious via the oral-oral (oropharyngeal source) and fecal-oral (intestinal source) routes (Kew D, et al., 2005). In endemic areas, wild polioviruses can infect virtually the entire human population., It is seasonal in temperate climates, with peak transmission occurring in summer and autumn. These seasonal differences are far less pronounced in tropical areas (Parker SP, 1998). The time between first exposure and first symptoms, known as the incubation period, is usually six to 20 days, with a maximum range of three to 35 days, Virus particles are excreted in the feces for several weeks following initial infection (Racaniello V, 2006). The disease is transmitted primarily via the fecal-oral route, by ingesting contaminated food or water. It is occasionally transmitted via the oral-oral route, a mode especially visible in areas with good sanitation and hygiene , Polio is most infectious between seven and 10 days before and after the appearance of symptoms, but transmission is possible as long as the virus remains in the saliva or feces (Ohri , Linda K, Jonathan G, 1999). Polio virus transmission is by faecal–oral or occasionally oral–oral routes. Once the virus enters the body through the mouth it multiplies in the oropharynx and the small intestine. In the gastrointestinal tract, the virus invades the local lymphoid tissues and, in a minority of cases, then enters the bloodstream and spreads to the central nervous system. The virus may also spread to the central nervous system along the peripheral nerves. The incubation period for polio infection is usually between 7 and 14 days but may range from 2 to 35 days. By 3–5 days after exposure, the virus can be isolated in the blood, throat and faeces. The virus continues to be excreted in the stools for several weeks after infection(APHA, 2008; CDC,2009).

Diagnosis:-

A laboratory diagnosis is usually made based on recovery of poliovirus from a stool sample or a swab of the pharynx. Antibodies to poliovirus can be diagnostic, and are generally detected in the blood of infected patients early in the course of infection , Analysis of the patient's cerebrospinal fluid (CSF), which is collected by a lumbar puncture ("spinal tap"), reveals an increased number of white blood cells (primarily lymphocytes) and a mildly elevated protein level. Detection of virus in the CSF is diagnostic of paralytic polio, but rarely occurs (Alkinson W, et al., 2009).

If poliovirus is isolated from a patient experiencing acute flaccid paralysis, it is further tested through oligonucleotide mapping (genetic fingerprinting), or more recently by PCR amplification, to determine whether it is "wild type" (that is, the virus encountered in nature) or "vaccine type" (derived from a strain of poliovirus used to produce polio vaccine (Chezzi C, 1996). It is important to determine the source of the virus because for each reported case of paralytic polio caused by wild poliovirus, an estimated 200 to 3,000 other contagious asymptomatic carriers exist (Gawande A, 2004).

Treatment:-

There is no cure for polio. The focus of modern treatment has been on providing relief of symptoms, speeding recovery and preventing complications. Supportive measures include antibiotics to prevent infections in weakened muscles, analgesics for pain, moderate exercise and a nutritious diet(Donile, Thomas M, Robbins, Frederic C, 1997). Treatment of polio often requires long-term rehabilitation, including occupational therapy, physical therapy, braces, corrective shoes and, in some cases, orthopedic surgery(Hagerston MD, 2005).

Prevention:-

Two types of vaccine are used throughout the world to combat polio. Both types induce immunity to polio, efficiently blocking person-to-person transmission of wild

poliovirus, thereby protecting both individual vaccine recipients and the wider community (so-called herd immunity (Fine P, Carneiro I, 1999).

The first candidate polio vaccine, based on one serotype of a live but attenuated (weakened) virus, was developed by the virologist Hilary Koprowski. Koprowski's prototype vaccine was given to an eight-year-old boy on February 27, 1950 (Koprowski, Hillary, 2010). Koprowski continued to work on the vaccine throughout the 1950s, leading to large-scale trials in the then Belgian Congo and the vaccination of seven million children in Poland against serotypes PV1 and PV3 between 1958 and 1960. The second inactivated virus vaccine was developed in 1952 by Jonas Salk at the University of Pittsburgh, and announced to the world on April 12, 1955 (Spice B, 2005). The Salk vaccine, or inactivated poliovirus vaccine (IPV), is based on poliovirus grown in a type of monkey kidney tissue culture (vero cell line), which is chemically inactivated with formalin (Kew D, et al., 2005). After two doses of IPV (given by injection), 90% or more of individuals develop protective antibody to all three serotypes of poliovirus, and at least 99% are immune to poliovirus following three doses(Alkinson W, et al., 2009)..

IPV is highly effective in producing immunity to polio virus and protection from paralytic poliomyelitis. After 2 doses of the vaccine, over 90% of recipients develop protective antibodies to all three types of the polio virus. After 3 doses, at least 99% of the recipients will have protection against the disease. Protection against paralytic disease correlates with the presence of antibodies against the polio virus(NCIRS, 2009). Because OPV is inexpensive, easy to administer, and produces excellent immunity in the intestine (which helps prevent infection with wild virus in areas where it is endemic), it has been the vaccine of choice for controlling poliomyelitis in many countries. On very rare occasions (about one case per 750,000 vaccine recipients), the attenuated virus in OPV reverts into a form that can paralyze. Most industrialized countries have switched to IPV, which cannot revert, either as the sole vaccine against poliomyelitis or in combination with oral polio vaccine (WHO, 2008).

2.5.3.6.5.7 Hepatitis A

Hepatitis A, is one of the oldest diseases known to humankind, is a self-limited disease which results in fulminate hepatitis and death in only a small proportion of patients. However, it is a significant cause of morbidity and socio-economic losses in many parts of the world (WHO, 2000). Hepatitis" means inflammation of the liver. The liver is a vital organ that processes nutrients, filters the blood, and fights infections. When the liver is inflamed or damaged, its function can be affected, Hepatitis A is a contagious liver disease that results from infection with the Hepatitis A virus. It can range in severity from a mild illness lasting a few weeks to a severe illness lasting several months(CDC, 2012). In developing countries, and in regions with poor hygiene standards, the incidence of infection with this virus is high(Steffen, 2005). And the illness is usually contracted in early childhood. As incomes rise and access to clean water increases, the incidence of HAV decreases, Hepatitis A infection causes no clinical signs and symptoms in over 90% of infected children and since the infection confers lifelong immunity, the disease is of no special significance to those infected early in life (Jacobsen , Koopmans , 2005).

Hepatitis A is caused by infection with the hepatitis A virus (HAV), a nonenveloped RNA agent that is classified as a picornavirus.1 HAV replicates in the liver and is shed in the feces. Peak concentrations in stool occur during the 2 weeks before onset of illness. Virus is also present in serum, although in concentrations several orders of magnitude less than in feces. The most common mode of HAV transmission is fecal-oral, with the virus transmitted from person to person between household contacts, between sex partners, or by contaminated food or water. Because virus is present in serum during acute infection, bloodborne HAV transmission can occur, but it has been reported infrequently (*Lyn Finelli, Beth, Bell, 2008).*

Hepatitis A (formerly known as infectious hepatitis) is an acute infectious disease of the liver caused by the hepatitis A virus (HAV) (Rayan KJ, Ray CG, 2004). an RNA virus, usually spread by the fecal-oral route; transmitted person-to-person by ingestion

of contaminated food or water or through direct contact with an infectious person. Tens of millions of individuals worldwide are estimated to become infected with HAV each year (Wasley A, Fiore A, Bell, BP, 2006). The time between infection and the appearance of the symptoms (the incubation period) is between two and six weeks and the average incubation period is 28 days (Connor , 2005).

The incubation period of hepatitis A is 15–50 days, with an average of 28 days. The illness caused by HAV infection typically has an abrupt onset of signs and symptoms that include fever, malaise, anorexia, nausea, and abdominal discomfort, followed several days later by dark urine and jaundice. Hepatitis A usually does not last longer than 2 months, although some persons may have prolonged or relapsing signs and symptoms for up to 6 months. The likelihood of having symptoms with HAV infection is directly related to age. Among children younger than 6 years of age, most infections are asymptomatic; among older children and adults, infection is usually symptomatic. HAV infection occasionally produces fulminant hepatitis A. The case-fatality rate among persons of all ages with reported cases is approximately 0.3%, but it tends to be higher among older persons (approximately 2% among persons over 40 years of age (*Lyn Finelli, Beth , Bell , 2008*).

The best way to prevent Hepatitis A is by getting vaccinated. Experts recommend the vaccine for all children, some international travelers, and people with certain risk factors and medical conditions. The Hepatitis A vaccine is safe and effective and given as 2 shots, 6 months apart. Both shots are needed for long-term protection, Frequent handwashing with soap and water—particularly after using the bathroom, changing a diaper, or before preparing or eating food—also helps prevent the spread of Hepatitis A (CDC, 2012).

Transmission:-

The transmission of HAV by drinking-water supplies is well established, and the presence of HAV in drinking-water constitutes a substantial health risk. Within a water safety plan, control measures to reduce potential risk from HAV should focus on

prevention of source water contamination by human waste, followed by adequate treatment and disinfection. The effectiveness of treatment processes used to remove HAV will require validation. Drinking-water supplies should also be protected from contamination during distribution. Owing to the higher resistance of the viruses to disinfection, *E. coli* (or, alternatively, thermotolerant coliforms) is not a reliable indicator of the presence/absence of HAV in drinking-water supplies(WHO, 2011).

HAV is generally acquired by the faecal-oral route by either person-to-person contact or ingestion of contaminated food or water. Hepatitis A is an enteric infection spread by contaminated excreta; High concentrations of virus are shed in the stools of patients during 3 to 10 days prior to the onset of illness till one - two weeks after the onset of jaundice. Faecal excretion of HAV persists longer in children and in immunocompromised persons (up to 4 - 5 months after infection) than in otherwise healthy adults. Communicability is highest during this interval , Hepatitis A may be acquired from faecally contaminated food or water and from wastewater-contaminated drills or water supplies(WHO, 2000). The virus spreads by the fecal-oral route and infections often occur in conditions of poor sanitation and overcrowding. Hepatitis A can be transmitted by the parenteral route but very rarely by blood and blood products. Food-borne outbreaks are not uncommon (Brundage, Fitzpatrick , 2006). and ingestion of shellfish cultivated in polluted water is associated with a high risk of infection (Lees D, 2000). Approximately 40% of all acute viral hepatitis is caused by HAV. Infected individuals are infectious prior to onset of symptoms, roughly 10 days following infection. The virus is resistant to detergent, acid (pH 1), solvents (e.g., ether, chloroform), drying, and temperatures up to 60 °C. It can survive for months in fresh and salt water. Common-source (e.g., water, restaurant) outbreaks are typical. Infection is common in children in developing countries, reaching 100% incidence, but following infection there is lifelong immunity. HAV can be inactivated by: chlorine treatment (drinking water), formalin (0.35%, 37 °C, 72 hours), per acetic acid

(2%, 4 hours), beta-propiolactone (0.25%, 1 hour), and UV radiation (2 μW/cm2/min)(Murry , Ronsenthal , Pfaller , 2005).

Diagnosis:-

Although HAV is excreted in the feces towards the end of the incubation period, specific diagnosis is made by the detection of HAV-specific IgM antibodies in the blood, IgM antibody is only present in the blood following an acute hepatitis A infection. It is detectable from one to two weeks after the initial infection and persists for up to 14 weeks. The presence of IgG antibody in the blood means that the acute stage of the illness is past and the person is immune to further infection. IgG antibody to HAV is also found in the blood following vaccination and tests for immunity to the virus are based on the detection of this antibody (Stapleton , 1995).

During the acute stage of the infection, the liver enzyme alanine transferase (ALT) is present in the blood at levels much higher than is normal. The enzyme comes from the liver cells that have been damaged by the virus, Hepatitis A virus is present in the blood (viremia) and feces of infected people up to two weeks before clinical illness develops (Musana , Yale , Abdulkarim , 2004).

Prevention:-

Hepatitis A can be prevented by vaccination, good hygiene and sanitation (Rayan KJ, Ray CG, 2004). There are two types of vaccines: one containing inactivated hepatitis A virus, and another containing a live but attenuated virus (Irvin GI, et al,2012). Both provide active immunity against a future infection. The vaccine protects against HAV in more than 95% of cases for longer than 25 years (Nothdurft, 2008). In the USA the vaccine was first phased in 1996 for children in high-risk areas, and in 1999 it was spread to areas with elevating levels of infection., The vaccine is given by injection. An initial dose provides protection starting two to four weeks after vaccination; the second booster dose, given six to twelve months later, provides protection for over twenty years (CDC, 2007). The vaccine was introduced in 1992 and was initially

recommended for persons at high risk. Since then Bahrain and Israel have embarked on eradication programmes (Andre, 2006).

2.5.3.6.5.8 Hepatitis E:-

Hepatitis E was not recognized as a distinct human disease until 1980, when specific tests for antibody against hepatitis A were first applied to the study of epidemic waterborne hepatitis in India. The results showed that the epidemics were not epidemics of hepatitis A. Actually, very few epidemics of waterborne disease in developing countries of Asia and Africa have been linked to hepatitis A, Hepatitis E is a waterborne disease, and contaminated water or food supplies have been implicated in major outbreaks(WHO, 2001). Hepatitis E virus causes acute sporadic and epidemic viral hepatitis. Symptomatic HEV infection is most common in young adults aged 15-40 years and is uncommon in children. Although HEV infection is frequent in children, it is mostly asymptomatic and anicteric (WHO.2001). Hepatitis E is a viral hepatitis (liver inflammation) caused by infection with a virus called hepatitis E virus (HEV). HEV is a positive-sense single-stranded RNA icosahedral virus with a 7.5 kilobase genome. HEV has a fecal-oral transmission route. It is one of five known hepatitis viruses: A, B, C, D, and E. Infection with this virus was first documented in 1955 during an outbreak in New Delhi, India (Gupta DN, Semetana HF, 1957).

Hepatitis E occurs in two forms with different clinical and epidemiologic features. The epidemic is associated with waterborne spread, severe acute disease, and infection with genotypes 1 and 2. The endemic, or autochthonous form, occurs in developed countries and is associated with food borne and zoonotic spread (Jay H. Hoofnagle, et al., 2012). Hepatitis E occasionally develops into an acute, severe liver disease, and is fatal in about 2% of all cases. Clinically, it is comparable to hepatitis A, but in pregnant women the disease is more often severe and is associated with a clinical syndrome called fulminant hepatic failure. Pregnant women, especially those in the third trimester, suffer an elevated mortality rate from the disease of around 20 %(WHO, 2012).

Transmission:-

Hepatitis E is prevalent in most developing countries, and common in any country with a hot climate. It is widespread in Southeast Asia, northern and central Africa, India, and Central America. It is spread mainly through fecal contamination of water supplies or food; person-to-person transmission is uncommon (WHO, n. d). HEV is excreted in faeces of infected people, and the virus has been detected in raw and treated sewage. Contaminated water has been associated with very large outbreaks. HEV is distinctive, in that it is the only enteric virus with a meaningful animal reservoir, including domestic animals, particularly pigs, as well as cattle, goats and even rodents, The role of contaminated water as a source of HEV has been confirmed, and the presence of the virus in drinking-water constitutes a major health risk. There is no laboratory information on the resistance of the virus to disinfection processes, but data on waterborne outbreaks suggest that HEV may be as resistant as other enteric viruses. Within a water safety plan, control measures to reduce potential risk from HEV should focus on prevention of source water contamination by human and animal waste, followed by adequate treatment and disinfection. The effectiveness of treatment processes used to remove HEV will require validation. Drinking-water supplies should also be protected from contamination during distribution (WHO, 2011).

Diagnosis

Since cases of hepatitis E are not clinically distinguishable from other types of acute viral hepatitis, diagnosis is made by biochemical assessment of liver function (laboratory evaluation of: urine bilirubin and urobilinogen, total and direct serum bilirubin, ALT and AST, alkaline phosphatase, prothrombin time, total protein, albumin, IgG, IgA, IgM, complete blood count). Acute hepatitis E is diagnosed when the presence of IgM anti-HEV is detected (Purcell RH, 1996; Ticehurst JR, 1999).

Storage of serum samples is acceptable for several days at 4°C, although anti-HEV will be preserved at 20°C, and a temperature of 70°C should be preferred when viremia is suspected, Hepatitis E should be suspected in outbreaks of waterborne

hepatitis occurring in developing countries, especially if the disease is more severe in pregnant women, or if hepatitis A has been excluded. If laboratory tests are not available, epidemiologic evidence can help in establishing a diagnosis, HEV RNA can be detected in acute phase faeces by PCR in approximately 50% of cases. Immune electron microscopy is positive in only about 10% of cases(Purcell RH, 1996). The viral proteins pORF2 and pORF3 have been expressed in various recombinant systems and form the basis for diagnostic tests and vaccine studies. To confirm the results of EIA or ELISA tests, Western blot assays to detect IgM and IgG anti-HEV in serum can be used, along with polymerase chain reaction PCR) tests for the detection of HEV RNA in serum and stool, (immunofluorescent antibody blocking assays to detect antibody to HEV antigen in serum and liver, and immune electron microscopy to visualize viral particles in faeces(Tsarev SA, 1993; Stapleton JT, 1994 ; Purcell RH, 1996; Mast EE, et al. 1998 ; Ticehurst JR, 1999).

Prevention:-

Improving sanitation is the most important measure, which consists of proper treatment and disposal of human waste, higher standards for public water supplies, improved personal hygiene procedures and sanitary food preparation. Thus, prevention strategies of this disease are similar to those of many others that plague developing nations, and they require large-scale international financing of water supply and water treatment projects. A vaccine based on recombinant viral proteins has been developed and recently tested in a high-risk population (military personnel of a developing country (Sherstha MP, et al. ,2007). The vaccine appeared to be effective and safe, but development stopped for economical reasons, since hepatitis E is rare in developed countries (Park SB, 2012).

A different vaccine (HEV 239, sold as Hecolin by its developer Xiamen Innovax Biotech) was approved for the disease in 2012 by the Chinese Ministry of Science and Technology, following a phase 3 trial on two groups of 50,000 people each from Jiangsu Province where none of the vaccinated became infected during a 12 month

period, compared to 15 in the group given placebo treatment (Allion Proffitt, 2012). The first vaccine batches came out of Innovax' factory in late October 2012, and will be sold to Chinese distributors (Park SB, 2012).

2.5.3.6.5.9 Helminthes:-

Helminths, more commonly known as worms or flukes, require a host body to survive and are generally passed in human and animal feces. Both helminths and protozoa are considered to be parasites. They spend part of their life in hosts that live in water before being transmitted to humans. Many types of worms can live for several years and weaken their host by using up their food (CAWST, 2009).

Common types of helminths that cause illness in developing countries include round worms, pin worms, hook worms and guinea worms. The WHO estimates that 133 million people suffer from intestinal worms each year. These infections can lead to severe consequences such as cognitive impairment, severe dysentery or anaemia, and cause approximately 9,400 deaths every year (WHO, 2002).

Many problems caused by these worms are chronic and long lasting (malnutrition, underweight, bowel obstruction, anaemia, retardation of mental and physical development), but can also lead to severe infections and death. Helminthic infections are common in vast regions of the world, especially in the developing countries, and they affect more than 1.5 billion people. In addition, millions of individuals in these countries also have other chronic infectious diseases such as malaria, tuberculosis and HIV. The constant and lifelong confrontation of these hosts with such infectious burden lead to a persistent activation of the immune system and unbalanced immune state (Laurent, 2005). The major helminth infections of humans are caused by nematodes (roundworm), trematodes(flukes) and cestodes (tapeworms). The transmission route is through the ingestion of eggs and contact with faecally contaminated soil and food , A problem is the use of inadequately treated wastewater in irrigation and faecal sludge in soil fertilization. This practice is often associated with an elevated prevalence of intestinal helminth infections and diarrhoeal diseases in

workers, farmers and consumers (WHO, 2011). In patients with a heavy worm load, infection is frequently symptomatic. Conditions associated with intestinal helminth infection include intestinal obstruction, insomnia, vomiting, weakness, and stomach pains(John David T. et al., 2006). and the natural movement of worms and their attachment to the intestine may be generally uncomfortable for their hosts(Walkins WE. And Pollitt E, 1997) . The migration of Ascaris larvae through the respiratory passageways can also lead to temporary asthma and other respiratory symptoms (John David T. et al., 2006). Also, the immune response triggered by helminth infection may drain the body's ability to fight other diseases, making affected individuals more prone to coinfection(Walkins WE. And Pollitt E, 1997). Reasonable evidence indicates helminthiasis is responsible for the unrelenting prevalence of AIDS and tuberculosis in developing countries, particularly African, countries(Borkow G. and Bentwich Z., 2000). A review of several data clearly revealed the effective treatment of helminth infection reduces HIV progression and viral load, obviously by improving helminth-induced immune suppression(Walson Jl. Et al., 2009). Worms may also contribute to malnutrition by creating anorexia (World bank, 1993). Although the exact cause of such anorexia is not known, researchers believe it may be a side effect of body's immune response to the worm and the stress of combating infection (Walkins WE. And Pollitt E, 1997). The nature of the intestinal helminths and the medications available to treat them also favor universal deworming programs. Infection is generally diffuse, so it is worth treating a wide sample of the population; furthermore, a drug such as albendazole is a cheap, safe intervention that is not particularly specific, so can be used fairly effectively against all three of the main intestinal helminthes (or any co infection of them) (World bank, 1993). Finally, because these worms cannot replicate inside their hosts, reducing transmission may be the best way to reduce prevalence,(Dell Rosso, Joy Miller and Tonia Market, 1996) .

3.5.3.6.5.10 Risk of disease from waterborne pathogens:-

Drinking water is only one of several means by which many infectious agents can be transmitted. It can, however, be of considerable importance, and many pathogens that are excreted in faeces have caused epidemics through contaminated water. The significance of a particular organism in water can vary considerably; for example, a potentially pathogenic organism will not always cause symptomatic disease in a particular individual. The chances of waterborne infections occurring in a community depend on:

- The concentration of pathogenic organisms in the water
- The virulence of the strain
- The per capita intake of contaminated water
- The infectious dose of the particular pathogen
- The susceptibility of individuals
- The incidence of the infection in the community (which will determine the numbers of pathogens being excreted) (WHO, 2011).

2.6 Water pollution

Pure uncontaminated water does not occur in nature. It contains impurities of various kinds natural and manmade. The natural impurities are not essentially dangerous. These comprise dissolved gases (e.g. nitrogen, carbon dioxide, hydrogen sulfate, and etc, which may be picked up during rain fall), and dissolved mineral (salts of calcium. Magnesium sodium, etc), which are natural constituents of water following its contact with soil and microscopic organisms. These impurities are derived from the atmosphere, catchment area and soil. Amore serious aspect of water pollution is that caused by human activities (Park, 2005). Water may be contaminated by microorganisms (bacteria, viruses, helminthes, and parasites) usually of fecal origin. The following is the list of the same of the water contaminates that have the greatest impact on public health: Rota viruses, Escherichia coli, vibrio cholera, shigella,

Entameaba histolytic, Guardia lamblia, etc. The present of fecal coli form (E. coli is used as indicator of fecal contamination) (Perrin, 2001). The most common and wide-spread danger associated with drinking water is contamination either directly or indirectly by sewage, waste, or by human or animal excrement. If such contamination is recent and if among the contributors there are carrier of communicable enteric diseases, some of the living causal agents may present (WHO, 1984). The sources of drinking water pollution are:

*Sewage which contains decomposable organic matter and pathogenic agents.

*Industrial and trade waste, which contains toxic agents ranging from metal salts to complex synthetic organic chemicals.

*Agricultural pollutants which comprise fertilizers and pesticides.

*Physical pollutant such as thermal pollution and radioactive substances (Park, 2005). Discharge into waters of solid, liquid or gaseous non toxic materials including organisms and different types of energy that directly or indirectly cause the turbidity or other changes to the quality of the water (Rank & Klemmensen, 2003). Using of contaminated water for drinking or in food preparation may then result in new cases of infections (WHO, 1997). Failure to insure drinking water safety may expose the community to the risk of the out breaks of intestinal and other infectious disease (WHO, 2006). In most countries the principal risks to human health associated with the consumption of polluted water are microbiological in nature. An estimated 80 % of all diseases and over one third of deaths in developing countries are caused by consumption of contaminated water (Howard, 2002). The health risks which may result from pollution of potable water supplies are communicable diseases, such as typhoid, summer diarrhea, hepatitis A, and amoebic dysentery. Non communicable diseases may be also result from pollution of potable water supplies, including carcinogenic effects caused by long-term exposure to chemicals and hormones (WHO, 2005).

2.7 Sampling

Samples must be taken from locations that are representive of the water source, treatment plant, storage facilities, distribution net work, point of water delivery to consumer, and points of use. Sampling sites in piped distribution system may be classified as:

*Fixed agreed with the supply agency, this are essential when legal action is to be used as means of insuring importance.

*Fixed but not agreed with the supply agency that are not necessarily recognized by the supply agency are used frequently in investigations including surveillance.

*Random or variable, 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). Apart from a separation into compartments (water, sediment and biota) different types of samples can be collected:

(1) Grab sample (also called spot - or catch samples)

One sample is taken at a given location and time. In case of a flowing river, they are usually taken from the middle of the flowing water (main) stream and in the middle of the water column. When a source is known to vary with time, spot samples collected at suitable time intervals and analyzed separately, can document the extent, frequency and duration of these variations. Sampling intervals are to be chosen on the basis of the expected frequency with which changes occur. This may vary from continuous recording, Or sampling every 5 minutes, to several hours or more.

2) composite samples

In most cases, these samples refer to a mixture of spot samples collected at the same sampling site at different times. This method of collection reduces the analytical effort, because variations are middled out in one analysis. It is a useful technique when daily variations occur and seasonal variations are the objective of the programme. If,

however, the series of spot samples are not mixed but analyzed individually, also information on The daily variability can be obtained, and afterwards the average can be computed. Sometimes the indication 'time-composite' is used to distinguish from 'locationcomposite' sampling. Time-composite sampling representing a 24-hour period is often used. For many determinations, the time interval between sampling events being 1-3 hours. To evaluate the nature of special discharges (e.g. variable in volume or irregular in time), samples should be collected at time intervals representing the period during which such discharges occur. Especially in effluents, one may sample a volume that is proportional to the discharge (flow based composite). This type of sampling is also required to measure the flux of pollution load discharged through a point source. Biota that is only active during certain periods of the day (e.g. activity during the night) can only be sampled accordingly. For parameters that will change after collection, and that can not be preserved, in-situ determinations should be applied if possible. If preservatives are to be added, add them to each sample and not in the end to the composite sample.

3) Integrated samples

Sometimes samples are collected at the same location but, due to horizontal or vertical variation in the composition of the river (or in water flow) or lake, they come from different points in the cross-section that are regarded with a different relative importance, To evaluate the average composition, total load or mass balance, integrated samples are collected, often in proportion to the river flow of the areas of sample collection(CPCB, 2007; 2008).

2.7.1 General Guidelines for Sampling

• Rinse the sample container three times with the sample before it is filled.

• Leave a small air space in the bottle to allow mixing of sample at the time of analysis.

• Label the sample container properly, preferably by attaching an appropriately inscribed tag or label. The sample code and the sampling date should be clearly marked on the sample container or the tag.

• Complete the sample identification form for each sample.

• The sample identification form should be filled for each sampling occasion at a monitoring station. Note that if more than one bottle is filled at a site, this is to be registered on the same form.

• Sample identification forms should all be kept in a master file at the laboratory where the sample is analysed.

2.7.2 Surface water Sampling

• Samples will be collected from well-mixed section of the river (main stream) 30 cm below the water surface using a weighted bottle or DO sampler.

• Samples from reservoir sites will be collected from the outgoing canal, power channel or water intake structure, in case water is pumped. When there is no discharge in the canal, sample will be collected from the upstream side of the regulator structure, directly from the reservoir.

• DO is determined in a sample collected in a DO bottle using a DO sampler. The DO in the sample must be fixed immediately after collection, using chemical reagents.

DO concentration can then be determined either in the field or later, in a level I or level II laboratory.

2.7.3 Groundwater Sampling

• Samples for groundwater quality monitoring would be collected from one of the following three types of wells:

• *Open dug wells* in use for domestic or irrigation water supply,

• *Tube wells* fitted with a hand pump or a power-driven pump for domestic water supply or irrigation

• *Piezometers*, purpose-built for recording of water level and water quality monitoring.

• Open dug wells, which are not in use or have been abandoned, will not be considered as water quality monitoring station. However, such wells could be considered for water level monitoring.

• Use a weighted sample bottle to collect sample from an open well about 30 cm below the surface of the water. Do not use a plastic bucket, which is likely to skim the surface layer only.

• Samples from the production tube wells will be collected after running the well for about 5 minutes.

• Non-production piezometers should be purged using a submersible pump. The purged water volume should equal 4 to 5 times the standing water volume, before sample is collected.

• For bacteriological samples, when collected from tubewells/hand pump, the spout/outlet of the pump should be sterilised under flame by spirit lamp before collection of sample in container (CPCB, 2007; 2008) .

2.7.4 Sampling for bacteriological examinations

Sampling for bacteriological examination should be collected in clean sterilized bottles made of neutral glass of capacity 200-250ml and provided with aground glass stopper having an over lapping rim. If water to be sampled contain or likely to contain chlorine a small quantity of sodium thiosulphate (0.iml of 3 per cent solution or small crystal of salt) should be added to bottles before sterilization. Sterile sampling bottles should be obtained from the laboratory which is to carry out the analysis (APHA, AWWA & WEF, 1998). Samples collected for bacteriological examinations should be commended as soon as possible within 6 hours after collection where feasible samples must be kept in ice book and analysis within 48 hours after collection, samples not preserved in this manner should not be acceptable for bacteriological examination. Certain particulars regarding, the sample should be taken in account like the date and time of collection and dispatch source of water, specially of recent rain fall and findings of the sanitary survey should supplied with samples (Park, 2005).

2.8 Drinking water treatment

Surface water may contain pathogenic organisms, suspended or organic substances. Appropriate treatment may be necessary to render the water supply bacteriological safe, physical and chemical acceptable. Modern technology provides a choice of treatment methods to produce water of a desired quality from any given source (WHO, 2002). The purpose of water treatment is to produce water that is safe and wholesome. The method of treatment to be employed depends upon the nature of raw water and the desired standards of water quality. Ground water (wells and springs) may need no treatment other disinfection, surface water (rivers, stream and lakes) which tends to be turbid and polluted required extensive treatment (Park, 2005). Water can be treated at various stages between the source and the end users, a limited number of technologies can be applied at source but most are used after water has been abstracted (IWSC, 2006). The concept of multiple barriers for water treatment is the cornerstone of safe drinking water production, traditionally the barriers have included:

- Protection of source water (screening and straining).
- Storage.
- Filtration.
- Disinfection.
- Protection of the distribution system (UNHCR, 1992; WHO, 2004).

2.8.1 Protection of source water

Protection of water sources can minimize the need for complex, costly or time and energy consuming treatments (IWSC, 2006). Protection of source water can help to minimize microbial risk associated with the water entering a drinking water treatment plant. Possible control measures to protect source water include land acquisition, water shed-inspection programmed. Water used

for drinking should be originating from the highest quality source possible (WHO, 2004).

2.8.2 Storage

Storage provides a reserve of water from which further pollution is excluded. As a result of storage a vary considerable amount of purification takes place, this natural purification consist of three types:

2.8.2.1 Physical

By mere storage the quality of water improves, about 90 % of the suspended impurities settled down in 24 hours by gravity and the water becomes clear.

2.8.2.2 Chemical

Certain chemical changes also take place during storage. The aerobic bacteria oxidized the organic matter present in the water with aid of dissolved oxygen. As a result the content of free ammonia is reduced and a rise in nitrate occurs.

3.8.2.3 Biological

A Tremendous drop takes place in bacterial count during storage. It is found that when river water is in storage the total bacteria count drops 90 % in the 5-7 days. This is one of the greatest benefits of storage. The optimum period of storage of river water to be about 10-14 days, if the water is stored for long period, then is likelihood of development of vegetable growth such as algae which impart a bad smell and color to water (Park, 2005)

2.8.3 Filtration

Filtration is the second stage in the water purification, and a quite an important stage because 98-99 % of the bacteria are removed by filtration. Two types of filters are in use, the slow sand filters (biological filters) and the rapid sand filters (mechanical filters)(Park, 2005).

2.8.3.1 Slow sand filter (SSF)

Slow sand filters were first used for water treatment in 1804 in Scotland and subsequently in London. During the 19th century, their used spread throughout the world. Even today they are generally accepted as the standard method of water purification. Slow sand filter essentially consist of supernatant (raw water), a bed of gravel sand, an under-drainage system and system of filter control valves (Park, 2005). Slow sand filtration involves passing water through a sand filter by gravity at a very low filtration rate without use of coagulation pretreatment (WHO, 2004). As water passes through the filter, microbes and other substances are removed, the removal mechanisms are believed to be combination of biological and physical mechanisms (Weber-shirk &Dick, 1997).

2.8.3.2 Rapid sand filters

In 1885 the first rapid sand filters were installed in USA, since that time they have gained considerable popularity especially in highly industrialized countries. Rapid sand filters are of two types: the gravity type (e.g. Paterson's filters) and the pressure type (e.g. candy's filters). Both the types are in use and they consist of coagulation, rapid mixing, flocculation, sedimentation, and filtration (Park, 2005).

2.8.3.2.1 Coagulation

The water is first treated with a chemical coagulant such as alum, the dose of which varies from 5-40ml or more per liters depending upon the turbidity, color, temperature, and the PH value of water (Park, 2005). Coagulation promotes the interaction of small particles to form larger particles, in practice the term refers to coagulant addition that will form the hydrolysis products that cause coagulation (WHO, 2004).

2.8.3.2.2 Rapid mixing

The treated water is then subjected to violent agitation in mixing chamber for a few minutes. This allows a quick and through dissemination of alum throughout the bulk of water which is very necessary (Park, 2005).

2.8.3.2.3 Flocculation

The next phase involves a slow and gentle stirring of the treated water in flocculation chamber of about 30 minutes. This slow and gentle stirring results in the formation of a thick. The thicker precipitate or flock diameter the greater the settling velocity (Park, 2005). The contact time between the raw water and the coagulant as well as the formation of flock precursors are small in along flexible hosepipe under pressure (Peter, Delphine, & Noortigate, 2003). Flocculation is the physical process of producing inters particle contacts that lead to the formation of large particles (WHO, 2004).

2.8.3.2.4 Sedimentation

The coagulated water is led into sedimentation tanks where is detained for period varying from 2-4 hours when the flocculent precipitate together with impurities and bacteria settle down in the tanks. For proper operation the tanks should be cleaned regularly from time to time to remove precipitate which settles at the bottom for avoid a breeding ground of molluses and sponges (Park,

2005). Sedimentation is a solid- liquid separation process in which particles settle under the force of gravity (WHO, 2004). The efficiency of sedimentation process may be improved by using inclined plate or tube for conventional treatment process, chemical coagulation is critical for effective removal of microbial pathogen, in the absence of chemical coagulant removal of microbes is low because sedimentation velocities are low (Medema et al. , 1998).

2.8.3.2.5 Filtration

The clarified water is subjected to rapid sand filtration; filtration removes microbial pathogens mainly by size exultation that is microbes larger than the membrane pores are removed. Chemical coagulation is not usually needed before membrane treatment for removal of microbes (WHO, 2004).

The membrane filtration process most commonly used to remove microbes from drinking water are microfiltration (MF), ultra filtration (UF), nano filtration (NF),and reverse osmosis(RO) (AWWA, 1996; Taylor & Wiesner, 1999).

2.8.4 Disinfection

Dirty and polluted water can contain many harmful organisms. The disease causing organisms (pathogens) include bacteria, bacteria spores, viruses, protozoa, and helminthes. These can cause diseases like cholera, bacillary dysentery, typhoid, infectious hepatitis and diarrhea. Disinfection of water aims to kill these pathogens without leaving harmful chemical substances in the water (Oxfam, 2001). Disinfection defined as the process by which an article, surface or medium is made water free from all pathogenic microorganisms that are capable or giving rise to infections (Statish, 2002). Disinfection serves to destroy pathogenic organisms which may cause various types of water- borne

diseases and it can considered as the final stage in the water treatment process (UNHCR, 1992). Disinfection method may be either physical or chemical:

*Physical methods including boiling, ultra violet (UV), irradiation etc.

*Chemical methods including use of oxidants (halogens, and halogen compounds such as chlorine, bromine, iodine, ozone, potassium permanganate and hydrogen peroxide etc. (SSMO, 2003). Chemical disinfectants for water should be having the following attributes:

* Destroy all pathogens present in water within an acceptable amount of time.

*Be able to perform within the range of temperatures and physical conditions encountered.

*Disinfect without leaving any harmful substances in water.

*Permit simple and quick measurement of strength and concentration.

*Leave sufficient active residual concentration as a safe guard against post treatment contamination.

*Ready and dependable availability at a reasonable cost (Oxfam, 2001).

2.8.4.1 Factors affecting disinfection

The principal factors that influence disinfection efficiency are:

*Disinfectant type and its concentration

*Contact time (CT) this important for chemical disinfectants

*Temperature of the water (High temperature speed up chemical reactions

*PH of the water

*Kind and concentration of microorganisms in water

* Other constituents of the water which may impede disinfection or render it impossible, also there are some constituents react with chlorine such as iron and manganese compounds, ammonia compound (forming chloro amines) as well as numerous of organic particles. The present of these substances reduce the germicidal effect considerably (SSMO, 2003; Steven, 2005). System with high assimible organic carbon (AOC) level needed to maintain high disinfectants residual to control coli form occurrence (WHO, 2004). The presence of biodegradable organic matter (BDOC) in water will promote bacteria growth, and may be related to the occurrence of the coli form bacteria in distribution systems (Bourbigot, Dodin &Lheritier, 1984; Camper et al., 1991; Lechevallier et al., 1991; Geldreich & Steven, 1987; Lechevallier, Babcock & Lee, 1987). Entameoba histolytic a, entero viruses and protozoa in drinking water are more resistance to disinfection than the E. coli, so the absence of E. coli wills not necessary indicates water freedom from these organisms (WHO, 1997).

2.8.4.2 Chlorination

Chlorination the most important technological developments in the water treatment, during the twentieth century introduction in 1908, it's provided a cheap reproducible method of ensuring the bacteriological quality of drinking water (Moeller, 2005). Chlorination can be achieved using liquefied chlorine gas, sodium hypo chlorite, solution or calcium hypochlorite granules and on-site chlorine generators (WHO, 2004).

2.8.4.3 Chlorine

Chlorine is the one of the most widely used chemicals for microbial control in drinking water treatment process; it is powerful antimicrobial substance due to its potential oxidizing capacity in addition to drinking water disinfection (Virto et al. 2005). Chlorine is widely used as a disinfectant; it is commercially available as calcium hypochlorite powder (solid), sodium

hypochlorite (liquid) or as chlorine gas. Chlorine is very active and reacts quickly with organic and inorganic matter in water. For disinfection is to be achieved, due allowances must be time –wise and quantity-wise for the chlorine to react with other compounds like ammonia, metal iron, and organic compound (WHO, 2002). Chlorine links with organic particles and is neutralized by the combination, thus chlorine must be added until all the organic particles of the water have been oxidized, and then there are free chlorine released in the water allowing disinfection, for effective chlorination dose of free chlorine is range 0.2-0.5mg/L for period of time at least half an hours (Perrin, 2001). The amount of chlorine required depends on organic matter and harmful organisms in water, the dose should be leave residual level of chlorine (0.2-0.5 mg/L) a higher levels will be leave a taste and people will not consume the water (WHO, 1997). In recent times was found that through chlorination certain undesirable side effects might occur particular in industrialized areas, synthetic organic compounds may enter the hydrologic cycle in high concentration, the present of chlorine enhances the danger of the formation of carcinogenic compounds e.g. chloro form, and other halo methane's (SSMO, 2003).

2.8.4.4 Mode of chlorine action

Chlorine gas and water react to form hypochlorous acid (HOCL) and hypochloric acid (HCL). In turn HOCL dissociated into hypochlorite ion (OCL) and hydrogen ion (H) according to the following reactions:

*$CL_2 + H_2O \longleftrightarrow$ HOCL+ HCL

*HOCL $\longleftrightarrow$ $H^+ + OCL^-$

The reactions are reversible and PH dependent.

*Between PH 3.5 and 5.5 HOCL is predominant species

*Between PH 5.5 and 9.5, both HOCL and OCL ion species exist in various proportions

*Above PH 8 OCL^- predominant (WHO, 2004). The disinfection action of chlorine is mainly due to hypochlorous acid, and to a small extent due to the hypochlorite ion, the hypochlorous acid (HOCL) is the most effective form of chlorine water disinfection. It is more effective (70-80 times) than hypochlorite ion (Park, 2005). The PH of the water it's critical for effective chlorination where the PH is too high, chlorine will be consumed in reactions to restore the PH back to neutral. In general, the optimum range of PH for chlorination is 6.5-8.5 (Howard, 2002).

In drinking water supply, the present of cells indicates the tolerance in the water supply for living microorganisms. Cells which are extremely large compared to water molecules, live in all water systems. The membrane of the cell is tough enough to which stand the dissolved action of the water molecule. But chlorine which has been added to water reacts with the cell wall. In a simplified explanation all chlorine molecules has to do is touch a cell and the touch outer membrane of the cell is broken. Then the water molecules can break through into the cell and destroy it (Robert, 2004). Certain bacteria show high level of resistance of free chlorine; spores forming bacteria such as Bacillus or Clostridium are highly resistant when disseminated as spores. Acid-fast and partially acid –fast bacteria such as Mycobacterium and Norcadia can also be a highly resistance to chlorine disinfection. One study showed that nearly all the bacteria surviving chlorine disinfection were gram-positive or acid-fast, possibly because gram-positive bacteria have thicker walls than gram-negative ones (Norton & Lechevallier, 2000).

2.8.4.5 Storage of treated water

After having been treated the water must be stored before distribution generally in bladder or onion tanks (Peter, Delphine & Noortigate, 2003). If the cleaned water is left covered for two days before use, then most of microorganisms will have died because of the cold or lack of food (WHO, 2002).

2.8.4.6 Water Distribution Network

Most and major metropolitan areas obtain fresh water from lakes or rivers. Water is pumped from the fresh water body, then its treated, disinfected and distributed through piped to the storage tanks, from there it is distributed to individual homes to businesses, composes, factories, park, and etc (Robert, 2004). The entire treated water carries net-work from the source or the storage unit to the consumers through distribution system (Perrin, 2001).

Drinking water monitoring based upon tests for coliform bacteria as indicators of fecal contamination originated approximately 100 years ago (Cox, 1997). At that time, most waterborne disease outbreaks were caused by pathogenic organisms and could be clearly traced to fecal contamination of drinking water. The prevention of gastrointestinal illness from drinking water exposure meant keeping human fecal material out of water, and the best available technology for detecting fecal contamination was to monitor drinking water for the presence of coliform bacteria. Today, water is treated and piped through elaborate distribution systems. The age and complexity of distribution systems, coupled with the increased availability and use of chemicals, has increased the likelihood for contamination events and waterborne disease not related to source water treatment deficiencies. There is also endemic disease that is suspected to occur due to contamination of distribution systems (Payment et al., 1991). Monitoring water for indicators and for other conditions that may provide information on distribution system deficiencies and integrity problems is

an important tool for protecting the public health (EPA, 2006). Water can be transported from the source to the treatment plant, if any, and the distribution system, and eventually reach consumers through one of the following methods:

2.8.4.6.1 Through gravity flow

This is the ideal set-up when the location of the water source is at a considerably higher elevation than the area to be served. The operation cost of a gravity system is very low, as it does not require energy cost.

2.8.4.6.2 Through pumping with storage

Water is either (a) pumped to a distribution pipe network, then to consumers, with excess water going to a storage tank, or (b) pumped to a storage tank first, then water is distributed by gravity from the tank to the consumers. The maintenance and operation cost of this system is higher than a gravity system.

2.8.4.6.3 Through direct pumping to the distribution system:

In this system, water is pumped directly from the source to the distribution system to the consumers. Where capital cost for a reservoir is not affordable at the initial stage of the water system, direct pumping to the distribution is usually resorted to. Variable speed or variable frequency drive pumps are most ideal for direct pumping operations, but the capital costs for such equipment are higher than for conventional water pumps.(world bank,2012). There are two type of Water Distribution Network Branch Network and Loop Network(Niklesh R .Murekar, et al.,2011). Treated water conveyed through a piped network is exposed to numerous surfaces. It is important that no materials placed in contact with the drinking water in the network promote microbial growth or leach any contaminants into the water that can support microbial growth (WHO.2004)

3.8.4.6.4 Branched System

Branched systems are easy to design. The direction of the water flow and the flow rates can readily be determined for all pipes. This is different in looped distribution

networks, where consumers can be supplied from more than one direction. Looped networks

greatly improve the hydraulics of the distribution system. This is of major importance in the event that one of the mains is out of operation for cleaning or repair(May,L.W.,2000).

Also Branched systems referred to as a Dead-end System, the size of the main line in this distribution system decreases as its distance from the source increases, in consideration that the further pipes have to carry less water. The design of a branched system is generally straightforward, where the direction of water flow in all pipes and the flow rate can be

readily determined , illustrates a branched or dead-end system. One of the advantages of a branched system is generally lower costs (World bank,2012) . Branched networks are predominantly used for small-capacity community supplies delivering the water mostly through public standpipes and having few house connections, if any. Although adequate, having in mind simplicity and acceptable investment costs, branched networks have some disadvantages are:

1 A main break will cause all downstream consumers to be out of service.

2 It results in poor chlorine residuals and aging of water in low demand areas.

3 During high demands, the velocities are faster, hence head losses are higher.

4 Accumulation of sediments, due to stagnation of the water at the system ends ("dead" ends) occasionally resulting in taste and odors problems (May,L.W.,2000).

2.8.4.6.5 Looped System:

A looped network usually has a skeleton of secondary mains that can also be in a form of branch, one loop ('ring'), or a number of loops. From there, the water is conveyed towards the distribution pipes and further to the consumers. The secondary mains are connected to one or more loops or *rings*. The network in large (urban) distribution systems will be much more complex, essentially a combination of loops and branches with lots of interconnected pipes that requires many valves and special

parts. To save on equipment costs, over-crossing pipes that are not interconnected may be used but at the cost of reduced reliability (May,L.W.,2000).

A distribution network is looped when there are only few or no pipe dead-ends, such that water can move through the system freely. The advantages of a looped system are:

• The lower water velocities in the main reduce head losses, resulting in greater capacity.

• Main breaks can be isolated, minimizing service interruptions to consumers.

• Usually better chlorine residual content is achieved.

The disadvantage is generally more costs because of the need for more pipes to create the loops. (World bank,2012).

2.6.4.6.6 Factors in Selecting Pipeline Materials

2.8.4.6.6.1 Flow Characteristics: The friction head loss is dependent on the flow Characteristics of pipes. Friction loss is a power loss and thus may affect the operating costs of the system if a pump is used.

2.8.4.6.6.2 Pipe Strength: Select the pipe with a working pressure and bursting pressure rating adequate to meet the operating conditions of the system. Standard water pipes are satisfactory usually only in low pressure water supply systems.

2.8.4.6.6.3 Durability: Select the type of pipe with good life expectancy given the operating conditions and the soil conditions of the system. It should have an expected life of 30 years or more.

2.8.4.6.6.4 Type of Soil: Select the type of pipe that is suited to the type of soil in the area under consideration. For instance, acidic soil can easily corrode G.I. pipes and very rocky soil can damage plastic pipes unless they are properly bedded in sand or other type of material.

2.8.4.6.6.5 Availability: Select locally manufactured and/or fabricated pipes whenever available.

3.8.4.6.6.6 Cost of Pipes: Aside from the initial cost of pipes, the cost of installation should be considered. This is affected by the type of joint (such as screwed, solvent

weld, slip joint, etc.), weight of pipe (for ease of handling), depth of bury required, and width of trench and depth of cover required.(World bank,2012).

2.8.4.6.7 Pipe Materials

2.8.4.6.7.1 Galvanized Iron (GI) Pipes: GI pipes are available in sizes of 13, 19, 25, 31, 38, 50, 63 and 75 mm and in lengths of 6 m. They are joined by means of threaded couplings.

Advantages:

• Strong against internal and external pressure.

• Can be laid below or above ground.

• People in rural areas know how to install this kind of pipes.

Disadvantages:

• GI Pipes can easily be corroded, thus the service life is short.

• These have rougher internal surface compared to plastic pipes, hence, Have higher friction head losses.

2.8.4.6.7.2 Plastic Pipes: Polyvinyl Chloride (PVC) and Polyethylene (PE) are commercial plastic pipes. They are available in different pressure ratings and sizes of 13, 19, 25, 31, 38, 50, 63, 75, 100 up to 200 mm. PVC is supplied in lengths of 3 m and6 m while PE is available in rolls and, for diameters greater than 100 mm, in straight lengths. Suppliers have to be consulted with respect to the pressure ratings to be used. PE pipes are joined by butt welding. PVC pipes can be joined either through solvent cement welding or through the use of special sockets with rubber rings.

Advantages:

• Smooth internal surface.

• Resistant to corrosion.

• Extremely light and easy to handle.

• Do not tuberculate

Disadvantages:

• Lose strength at high temperatures (500° C+).

• Not suitable for laying above the ground.

• Can deform during storage.

• Require good and carefully prepared bedding materials. (World bank,2012).

2.8.4.6.8 Distribution System Problems

The distribution system problems are grouped into the following sequential focus areas:

2.8.4.6.8.1 Pathways that Breach Distribution System Integrity

• Main Breaks, Repairs and Installation

• Operation and Maintenance Deficiencies

• Cross-connections and Backflow

• Intrusion

• Permeation

• Finished Covered Storage Tank Deficiencies

• Biofilms

• Corrosion and Leaching

2.8.4.6.8.2 Distribution System Contamination

• Fecal Contamination

• Toxic or carcinogenic contamination

2.8.4.6.8.3 Public Health Risk

Waterborne disease Outbreaks and Endemic Illness By evaluating indicators in a sequential manner (e.g., it is possible to have a breach in distribution system integrity but not cause contamination, and it is also possible to have a contamination event, but not cause a waterborne disease), the indicators can be considered with regard to their effectiveness as predictive and/or forensic tools. The pathways that breach distribution system integrity can generally be thought of as external (i.e., cross-connection, intrusion, main breaks, etc.) or internal(i.e., biofilms, corrosion and leaching).(FPA,2006). Flushing and pigging are routine maintenance practices often conducted within the distribution system to address consumer complaints and to

reduce the retention time of water to improve water quality. Utilities have typically manually flushed water from the system using fire hydrants or flushing hydrants to control microbial growth, These practices can affect the distribution system water quality in a negative manner if not conducted properly. Improper flushing can result in moving a contaminant (Brandt et al., 2004).

2.8.4.6.8.1.1 Main Breaks, Repairs, and Installation

Contamination of pipe interiors is not uncommon during installation. Pierson et al. (2002). Contamination concerns during new main installation and repair or replacement. Inadequate flushing velocities to purge contaminants from the new pipe, unsanitary conditions during work efforts, and introduction of contaminated sediment into the pipe that was not subsequently remove all create feasible contamination scenarios (Besner et al.,2002.)

2.8.4.6.8.1.2 Operation and Maintenance Deficiencies:

Flushing and pigging are routine maintenance practices often conducted within the distribution system to address consumer complaints and to reduce the retention time of water to improve water quality. Utilities have typically manually flushed water from the system using fire hydrants or flushing hydrants to control microbial growth, These practices can affect the distribution system water quality in a negative manner if not conducted properly. Improper flushing can result in moving a contaminant further into the distribution system (Brandt et al., 2004).

2.8.4.6.8.1.3 Permeation

Permeation of piping materials and nonmetallic joints can be defined as the passage of contaminants external to the pipe through porous, nonmetallic materials, into the drinking water (Friedman et al., 2002). The problem of permeation is generally limited to plastic, nonmetallic pipe. In addition, new PVC pipes exhibit lower permeation rates than new polyethylene or poly butylenes pipes (DWI0772, 1997). More than 100

incidents of drinking water contamination resulting from permeation of subsurface mains and fittings have been reported in the United States (Glaza and Park, 1992). BTEX and organic solvents are most common contaminants that permeate plastic pipe (Friedman et al., 2002).

2.8.4.6.8.1.4 Finished Covered Storage Tank Deficiencies

Storage tank deficiencies, such as vents without screens, inadequate hatches, access hatches that are not locked, and physical openings in storage tank roofs, can result in the entry of contaminants. Coatings on the storage tank interior can also result in contamination if the coating fails or is not properly cured. Potential public health issues associated with finished water storage facilities are described in a distribution system white paper on covered storage (AWWA & EES, 2002).

2.8.4.6.8.1.5 Cross-connections and Backflow

A cross-connection is an unprotected connection between a public potable water system and any other system or source where unintended substances can be potentially introduced to the potable water supply, such as used water, industrial fluid, or gas, Backflow is the "undesirable reversal of flow of water or mixtures of water and other liquids, gases or other substances into the distribution pipes of the potable supply of water from any source or sources (USC-FCCCHR, 1993)." In order for a backflow event to occur, a cross connection and pressure loss that creates a pressure differential must exist within the distribution system, or the cross connection has created a pressure gradient in excess of normal distribution system pressure. From 1971 through 1998, "chemical and microbial contamination from crossconnections and backsiphonage were responsible for most distribution system related illnesses. Outbreaks could be traced to backflow prevention devices that were needed but not installed, had been inappropriately installed, or had been inadequately maintained" (Craun and Calderon, 2001).

2.8.4.6.8.1.6 Intrusion

Intrusion can occur when a transient or low pressure event occurs within the distribution system that results in a lower pressure within the pipe than the pressure outside the pipe. This pressure gradient can result in contaminants contained in soil and water surrounding the distribution pipe to be "sucked" into the distribution pipe if external water pressure exceeds internal pressure (LeChevallier et al., 2002). transient pressure waves can travel several miles throughout the distribution system until they are dissipated, thereby increasing the potential for contamination through leakage points over a wide-spread area (Friedman et al. ,2004b).

2.8.4.6.8.1.7 Biofilms

Biofilms are defined as a complex mixture of microbes, organic, and inorganic material accumulated amidst a microbially produced organic polymer matrix attached to the inner surface of the distribution system (USEPA, 2002). Contaminants, including total coliforms and some pathogens, may attach to or become enmeshed in biofilms on pipe walls in distribution systems. Many pathogens have been found to survive, if not grow, in these pipe biofilms where they are protected from disinfectants. Over time, coliform bacteria may detach or slough from the biofilm, causing persistent total coliform detections. Pathogens may also be included in the detached material and may result in waterborne disease. The biofilm can result in total coliform positive detections and other contamination events if disturbed, Organisms that have been found in biofilms include bacteria, viruses, protozoa, invertebrates, algae, and fungi (USEPA, 2002) . Less efficient treatment of source water during runoff or changing water quality conditions may cause a change in the organic matter of treated water, which in turn may enable increased biofilm growth in the distribution system (Besner et al., 2002).

2.8.4.6.8.1.8 Corrosion and Leaching

Corrosion is the gradual deterioration of metal pipe, metal fixtures, cement mortar lining in pipe, or other substances because of a reaction with the water (AWWA, 1999a). Corrosion can be the result of physical actions that erode the coating of a pipe,

chemical dissolution that leaches a pipe's lining or wall material, or electrochemical reactions that remove metal from the wall of the pipe (AWWA, 2000). Corrosion can result in the leaching of certain metals, such as lead and copper (AWWA, 2000). Biological growths within the distribution system can also cause corrosion by providing an environment in which physical and chemical interaction can occur. Leaching is defined as the dissolution of metals, solids, and chemicals into drinking water (Symons et al., 2000). Some of the factors that influence corrosion and leaching are water velocity, pipe material, and water quality within the distribution system, such as pH, alkalinity, temperature, chlorine residual, and hardness of the water. Contaminants from pipe linings, tank coatings, fittings, or other materials can sometimes leach into the drinking water, causing contamination. Cement-lined pipes and storage tanks can leach calcium carbonate into the water, which may significantly increase the alkalinity and pH of the water. This is especially true when the cement lined material is new, but also depends on the type of cement used, the contact time pipe.(USEPA,2006).

2.8.4.6.9 Protection of distribution system

Protection of the distribution system is the last and one of the most important of the multiple barriers necessary for provision of safe drinking water. Any microbial contamination of this point has a high probability of resulting in public health risk even if previous control steps have been applied effectively. Because of the extensive nature of the distribution system, with many kilometer of pipe (Gelderich, 1996; Geldericg & Lechevallier, 1999; Ainsworth, 2004). Hazard control strategies should be focus on three essential elements as following:

*Maintaining the quality of the treated water by adequate maintance of distribution system

*Minimizing bacteria growth

*Preventing recontamination of water during distribution (WHO, 2004).

The growth of bacteria and occurrence of coli forms depend on a complex interaction factors including water temperature, disinfectant type and residual, pipe material, corrosion and other engineering and operation parameters (Berger, Lechevallier & Reasoner, 1992; Lechevallier et al., 1991; 1993; Lechevallier, Wetch &Smith, 1996). Many DWQS associated an acceptable margin of non compliance of the standards with certain parameters (for example microbiological ones). The WHO-GL suggest that for treated water in the distribution system: total coli form bacteria must not be detected in any 100 ml sample. In the case of large supplies, where sufficient samples are examined coli form bacteria must not be present in 95% of samples taken through out any 12 months period (WHO, 2002).

Contamination of water supplies should be avoided at all times. In most small water supply systems, however, economic reasons prevent 24-hour daily water service. This creates a risk of polluted water infiltrating into the pipelines through leaks in pipe Joints and service taps. To counter the health risk, 0.3 mg/L residual chlorine should be maintained throughout the distribution system.

Other measures to preserve the quality of water are the following:

1. Install water mains using adequate separation from potential sources of contamination such as sewers, storm water pipes, septic tanks, etc.
2. Avoid cross-connections and prevent backflow.
3. Provide at least the minimum allowable pressure and adequate flow at all delivery points in the distribution system.
4. Avoid situations that may give rise to negative pressures.
5. Control the pressure up to the maximum allowable while avoiding pipe breakage.
6. Minimize low-flow dead-ends to avoid stagnant water. Effective circulation of water in the pipelines should be maintained to prevent the deposition of sediments and minimize the growth of bacteria.

7. Install non-return valves on source facilities to prevent backflow that might cause contamination.

8. Promptly repair leaks in pipes to keep dirty water from coming in when pressure in the pipe is reduced.

9. Cover reservoirs to prevent contamination. Ensure that all hatches and structures of the reservoir are secured and vermin-proof.(World bank,2012).

Water safety plans (WSPs) consistently ensure drinking water quality and the prevention of contamination during storage, distribution and handling of drinking-water. These objectives are equally applicable to large piped drinking-water supplies, small community supplies and household systems. Surveillance operated by community-based managers assures proper hygiene in the collection and storage of household water. In assessing the adequacy of the drinking-water supply, the following basic service parameters should normally be taken into consideration:

- Quality: whether the supply has an approved WSP that has been validated and is subject to periodic audit to demonstrate compliance.
- Quantity : the proportion of the population using water from different levels of drinking-water supply (e.g., no access, basic access, intermediate access and optimal access);
- Accessibility: the percentage of the population that has reasonable access to an improved drinking-water supply.
- Affordability: the tariff paid by domestic consumers; and
- Continuity: the percentage of the time during which drinking-water is available (daily, weekly and seasonally) (WHO/UNICEF, 2010).

3.9 Climate Change Effects:

Climate change may affect our water supplies in terms of quality, quantity and availability. Evaporation is likely to reduce fresh water resources, with the additional influence of salt water incursion due to higher mean sea levels. Reduction in ground water will affect aquifer water resources and force greater dependence on surface waters, which have higher levels of contamination.

Chemical contamination is also likely to increase due to less dilution of industrial pollutants.The likely increased incidence of extreme weather events poses a threat to water supplies and the potential for contamination by means of flooding, increased run off and damage to water and sewage treatment works. Higher mean temperatures of surface water, and increased nutrient load, will promote the growth of cyanobacteria, causing algal blooms. Finally, upland sources from peat covered catchments are likely to contain enhanced levels of dissolved organic carbon, particularly when re-wetting follows drought periods, producing risks of trihalomethane formation on disinfection with chlorine (Tanwell-smith ,1994). Climate change has far-reaching implications for public health. due to re-emergence of communicable diseases and their shifting distribution [Semenza , Menne ., 2009). And waterborne diseases are also of particular interest because their incidence has been linked to ambient temperature and precipitation. Elevated temperatures accelerate the replication cycles of water-borne microorganisms, and extended summer seasons may increase the chance of mistakes in water handling. Extreme and erratic rain events can flush pathogens into water treatment and distribution systems, resulting in community outbreaks (Kisteman ,et al.2002 ; Ebi KL., Semenza ,2008). Increases in water temperature, precipitation frequency and severity, evaporation-transpiration rates, and changes in coastal ecosystem health could increase the incidence of water contamination with harmful pathogens and chemicals, resulting in increased human exposure. Research should focus on understanding where changes in water flow will occur, how water will interact with sewage in surface and underground water supplies as well as drinking water distribution systems, and how to better predict and prevent human exposure to waterborne pathogens and biotoxins (EHP and NIEHS, 2010).

Waterborne pathogens are spread through contaminated drinking water, exposure to contaminated water while swimming or other activities, All of these transmission patterns may be affected by climate variability and thus potentially

by climate change For drinking water to be a source of illness, the water must first become sufficiently contaminated, escape treatment, or treatment must fail. Water may become contaminated by animal or human waste at source. Human sewage, leaking septic systems, manure runoff from agricultural lands, and wild animal wastes may all contaminate surface water later used for drinking water. Groundwater may become contaminated by surface contamination of wells, subsurface inflows, improperly situated septic fields, or leaking dumps (chemical contamination). Drinking water may also become contaminated during or after the treatment process (Rose et al., 2001).

Under climate change conditions, summer water flows are also expected to decrease (Fortin et al., 2007; Roy et al., 2008; Vescovi et al., 2009). Low flows can cause a reduction in habitat availability, water quality (Bradford and Heinonen, 2008). Changes in the distribution of river flows and groundwater recharge over space and time are determined by changes in temperature, evaporation and, crucially, precipitation (Chiew, 2007). The current evidence of the impact of climate on the epidemiology of waterborne disease is considered under three headings; the impact of heavy rainfall events, the impact of flooding and the impact of increased temperature (Hunt,2003).

Climate changes have significant effects on the available sources of water, as well as on the competing demands on its use. Small water utilities have to be alert to these effects as they pose threats on their long-term viability and sustainability. Effects of climate change could include more frequent and intense rainfall events, leading to increased overland and shallow sub surface flow which can mobilize pathogens and other contaminants. Increased frequency and magnitude of flood events impacts not only availability of clean water, but chemical storage and sewage facilities, compromising quality. Sea-level rise in coastal areas will affect groundwater aquifers as well as flood low-lying areas, reducing the availability of freshwater. Alterations in temperature regimes, particularly those affecting absolute minimum and maximum

temperatures, could result in changes in reproduction survival and infectivity rates of various pathogens(Zafar Adeel et al.,2008).

2.9.1 Effects of Warmer Climate

1. Changes in discharge characteristics of major rivers due to upstream changes;
2. Changes in recharge characteristics of major groundwater aquifers due to upstream changes;
3. Increased water temperature leading to increased evaporation and eutrophication in surface sources;
4. Water treatment and distribution challenges;
5. Increased competing demands for domestic and irrigation;
6. Increased urban demand with more heat waves and dry spells;
7. Increased drawdown of local groundwater resources to meet the increasing water demands. Rising temperatures, heavy rainfall, and increased flooding are some of the climate change-induced weather patterns that fuel the proliferation of waterborne diseases. Research indicates that increased ambient temperatures are often correlated with waterborne disease outbreaks in developing countries (Checkley et al, 2000 ; Abu-Elyazeed et al, 1999; Hashizume et al, 2007). To add perspective to this argument, the pathogens that cause waterborne diseases are generally temperature dependent, which means rising water temperatures result in increased growth of bacteria in water (Schijven and Husman, 2005), leading to increased rates of diarrheal diseases (Sanchez and Holmgren, 2005).

2.9.2 Effects of More Intense Rainfall Events:

1. Increased turbidity and sedimentation;
2. Loss of reservoir storage;
3. Water filtration or filtration/avoidance treatment challenges;
4. Increased risk of direct flood damage to water utility facilities. (world bank,2012)

Increased precipitation will increase the risk of flooding in many areas of the world. Floods can increase human exposure to pathogens, as contaminants are spread by floodwaters. Developing countries are particularly susceptible to this, as water carries

wastes, and drainage and sewage systems can become backed up. Water treatment facilities can become damaged, which can result in the distribution of untreated or improperly treated water. Sewer and water pipes can break, which can cause drinking water to become contaminated with sewage. Floods can also transport fecal matter from the ground or sewers that have overflowed, and contaminate wells, boreholes and surface waters.

There are main categories of diseases that result from floods. The most iportant includes waterborne diseases, the most common being a variety of diarrheal illnesses(WHO,2007). Similarly, heavy rainfall increases the risk of waterborne diseases. During periods of heavy rainfall, overland and shallow subsurface water run-off can occur and transport pathogens into drinking water sources, increasing the risk of exposure to waterborne pathogens. Many studies have found high levels of fecal contamination in water sources during rainy seasons (Musa et al, 1999 ; Gasana and et al, 2002). These studies help to explain the high rates of diarrheal diseases (Musa et al, 1999 ; Bordalo and Savva-Bordalo, 2007; Morse et al, 2007) and waterborne disease outbreaks (Lawoyin et al, 1999); Effler et al, 2001) during this season. Numerous studies have also found evidence linking waterborne disease outbreaks to flooding events in developing countries (Campanella, 1999 ; Pathela et al, 2006 ; Qadri et al, 2005). Tidal surges, heavy rainfall, or rapid snowmelt can increase the pathogen load in water reservoirs and overwhelm water treatment facilities when flooding occurs. For instance, recent flooding have been associated with outbreaks of waterborne diseases in the country (UNEP, 2007; Namanya, 2009). Given the linkages between weather and waterborne disease, and the changes already experienced in atmospheric temperature, precipitation, runoff and hydrological extremes, climate change is expected to increase the burden of infectious waterborne disease, especially for vulnerable populations (Bates et al, 2008; McMichael et al, 2004). Sea level rise will increase salinisation of groundwater , seriously impacting the health of the population, This will promote algal blooms and increase the bacterial and fungal content. This will, in turn, impact adversely upon ecosystems, human health,

and the reliability and operating costs of water systems, Rapidly growing urbanization combined with increasing demand for freshwater and non-existent or inadequate sanitation infrastructure poses a threat to public health and increases water-borne diseases. Sanitation systems may be damaged by flooding and infrastructural deterioration caused by extreme weather conditions, interrupting services and further compromising the quality of drinking water (IPCC, 2008).

2.10 water quality index:-

Water quality Index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water. It reduces the large amount of water quality data to a single numerical value. It is calculated from the point of view of human consumption. Water quality and its suitability for drinking purpose have been considered for calculation of WQI. In this method the weightage for various water quality parameters is assigned to be inversely proportional to the recommended standards for the corresponding parameters (Vasanthavigar , et.al , 2010).

For healthy living, potable safe water is absolutely essential. It is a basic need of all human being to get the adequate supply of safe and fresh drinking water. One of the most effective ways to communicate water quality is Water Quality Index (WQI), where the water quality is assessed on the basis of calculated water quality indexes. Quality of water is defined in terms of its physical, chemical, and biological

Parameters. However, the quality is difficult to evaluate from a large number of samples, each containing concentrations for many parameters (Almeida, 2007).

A water quality index provides a single number that expresses overall water quality at a certain location on several water quality parameters and turns complex water quality data into information that is understandable and useable by the general people. WQI is a mathematical instrument used to transform large quantities of water quality data into a single number which represents the water quality level while eliminating the subjective assessments of water quality and biases of individual water quality experts. (Islam, s. et al. 2011).

3.10.1 Calculation of Water Quality Index

Water quality index [WQI] = QiWi

Where, Qi is water quality rating

Qi = 100*[Va-Vi]/[Vs-Vi]

Va = Actual value of the parameters present in water sample

Vs = Standard value

Vi = ideal value

Wi = K/Sn , Where Wi = Unit weightage

K[constant] = 1/[(1/S1) + (1/S2) + (1/S3) + ….. + (1/Sn) **(**Maruthi Devi, et al.2011).

WQI has been classified into five classes according to arithmetic method in the following table:

WQI	**Quality of water**
0-25	**excellent**
26-50	**good**
51-75	**poor**
76-100	**Very poor**
Above 100	**Unfit for drinking**

3. Materials and methods

3.1 study design: descriptive cross sectional study

3.2 study area:

Shendi Town is well known historically, and it is the third largest Town in River Nile State. It is in River Nile State, where the Headquarter of Shendi locality is located.

Shendi is located about 176 km north of Khartoum , and 130 km south of El damer(capital of River Nile State).It is bound by River Nile in the west and Kasala State in the East, also bound by south Shendi administrative unit in the South and north Shendi administrative unit in the North.

The urban area of Shendi town is composed of 55 Blocks, but only 34 Blocks are populated .These Blocks are divided into two main classes according to economic status and availability of services :-

Class one contains 14 Blocks and
Class two contains 20 Blocks.

Geographically it lies between line 36 East to 31 west longitudinal and line 19 north to 15 south latitudinal. It is in the arid zone of Sudan with annual rain fall ranging between 0 and 119 mm per year .(Suleiman ,2011) Culturally the population of Shendi is a mixture of various cultures that occur in Sudan through the main Northern tribes, particularly E l-Galen, are predominant (Suleiman 2011). The total population of Shendi Town is estimated at about 97486 and number of families in Shendi Town is 11000, with average family size of about 9 members (EPI, 2012).

Shendi town has no sewerage system , the population depend on septic tanks, aqua privies, pour flush latrines and traditional pit latrines for disposal of fecal waste and other liquid waste.

Shendi town has a distribution system of drinking water. The whole town depends on ground water as source of drinking and other activities .Net work of drinking water was established since 1965, type of distribution system is looped .The net work of drinking water is made of asbestos pipes, galvanized iron pipes and plastic pipes.Net work of drinking water covers about 75% of the Town. The drinking water supply is managed by Civil Water Corporation (CWC). The area around Shendi is rich by agricultural activities due to availability of water from River Nile, and the main crops are fruits, vegetables, cash crops and sorghum. The educational services in Town is provided by: basic education which consists of 28 primary schools, secondary education that includes 8 secondary schools and Shendi University which was established in the Year 1990 and now includes 10 Faculties and numbers of centers .Also there are many health institutions in shendi town such as Elmmak Nimer Hospital, Shendi Teaching Hospital, shendi Military Hospital, and some other health centers, in addition to private health units .

3.3 Study population: - residents of shendi town, water supply system, household and records.

3.4 sample size:- it is determined by the following equation

$$n= \mathbf{N \times z^2(pq)/Nd^2+z^2(pq)}$$

Where:

n= sample size

N= total population (97486)

Z= confidence interval = 95% equal 1.96 (constant).

P= success factor equal (0.5)

q= failure factor = (1-p) equal (0.5) d= error factor = 5% equal

(0.05) $n = 97486 \times (1.96)^2 \times 0.5 \times 0.5 / 97486 \times (0.05)^2 + (1.96)^2 \times 0.5 \times 0.5$

So n = 383

Note: - bacteriological samples were determined according to WHO guidelines (one sample for each 5000 of population monthly, total population is 97486 so sample size = 97486/ 5000 = 19.5 ≈ 20 for a year n= 20 *12 equal 240 samples.

Physical and chemical sample size = 383 – 240 equal 143 samples.

3.5 sampling technique: In this study two type of samples are used,

1- Stratified random sampling: where divided residents of town for two groups according to their economic status, then randomly select study unit.

2- Simple random sampling: where coding all blocks of shendi town and then randomly select blocks and house hold as study units according to sample size, also the same thing for health institutions and water supply facilities.

3.6 data collection: the data were collected by the following methods

1- questionnaire: is designed according to aims of study, where it contented on thirty two closed question and filled with population of Shendi Town .

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), manager of distance & building planning, and medical managers of health institutions in shendi town to obtain the required information.

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

4-records:searched in records at health units like Elmmak Nimer hospital, Shendi teaching hospital , Shendi military hospital and centers of health insurance to know the confirmed cases of water-borne diseases.

5-laboratory: samples were collected from the identified sites of drinking water supply (source, network and storage facilities) at shendi town and were analyzed at public health laboratory in Atbara Town to determine physical , chemical and bacteriological quality of drinking water.

3.7 Data analysis:

Data were analyzed by computer using both Microsoft Excel and Statistic Package for Social Sciences program (SPSS), and the results are presented in percentage tables and other statistical graphs. This was followed by testing for the significance between different factors by subjecting some data to statistical examinations, like T test and chi square test to find P values.

3.8 materials & methods: in this study different materials and methods were used to examine samples.

3.8.1 Samples collection: After obtaining sterilized bottles from public health laboratory of the Ministry Of Health – River Nile state, samples were collected from identified sites in Shendi Town.

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

*Clean the tap to remove any attachments that may cause splashing by using clean cloth.

*Open the tap at maximum flow and let the water run for 1-2 minutes.

*Sterilize the tap for a minute with cigarette lighter.

*Open the tap before sampling, allow the water to flow for 1-2 minutes at medium flow rate.

*Open the sterilized bottle and took out bottle carefully unscrew the tap.

*Fill the bottle and immediately hold the bottle under the water jet and fill it and leave small air space to shaking before analysis.

*Cap the bottle carefully and keep it in the ice box before Transportation to laboratory.

3.8.2 Bacteriological analysis:

Equipment, materials and apparatus:

- Sterilized glass bottles
- Flasks
- Durham tubes
- Needles and gloves
- Pipette, loops and petri dishes
- Oven, autoclave and incubator
- Refrigerator
- Kov'cs , ethanol and cotton
- Brilliant green bile broth, lauryl tryptose broth and EMB media.
- Peptone water and distilled water.
- Flame and forceps.
- Samples carrier and marking pencils.

Analysis of samples was completed by using presence - absence method (P- A) according to standard methods for examinations of water as following:

1. Fill the sterilized bottle with 20 mL of water sample.
2. Wipe the outside of the pillow with alcohol before opening it.
3. Scissors were been used to cut open one end of the pillow.
4. Add the powder (lauryl treptose media) to water sample.
5. Put the cap on the bottle and shake it to mix the powder and water.

6. Put the bottle somewhere with a constant temperature (25 – 35oC) for 24 to 48 hours.

7. Check the bottle after 24 hours to see if there is a colour change. If there is no colour change, then let the bottle for another 24 hours.

8. Any sample that shows a colour change from yellow to black, black precipitate forms or gas production is positive for coliform presence (positive result) .

9. Any sample that shows no colour change is negative for coliform absence (negative result).

Thermo tolerant confirmation test:

1- Positive results of previous coliform test were taken.
2- Each sample was inoculated in brilliant green bile broth and peptone water
3- All samples were incubated at 44c˚for 24 hours.
4- Any sample that shows colour change (red ring) and gas production is positive for coliform presence truly.

Note: these above steps were repeated in all samples according to sample size.

E. coli confirmation test:

1-positive results of previous test were taken.

2- Each sample was cultured on EMB media in petri dish.

3- All petri dishes were incubated at 37C˚ for 24 hours.

4-Any sample that shows green metallic shine colonies are E. coli presence.

Note: these above steps were repeated in all samples according to sample size.

3.8.3 Physical analysis:

Turbidity: reagents and equipment (palintest colour/ turbidity set, palintest automatic wavelength selection photometer).

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

1-Filter a portion of the sample through a GF/B filters paper.

2- Fill a test tube with filtered sample and retain for use as the BLANK tube.

3-Fill a test tube with unfiltered sample to the 10 ml mark.

4- Select turbidity choice on photometer.

5- Take photometer reading in usual manner after using the filtered sample as blank.

Note: these above steps were repeated in all samples according to sample size.

Total dissolved solids (TDS)/ Conductivity:

Apparatus, reagents and requirements

* Conductivity / TDS meter

* Conductivity cell

* Standard solution

*distilled water

*phosphoric acid

*volumetric flasks and graduated cylinder

Calibration for TDS/conductivity:

1/ standard solution were prepared to give TDS in range 300-999 ppm and conductivity in range 0- 1999 µs, by using phosphoric acid with concentration 20% and distilled water.

2/ 100 ml of phosphoric acid was dissolved in 2000ml (2liters) of distilled water.

3/ 5ml of standard solution was added to 5ml of water sample to electrode.

4/ the conductivity/ TDS meter was immersed in the standard solution .

5/ then it were allowed to stand until it achieved stable reading of TDS at 999 ppm and conductivity at 1999 µs/cm.

6/ after that the instrument was ready for use.

TDS procedures:

1/ after calibration the instrument for water sample was put in the glass beaker.

2/ TDS/ conductivity meter was immersed into this water sample.

3/ TDS were selected from conductivity/ TDS meter.

4/ then it was allowed to stand until it achieves stable reading.

5/ the reading was noted in ppm.

Note: these above steps were repeated in all samples according to sample size.

Conductivity procedures:

1/ after calibration the conductivity cell was rinsed by using standard solution.

2/ temperature was adjusted to 25 C°.

3/ then the cell constant was computed.

4/ conductivity cell was rinsed with sample.

5/ conductivity was selected from conductivity meter and allowed to stand until it achieves stable reading.

6/ the reading was noted in µs.

Note: these above steps were repeated in all samples according to sample size.

3.8.4 Chemical analysis:

PH: reagents &equipment (palintest phenol red clear tablets, palintest automatic wavelength selection photometer and round test 10ml glass).

Procedures: test completed according to standard methods for examination of water as fallowing steps:

1- Fill test tube with sample to 10 ml mark as blank

2- Fill other test tube with sample to 10 ml mark and add one phenol red tablet then crush and mix to dissolve.

3- Wait to minute to allow full color development.

4- Select pH choice on photometer.

5- Take photometer reading in usual manner after using blank sample.

Note: these above steps repeated in all samples according to sample size.

Total iron (Fe):reagents and equipment (palintest iron LR tablets, palintest automatic wavelength selection photometer and round test tubes 10 ml glass).

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

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

2- Fill other test tube with sample to the 10 ml mark and add one LR tablet then crush & mix to dissolve.

3- Wait for one minute to allow full color development.

4- Select Fe choice on photometer.

5- Take photometer reading in usual manner after using the blank sample.

6- The result is displayed as mg /l Fe.

Note: these above steps repeated in all samples according to sample size.

Hardness: reagents and equipment (palintest hardicol NO 1 tablets, palintest hardicol NO 2 tablets , palintest automatic wavelength selection photometer and round test tubes 10 ml glass.

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

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

2- Fill other test tube with sample to 10 ml mark and add hardicol NO 1 tablet then crush & mix to dissolve.

3- add one hardicol NO 2 tablet then crush & mix to dissolve and ensure all particles are completely dissolved.

4- Wait for two minutes to allow full color development.

5- Select hardness choice on photometer.

6- Take photometer reading in usual manner after using the blank sample.

7- The total hardness result is displayed as mg/l $CaCO_3$.

Note: these above steps repeated in all samples according to sample size.

Fluoride (F): reagents and equipment (palintest fluoride NO 1 tablets, palintest fluoride NO 2 tablets , palintest automatic wavelength selection photometer and round test tubes 10 ml glass.

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

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

2- Fill other test tube with sample to 10 ml mark and add fluoride NO 1 tablet then crush & mix to dissolve.

3- Add one fluoride NO 2 tablet then crush & mix to dissolve.

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

5- Select fluoride choice on photometer.

6- Take photometer reading in usual manner after using the blank sample.

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

Note: these above steps to be repeated in all samples according to sample size.

Nitrate (NO_3): reagents and equipment (palintest nitricol tablets, palintest automatic wavelength selection photometer and round test tubes 10 ml glass.

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

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

2- Fill other test tube with sample to 10 ml mark and add one niticol tablet then crush & mix to dissolve.

3- Wait for ten minutes to allow full color development.

4- Select nitrogen choice on photometer.

5- Take photometer reading in usual manner after using the blank sample.

6- The nitrogen result is displayed as mg/l N.

7- Convert the result from mg/l N to mg/l NO_3 with multiply by (4.4).

Note: these above steps to be repeated in all samples according to sample size.

Sulphate (SO_4): reagents and equipment (palintest sulphate turb tablets, palintest automatic wavelength selection photometer and round test tubes 10 ml glass.

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

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

2- Fill other test tube with sample to 10 ml mark and add one sulphate turb tablet then crush & mix to dissolve. A cloudy solution indicates the presence of sulphate.

3- Wait for five minutes then mixed again to ensured uniformity.

4- Select sulphate choice on photometer.

5- Take photometer reading in usual manner after using the blank sample.

6- The sulphate result is displayed as mg/l SO_4.

Note: these above steps were repeated in all samples according to sample size.

Table (1) Physio-chemical analysis for water samples

Sampling date	Sample NO	source	location	TURB. NTU	TDS PPM	Conduct. µs/cm	pH	F mg/l	Hardness $CaCO_3$ mg/l
Summer 2014	1	tap	Block 4	0.76	1688.2	3368.7	7.7	1.1	120
	2	storage	Block 28	3.97	1641.7	3353.2	7.6	0.8	220
	3	well	Block 8	1.87	1603	3198.3	7.6	1.1	175
	4	tap	Block 25	1.88	1626.3	3298	7.7	0.7	150
	5	well	quraish	1.51	1572.4	3128.6	7.6	1.1	170
	6	well	Block 18	0.90	289.6	543.5	7.6	1.3	175
	7	well	Block 4	1.26	3104.5	6218.4	7.9	0.8	95
	8	well	Block 13	5.38	3167.3	6365.7	7.8	0.5	130
	9	storage	Block 19	2.1	2516.8	3244.7	8.1	0.4	280
	10	Tap	Block 18	0.72	1657.2	5668.6	7.6	1.1	205
	11	tap	Block 12	1.7	3051.1	3353.2	7.8	0.7	115
	12	tap	Block 19	1.84	1634	3306.7	7.7	0.5	145
	13	well	Block 8	2.63	1626.3	3110.8	7.8	1.0	150
	14	well	Block 4	1.03	1742.4	3496.5	7.8	0.6	150
	15	tap	Block 3	1.24	1626.3	3268	7.8	0.0	125
	16	well	Block 14	2.1	1649.5	3299	7.7	1.1	105
	17	tap	Block 7	1.55	1610.8	5041.5	7.8	0.4	290
	18	storage	quraish	2.51	1618.5	3252.5	7.8	0.6	245
	19	tap	Block 12	1.4	1688.2	3360.9	7.8	0.7	380
	20	tap	quraish	11.8	1634	3275.7	7.6	0.6	190
	21	tap	Block 13	3.6	1703.7	3416.7	7.8	0.5	195
	22	tap	Block 6	1.1	1711.4	3422.9	7.7	0.6	120
	23	well	Block 12	1.82	1726.9	3461.7	7.9	0.6	105
	24	storage	Block 2	1.33	1897.3	3453.8	7.9	0.3	75
	25	storage	Block 8	1.45	2679.4	5265.9	7.7	0.5	195

Table (1) shows that the lowest values of turbidity , TDS, conductivity, pH, F and hardness are: 0.72 NTU, 289.6 PPM, 543.5 µs/cm, 7.6, 0.3mg/l and 75 mg/l, also the highest values are: 11.8 NTU, 3167.3 PPM, 6365.7 µs/cm, 8.1, 1.3 mg/l and 380mg/l respectively.

Table (2) Physio-chemical analysis for water samples.

Sampling date	Sample NO	source	location	TURB. NTU	TDS PPM	Conduct. µs/cm	pH	F mg/l	Hardness $CaCO_3$ mg/l
Summer 2014	26	tap	Block 5	2.94	2671.7	5303.8	7.7	0.3	115
	27	well	Block 9	0.92	1726.9	3461.6	7.5	0.5	170
	28	well	quraish	5.47	1858.6	3314.4	7.7	0.8	205
	29	tap	quraish	0.52	2842	5529.2	7.5	1.1	300
	30	tap	Block 4	5.45	1737.3	3484.8	8.2	0.5	95
	31	well	Block 20	2	1641.3	3283.3	7.9	1	105
	32	tap	Block 14	0.9	1672.7	3197.9	8.1	0.5	135
	33	well	Block 16	2.5	1703.7	3438.4	8.4	1.3	115
	34	well	Block 21	2.4	1579.8	3059.3	7.8	0.4	110
	35	storage	Block 23	0.9	1649.5	3291.2	7.7	0.6	175
	36	well	Block 38	1	3244.6	6489.5	7.9	0.2	105
	37	well	Block 10	1.5	2470.3	3391.9	8.4	0.6	100
	38	well	Block 22	3.4	3244.6	6566.9	7.8	0.2	95
	39	tap	Block 16	1.1	1688.2	3391.9	7.8	0.4	105
	40	tap	Block 24	0.5	1626.2	3260.2	7.8	0.6	195
	41	well	Block 29	0.7	1657.2	3314.4	8.0	0.2	180
	42	tap	Block 11	0.7	1726.9	3469.3	7.7	1.1	150
	43	well	entrance	0.9	1572	3159.6	7.8	0.4	155
	44	tap	Block 30	0.7	1711.4	3422.9	7.8	0.3	120
	45	well	Block 24	0.6	1665	3329.9	7.8	0.3	120
	46	well	Block 14	0.9	3066.6	6172	7.8	0.3	120
	47	tap	Block 23	0.3	1657.2	3329.9	7.7	0.5	125
	48	tap	Block 38	0.9	1711.4	3415.1	7.6	0.3	130
	49	tap	Block 30	1.4	1742.4	3500.3	7.5	0.3	120
	50	well	Block 1	1.7	1672.7	3353.2	7.7	0.4	150

Table (2) shows that the lowest values of turbidity , TDS, conductivity, pH, F and hardness are: 0.3 NTU, 1572 PPM, 3159.6 µs/cm, 7.5, 0.2mg/l and 95 mg/l, also the highest values are: 5.47 NTU, 3244.6 PPM, 6469.5 µs/cm, 8.4, 1.3 mg/l and 300mg/l respectively.

Table (3) chemical analysis for water samples

Sampling date	Sample NO	Source	location	Fe^{+2} mg/l	SO_4 mg/l	NO_3 mg/l
Summer 2014	3	well	Block 8	0.01	9	0.5
	5	well	quraish	0.3	9	1.76
	6	well	Block 18	0.01	9	0.9
	7	well	Block 4	0.3	21	1.3
	8	well	Block 7	0.5	5	1.3
	13	well	Block 8	0.01	18	0.0
	14	well	Block 4	0.04	9	1.76
	16	well	Block 14	0.2	6	30.8
	23	well	Block 12	0.0	3	2.2
	27	well	Block 9	0.1	7	0.9
	28	well	quraish	0.04	14	0.9
	31	well	Block 20	0.1	16	5.3
	33	well	Block 16	0.1	18	0.0
	34	well	Block 21	0.04	21	4
	36	well	Block 38	0.04	17	0.5
	37	well	Block 10	0.2	20	2.7
	38	well	Block 22	0.02	21	7.5
	41	well	Block 29	0.1	17	1.76
	43	well	entrance	0.1	13	1.76
	45	well	Block 24	0.1	15	1.76
	46	well	Block 5	0.03	24	9
	50	well	Block 1	0.04	19	4.6

Table (3) shows that the lowest concentrations of Fe^{+2}, SO_4, and NO_3 are: 0.0 mg/l, 3mg/l and 0.0 mg/l, also the highest concentrations are: 0.3mg/l, 24mg/l and 30.8 mg/l respectively.

Table (4) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo-tolerant test/ BGB	E. coli Test/ EMB
Summer 2014	1	zeer	Block 8	+VE	+VE	-VE
	2	tap	Block 18	+VE	+VE	-VE
	3	tap	Block 8	+VE	+VE	-VE
	4	storage	quraish	-VE	-VE	-VE
	5	storage	Block 28	-VE	-VE	- VE
	6	tap	quraish	-VE	-VE	- VE
	7	well	quraish	+VE	+VE	+ VE
	8	tap	Block 7	+VE	+VE	- VE
	9	tap	quraish	+VE	+VE	- VE
	10	well	Block 8	+VE	+VE	- VE
	11	tap	Block 19	+VE	+VE	- VE
	12	storage	Block 25	+VE	+VE	-VE
	13	well	Block 8	+VE	+VE	+VE
	14	tap	quraish	+VE	-VE	-VE
	15	zeer	quraish	+VE	-VE	-VE
	16	well	Block 8	+VE	+VE	-VE
	17	well	Block 4	+VE	+VE	-VE
	18	well	Block 13	+VE	+VE	-VE
	19	tap	Block 5	+VE	-VE	-VE
	20	well	Block 6	+VE	+VE	-VE
	21	storage	Block 8	+VE	-VE	-VE
	22	well	quraish	+VE	-VE	-VE
	23	zeer	Block 18	+VE	-VE	-VE
	24	tap	Block 19	+VE	+VE	+VE
	25	well	Block 4	+VE	-VE	-VE
	26	tap	Block 6	-VE	-VE	-VE
	27	tap	Block 12	+VE	+VE	+VE

Key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (4) shows that 14.8% of samples are indicated presence of feacal pollution.

- Note: all samples were received at laboratory within six hours from time of collection.

Table (5) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
Summer 2014	28	tap	Block 12	+VE	-VE	-VE
	29	tap	Block 3	+VE	-VE	-VE
	30	tap	Block 4	+VE	+VE	-VE
	31	storage	Block 6	+VE	+VE	+VE
	32	tap	Block 9	+VE	+VE	-VE
	33	storage	Block 7	+VE	+VE	+VE
	34	storage	Block 6	+VE	+VE	-VE
	35	tap	Block 12	+VE	-VE	-VE
	36	well	Block 12	+VE	-VE	-VE
	37	tap	Block 13	-VE	-VE	-VE
	38	tap	Block 19	+VE	+VE	-VE
	39	tap	Block 5	+VE	-VE	-VE
	40	well	Block 4	+VE	+VE	-VE
	41	tap	Block 11	+VE	+VE	+VE
	42	zeer	quraish	-VE	-VE	-VE
	43	tap	Block 37	+VE	+VE	+VE
	44	tap	Block 1	+VE	+VE	+VE
	45	well	Block 29	+VE	+VE	+VE
	46	tap	Block 20	+VE	+VE	-VE
	47	well	entrance	+VE	+VE	-VE
	48	storage	Block 30	+VE	+VE	-VE
	49	storage	Block 16	+VE	+VE	-VE
	50	tap	Block 16	+VE	+VE	+VE
	51	well	Block 1	+VE	+VE	+VE
	52	storage	Block 22	+VE	+VE	-VE
	53	storage	Block 14	+VE	+VE	-VE
	54	storage	Block 1	+VE	+VE	-VE

Key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (5) shows that 29.6% of samples are indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection

Table (6) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
Summer 2014	55	storage	Block 24	+VE	+VE	-VE
	56	storage	Block 1	+VE	+VE	-VE
	57	tap	Block 12	+VE	+VE	-VE
	58	well	Block 16	+VE	+VE	+VE
	59	tap	Block 11	-VE	-VE	-VE
	60	well	Block 14	+VE	+VE	+VE
	61	tap	Block 14	+VE	+VE	-VE
	62	tap	Block 24	+VE	+VE	+VE
	63	storage	Block 20	+VE	+VE	+VE
	64	tap	Block 38	+VE	+VE	-VE
	65	tap	Block 22	+VE	+VE	-VE
	66	tap	Block 10	+VE	+VE	+VE
	67	well	Block 20	+VE	+VE	+VE
	68	tap	Block 21	+VE	+VE	+VE
	69	tap	Block 16	-VE	-VE	-VE
	70	tap	Block 20	+VE	+VE	-VE
	71	storage	Block 38	+VE	+VE	+VE
	72	well	Block 22	+VE	+VE	-VE
	73	storage	Block 10	+VE	+VE	+VE
	74	well	Block 24	+VE	+VE	+VE
	75	tap	Block 30	+VE	+VE	+VE
	76	tap	Block 22	+VE	+VE	+VE
	77	tap	Block 10	+VE	+VE	+VE
	78	tap	Block 36	+VE	+VE	-VE
	79	tap	Block 21	-VE	-VE	-VE
	80	well	Block 21	-VE	-VE	-VE

key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (6) shows that 50 % of samples indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection.

Table (7) water quality classification based on turbidity in summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	21	42	
26-50	good	19	38	
51-75	poor	5	10	
76-100	Very poor	1	2	
Above 100	Unfit for drink	4	8	
total		50	100	39.1

Table (7) shows that 42%, 38%,10% of samples are excellent, good, poor respectively and 8% of them unfit for drinking , the general WQI is good.

Figure (1) WQI of turbidity for drinking water samples in summer season

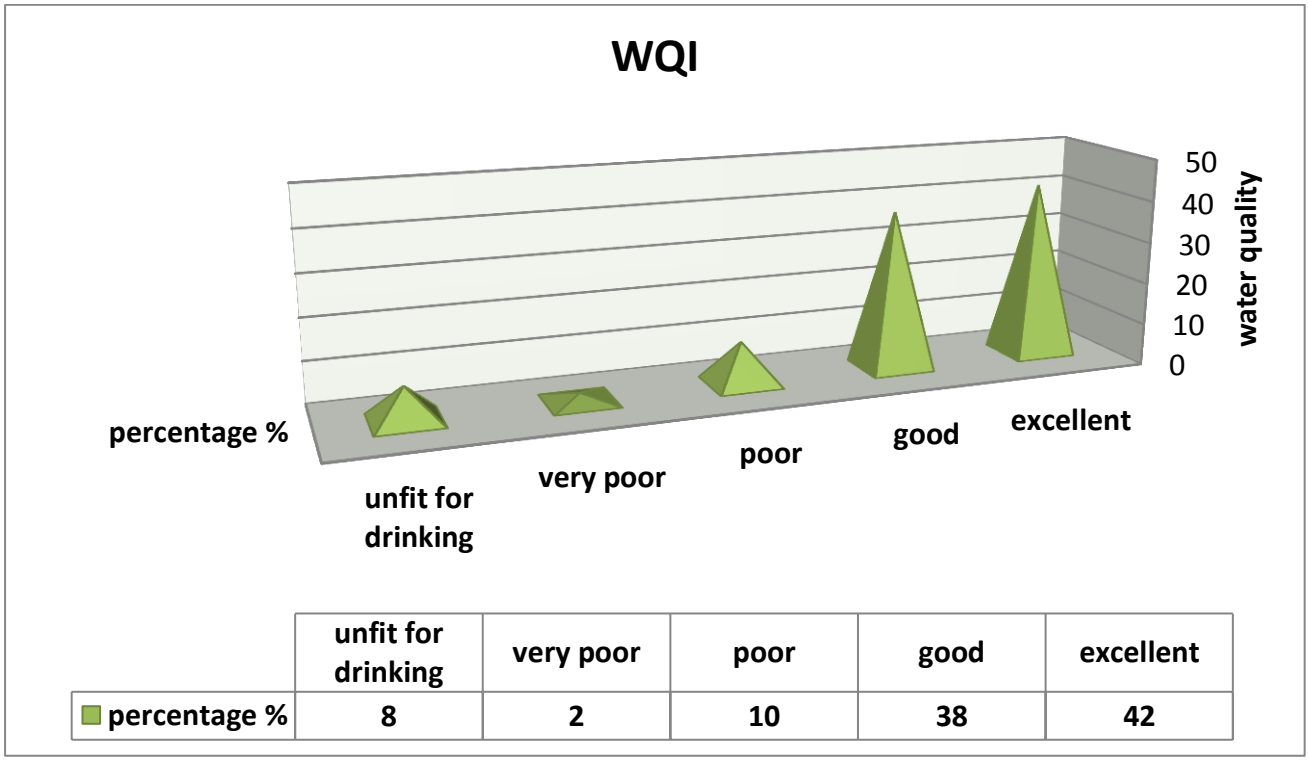


Figure (1) shows that 42%, 38%, 2% of water samples are excellent, good, very poor respectively and 8% of them is unfit for drinking.

Table (8) water quality classification based on pH samples in summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	0	0	
26-50	good	22	44	
51-75	poor	25	50	
76-100	Very poor	3	6	
Above 100	Unfit for drink	0	0	
total		50	100	43.3

The above table shows that 44%, 50%, 6% of samples are good, , poor, very poor respectively and the general WQI is good.

Figure (2) WQI of pH for drinking water samples in summer season

Figure (2) shows that 44%, 50% and 6% of water samples are good, poor and very poor respectively

Table (9) water quality classification based on TDS samples in summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	0	0	
26-50	good	1	2	
51-75	poor	0	0	
76-100	Very poor	0	0	
Above 100	Unfit for drink	49	98	
total		50	100	164.4

The above table shows 2%, 98%, of samples are good, , unfit for drink respectively and the general WQI is unfit for drinking.

Figure (3) WQI of TDS for drinking water samples summer season

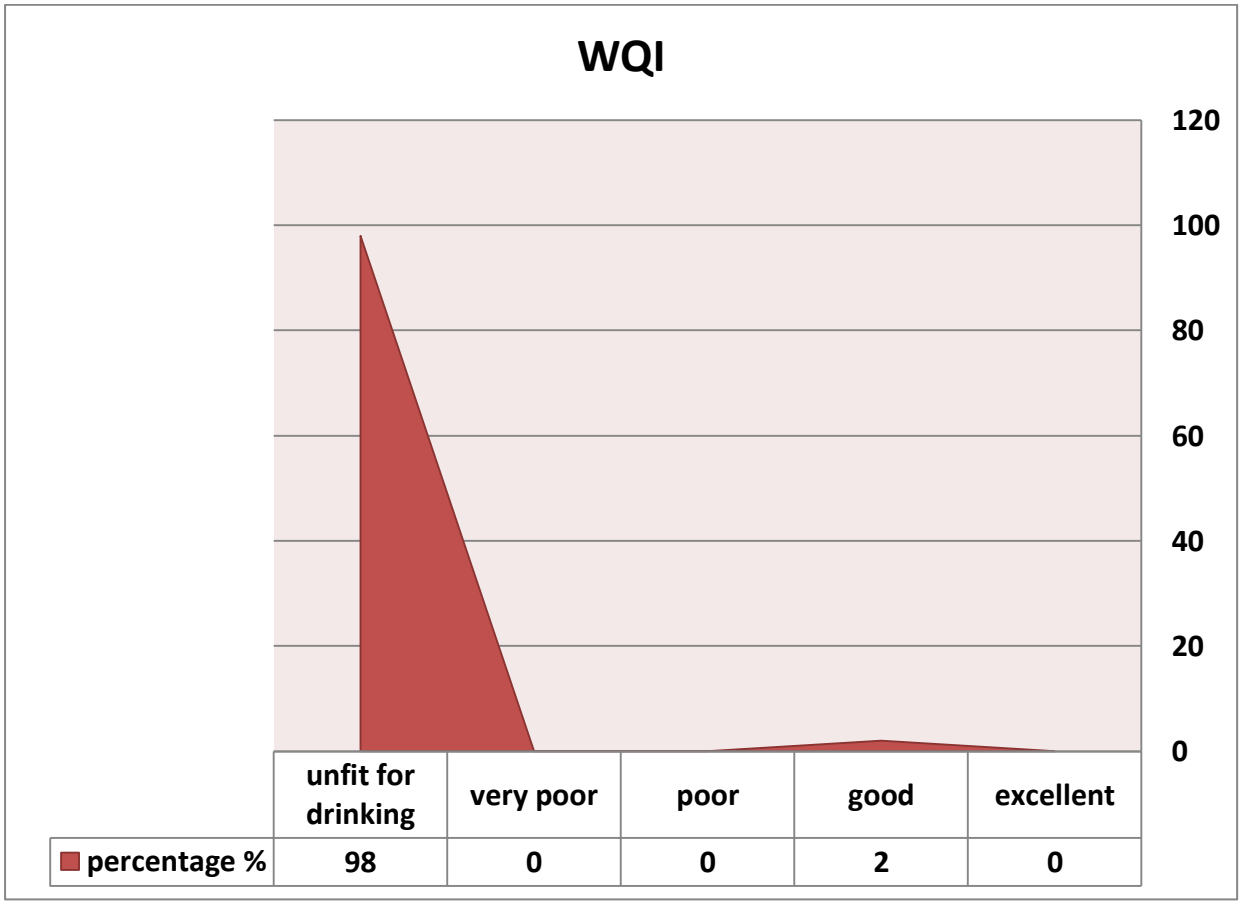


Figure (3) shows that 2% of water samples are good and 98% of them are unfit for drinking.

Table (10) water quality classification based on Fluoride content summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	11	22	
26-50	good	25	50	
51-75	poor	12	24	
76-100	Very poor	2	4	
Above 100	Unfit for drink	0	0	
total		50	100	61.7

The above table shows that 22%, 50%, 24% of samples are excellent, good, and poor respectively and the general WQI is poor.

Figure (4) WQI of fluoride for drinking water samples season

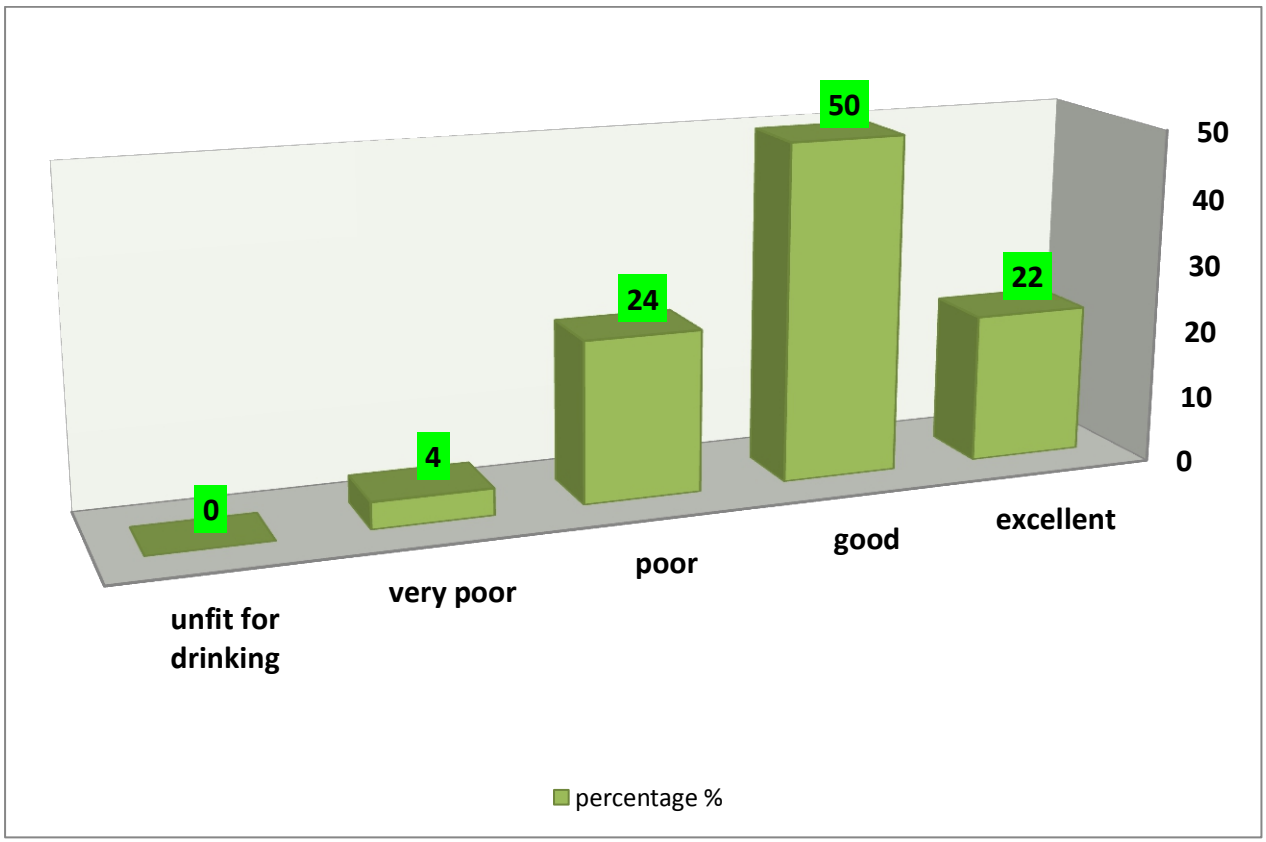


Figure (4) shows that 22%, 50%, 24% of water samples are excellent, good, and poor respectively and 4% of them are very poor.

Table (11) water quality classification based on Fe^{+2} content summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	11	50	
26-50	good	6	27.3	
51-75	poor	2	9.1	
76-100	Very poor	2	9.1	
Above 100	Unfit for drink	1	4.5	
total		22	100	51.7

The table shows 50%, 27.3%, 9.1% of samples are excellent, good , poor respectively and the general WQI is poor.

Figure (5) WQI of Fe^{+2} for drinking water samples summer season

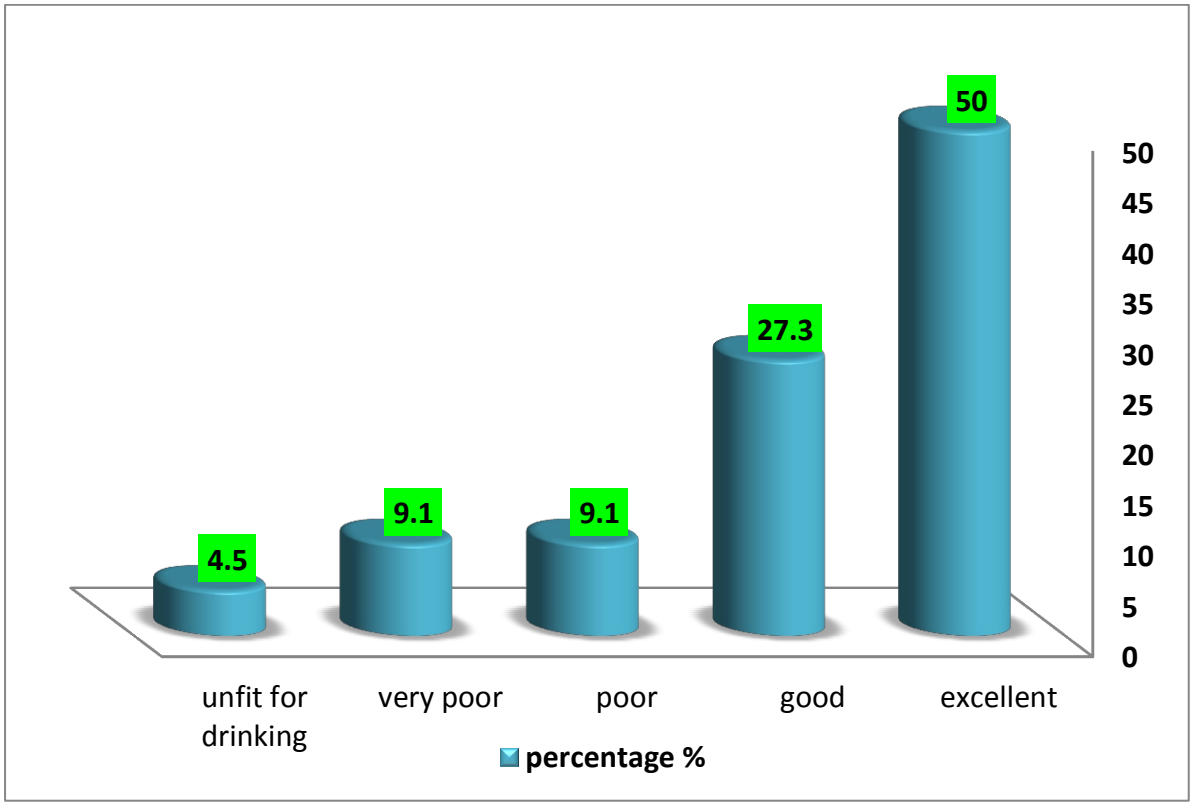


Figure (5) shows that 50%, 27.3%, 9.1% of water samples are excellent, good, and poor respectively and 4.5% of them are unfit for drink.

Table (12) water quality classification based on SO_4 content summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	22	100	
26-50	good	0	0	
51-75	poor	0	0	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		22	100	4.8

The above table shows that all samples are excellent and the general WQI is excellent.

Figure (6) WQI of SO_4 for drinking water samples summer season

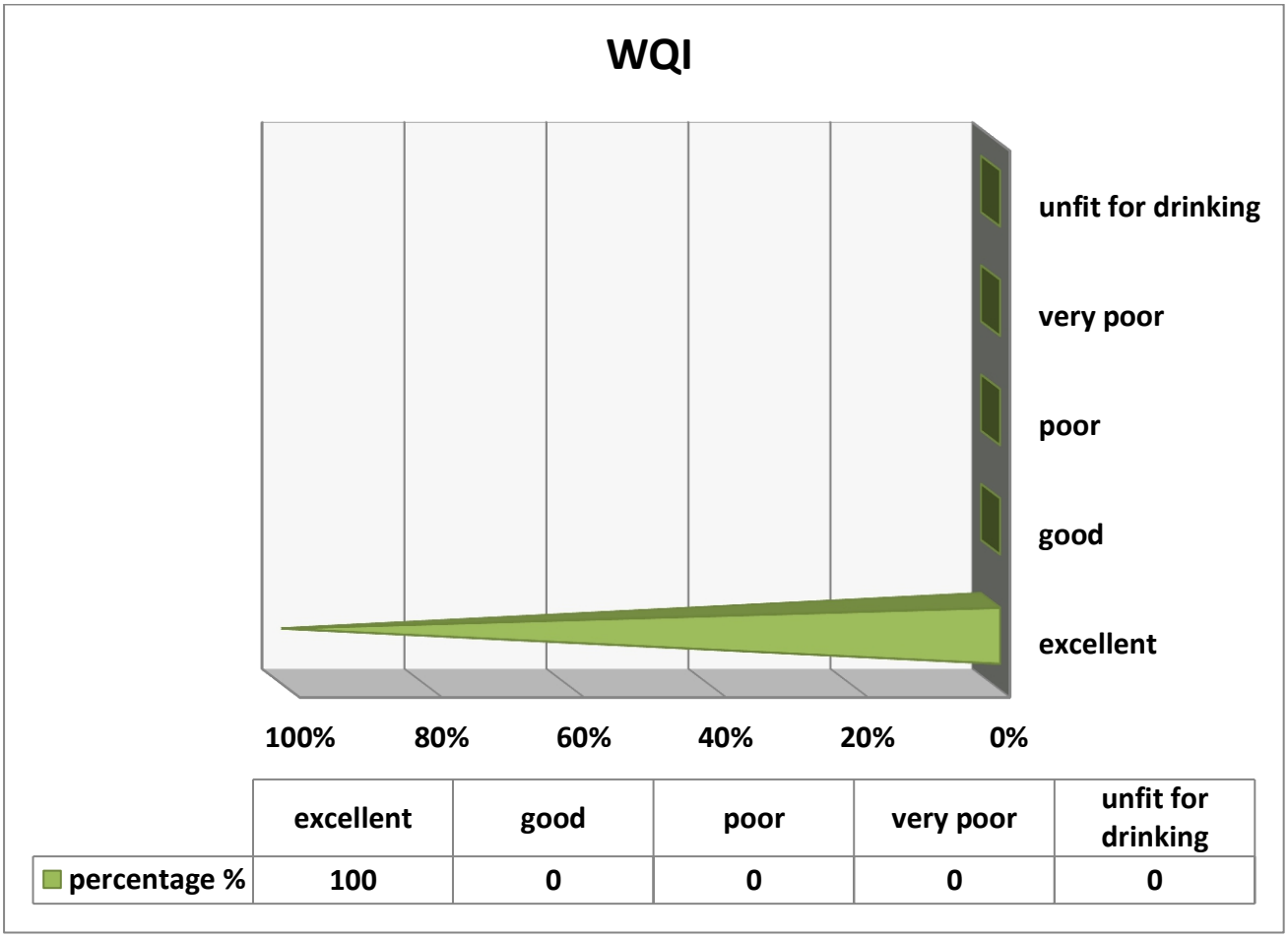


Figure (6) shows that 100% of water samples are excellent.

Table (13) water quality classification based on NO_3 content summer season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	21	95.5	
26-50	good	0	0	
51-75	poor	1	4.5	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		22	100	2.2

The above table shows that 95.5%, 4.5% samples are excellent, poor and the general WQI is excellent

Figure (7) WQI of NO_3 for drinking water samples in summer season

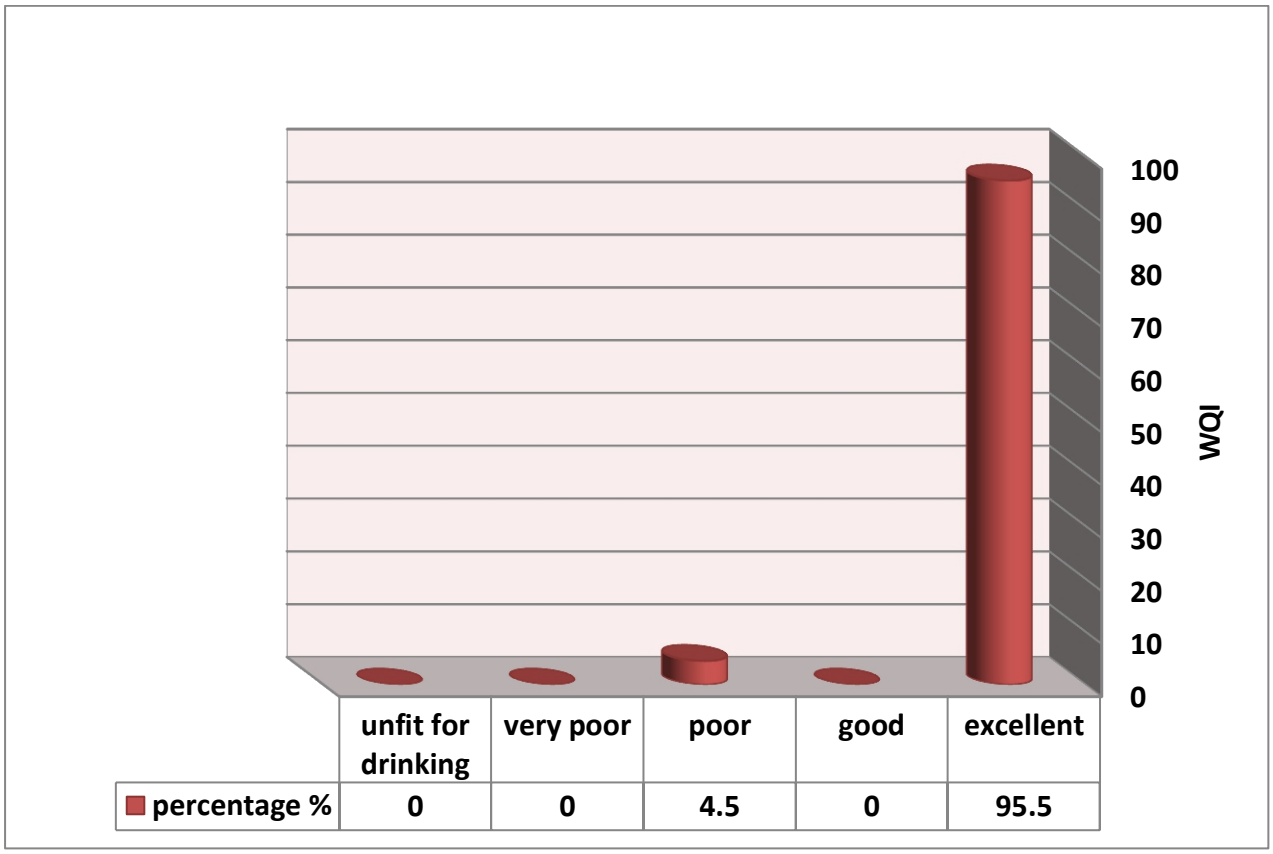


Figure (7) shows that 95.5% of water samples are excellent and 4.5 of them are poor.

table (14) Physio-chemical analysis for water samples

Sampling date	Sample NO	source	location	TURB. NTU	TDS PPM	Conduct. µs/cm	pH	F mg/l	Hardness $CaCO_3$ mg/l
Autumn 2014	51	well	quraish	1	305	611	7.5	0.6	245
	52	tap	Block 15	0.8	214	430	7.8	0.8	145
	53	tap	Block 1	1.5	145	291	7.8	0.2	105
	54	well	Block 14	1.1	187	375	7.9	0.4	150
	55	well	quraish	3.4	257	515	7.8	0.4	170
	56	well	Block 18	14.3	257	514	7.7	0.2	170
	57	tap	Block 14	1.3	189	379	7.6	0.0	145
	58	well	Block 15	0.9	204	408	7.7	0.1	145
	59	tap	Block 18	10.9	254	510	7.7	0.0	260
	60	tap	quraish	1.1	307	614	7.5	0.5	175
	61	tap	quraish	1.1	307	614	7.4	0.5	190
	62	storage	Block 29	0.9	269	539	7.7	0.2	175
	63	storage	quraish	1.5	256	512	7.6	0.2	105
	64	tap	Block 17	1.2	228	457	7.6	0.3	200
	65	storage	Block 16	2	145	290	7.8	0.2	100
	66	tap	Block 18	1.5	255	509	7.7	0.2	145
	67	well	Block 16	2.3	146	292	7.8	0.01	90
	68	storage	Block 17	1.9	225	450	7.7	0.5	150
	69	tap	Block 12	1.5	149	299	7.8	0.2	110
	70	tap	Block 2	0.7	148	297	7.8	0.4	100
	71	storage	quraish	1.8	253	508	7.5	0.1	165
	72	well	Block 1	2.2	214	429	7.4	0.1	160
	73	tap	quraish	3.3	300	601	7.6	0.4	220
	74	storage	Block 19	2.1	254	509	7.7	0.0	135
	75	well	Block 29	0.8	275	551	7.5	0.1	135

Table (14) shows that the lowest values of turbidity , TDS, conductivity, pH, F and hardness are: 0.7 NTU, 145 PPM, 291 µs/cm, 7.4, 0.0mg/l and 90 mg/l, also the highest values are: 14.3 NTU, 307 PPM, 614 µs/cm, 7.9, 0.8 mg/l and 260mg/l respectively.

Table (15) Physio-chemical analysis for water samples.

Sampling date	Sample NO	source	location	TURB. NTU	TDS PPM	Conduct. µs/cm	pH	F mg/l	Hardness $CaCO_3$ mg/l
Autumn 2014	76	tap	Block 19	1.1	255	509	7.5	0.0	160
	77	tap	Block 9	4.4	171	342	7.7	0.9	125
	78	well	Block 7	7.6	170	340	7.6	0.3	150
	79	well	Block 5	15.2	151	301	8.3	0.5	140
	80	tap	Block 8	1	219	438	7.5	0.7	140
	81	storage	Block 13	3	169	338	7.7	0.8	75
	82	well	Block 5	1.5	147	295	7.8	0.6	105
	83	tap	Block 6	1.3	148	296	7.5	0.4	125
	84	well	Block 8	1.3	219	448	7.5	1.1	140
	85	tap	Block 5	0.8	147	295	7.6	1.0	155
	86	tap	Block 7	5.4	170	340	7.6	0.4	95
	87	well	Block 12	1.8	148	297	7.8	0.3	110
	88	well	Block 8	1.5	220	442	7.5	0.3	90
	89	tap	Block 4	1.6	147	295	7.6	0.5	140
	90	well	Block 5	2.3	156	313	7.5	0.5	125
	91	well	Block 21	2.5	145	290	7.7	0.6	130
	92	well	Block 10	1.4	167	333	7.7	1.2	110
	93	well	Block 22	2.1	147	294	7.7	0.3	90
	94	tap	Block 24	0.8	271	542	7.2	0.5	200
	95	tap	Block 36	1	272	544	7.4	1.2	200
	96	storage	Block 23	1.3	272	545	7.4	0.2	190
	97	storage	Block 24	1.8	272	543	7.5	0.3	170
	98	tap	Block 37	1.1	272	544	7.5	0.4	175
	99	well	Block 38	1	186	373	7.6	0.2	145
	100	well	Block 20	3.4	152	305	7.5	0.1	110

Table (15) shows that the lowest values of turbidity , TDS, conductivity, pH, F and hardness are: 0.8 NTU, 147 PPM, 295 µs/cm, 7.2, 0.0mg/l and 75 mg/l, also the highest values are: 15.2 NTU, 272 PPM, 544 µs/cm, 8.3, 1.2 mg/l and 200mg/l respectively.

Table (16) chemical analysis for water samples

Sampling date	Sample NO	Source	location	Fe^{+2} mg/l	SO_4 mg/l	NO_3 mg/l
Autumn 2014	51	well	quraish	0.0	7	0.0
	54	well	Block 14	0.2	5	0.9
	55	well	quraish	0.02	8	0.5
	56	well	Block 18	0.01	1	0.5
	58	well	Block 15	0.04	0	0.0
	67	well	Block 16	0.02	5	0.0
	72	well	Block 1	0.02	6	0.9
	75	well	Block 29	0.02	0	26.4
	78	well	Block 7	0.0	0	2.2
	79	$Well_2$	Block 5	0.1	1	2.2
	82	$Well_1$	Block 5	0.02	0	0.9
	84	well	Block 8	0.04	12	3.5
	87	well	Block 12	0.1	11	0.0
	88	well	Block 8	0.1	18	3.5
	90	$Well_3$	Block 5	0.04	14	0.5
	91	well	Block 21	0.1	7	0.0
	92	well	Block 10	0.2	0	7.5
	93	well	Block 22	0.01	9	2.2
	99	well	Block 38	0.0	3	3.5
	100	well	Block 20	0.01	6	2.2

Table (16) shows that the lowest concentrations of Fe^{+2}, SO_4, and NO_3 are: 0.0 mg/l, 0 mg/l and 0.0 mg/l, also the highest concentrations are: 0.2 mg/l, 18 mg/l and 26.4 mg/l respectively.

Table (17) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
Autumn 2014	81	storage	Block 3	+VE	+VE	-VE
	82	tap	Block 7	+VE	+VE	-VE
	83	tap	Block 3	+VE	+VE	-VE
	84	well	Block 12	+VE	+VE	+VE
	85	well	Block 5	+VE	+VE	- VE
	86	storage	Block 6	+VE	+VE	+ VE
	87	tap	Block 13	+VE	+VE	- VE
	88	tap	Block 7	+VE	+VE	- VE
	89	tap	Block 9	+VE	+VE	- VE
	90	storage	Block 8	+VE	+VE	- VE
	91	well	Block 5	+VE	+VE	- VE
	92	tap	Block 13	+VE	+VE	-VE
	93	tap	Block 7	+VE	+VE	+VE
	94	tap	Block 4	+VE	+VE	-VE
	95	tap	Block 5	+VE	+VE	+VE
	96	well	Block 13	+VE	+VE	+VE
	97	tab	Block 12	+VE	+VE	-VE
	98	well	Block 8	+VE	+VE	+VE
	99	tap	Block 6	+VE	+VE	-VE
	100	tap	Block 8	+VE	+VE	-VE
	101	storage	Block 8	+VE	+VE	-VE
	102	storage	Block 4	+VE	+VE	-VE
	103	tap	Block 9	+VE	-VE	-VE
	104	tap	Block 8	+VE	+VE	+VE
	105	well	Block 6	+VE	+VE	+VE
	106	tap	Block 5	+VE	+VE	-VE
	107	storage	Block 19	+VE	+VE	-VE

Key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (17) shows that 29.6 % of samples indicated presence of fecal pollution

- Note: all samples were received at laboratory within six hours from time of collection.

Table (18) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
Autumn 2014	108	well	quraish	+VE	+VE	-VE
	109	well	Block 18	+VE	+VE	+VE
	110	tap	quraish	+VE	+VE	+VE
	111	tap	Block 18	+VE	+VE	-VE
	112	tap	Block 18	+VE	+VE	-VE
	113	well	Block 14	+VE	+VE	-VE
	114	well	Block 16	+VE	-VE	-VE
	115	well	Block 1	+VE	+VE	-VE
	116	tap	Block 2	+VE	+VE	-VE
	117	tap	Block 1	+VE	+VE	+VE
	118	tap	Block 15	+VE	+VE	-VE
	119	tap	quraish	+VE	+VE	-VE
	120	tap	Block 12	+VE	+VE	-VE
	121	storage	Block 16	+VE	+VE	-VE
	122	well	quraish	+VE	+VE	-VE
	123	tap	Block 19	+VE	+VE	-VE
	124	storage	Block 29	+VE	-VE	-VE
	125	tap	Block 14	+VE	+VE	-VE
	126	storage	quraish	+VE	+VE	-VE
	127	storage	Block 17	+VE	+VE	-VE
	128	well	Block 29	+VE	+VE	-VE
	129	tap	quraish	+VE	+VE	+VE
	130	storage	quraish	+VE	+VE	+VE
	131	tap	Block 7	+VE	+VE	+VE
	132	well	Block 15	+VE	+VE	-VE
	133	well	Block 22	+VE	+VE	+VE
	134	well	Block 21	+VE	-VE	-VE

Key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (18) shows that 22.2 % of samples indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection

Table (19) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
Autumn 2014	135	tap	Block 36	+VE	+VE	+VE
	136	tap	eldaim	+VE	-VE	-VE
	137	storage	Block 21	+VE	+VE	+VE
	138	tap	Block 11	+VE	+VE	-VE
	139	tap	Block 30	+VE	+VE	+VE
	140	storage	Block 37	+VE	+VE	+VE
	141	storage	Block 36	+VE	+VE	+VE
	142	tap	Block 23	+VE	+VE	+VE
	143	storage	Block 38	+VE	+VE	+VE
	144	storage	Block 24	+VE	+VE	+VE
	145	tap	Block 23	+VE	-VE	-VE
	146	tap	Block 37	+VE	-VE	-VE
	147	storage	Block 25	+VE	+VE	+VE
	148	storage	Block 10	+VE	+VE	+VE
	149	well	Block 10	+VE	+VE	-VE
	150	storage	Block 15	+VE	+VE	+VE
	151	tap	Block 23	+VE	+VE	+VE
	152	tap	Block 21	+VE	+VE	-VE
	153	storage	Block 29	+VE	+VE	+VE
	154	tap	Block 14	+VE	+VE	+VE
	155	storage	Block 21	+VE	+VE	+VE
	156	storage	Block 22	+VE	-VE	-VE
	157	tap	Block 10	+VE	+VE	+VE
	158	well	Block 38	+VE	+VE	+VE
	159	tap	Block 38	+VE	+VE	+VE
	160	storage	Block 20	+VE	+VE	-VE

Key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (19) shows that 69.2 % of samples are indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection.

Table (20) water quality classification based on turbidity in autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	14	28	
26-50	good	26	52	
51-75	poor	4	8	
76-100	Very poor	1	2	
Above 100	Unfit for drink	4	10	
total		50	100	50.9

The above table shows that 28%, 52%, 8% of samples are excellent, good, poor respectively and 10% of them unfit for drink, the general WQI is poor.

Figure (8) WQI of turbidity for drinking water samples autumn season

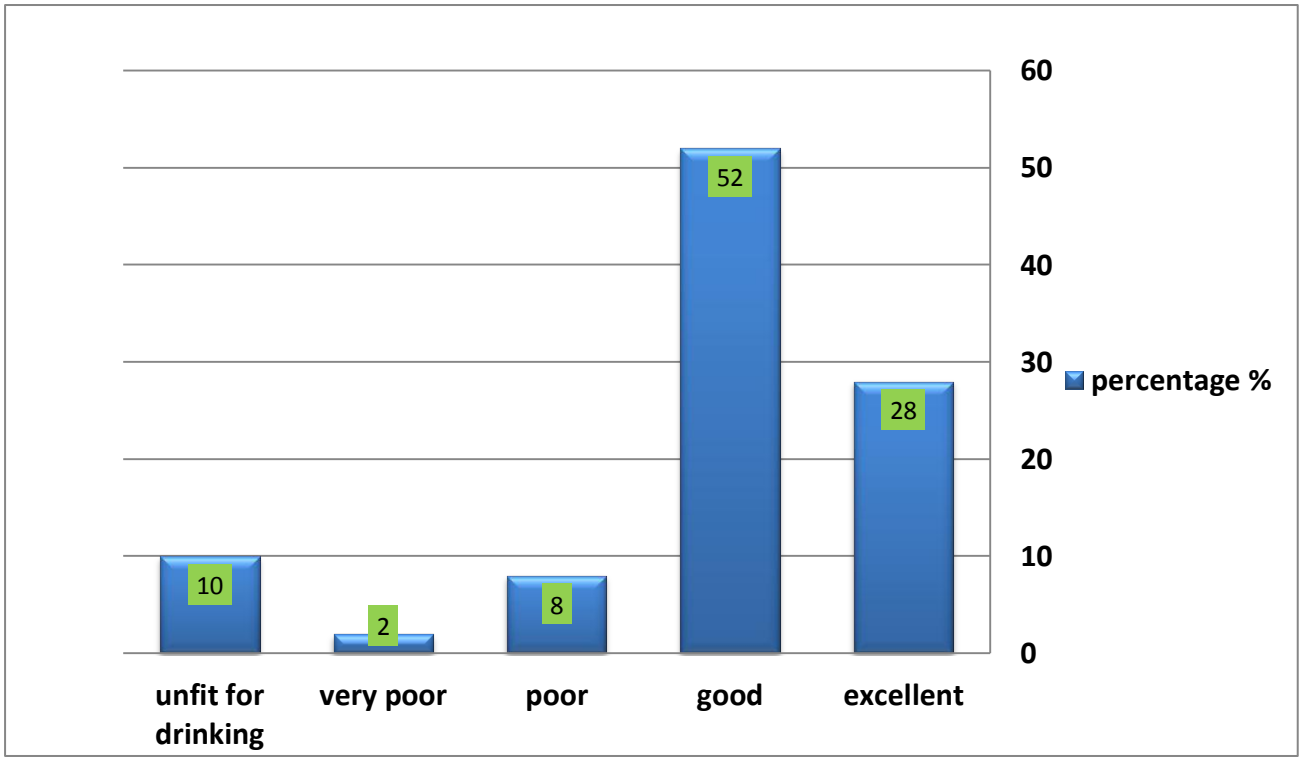


Figure (8) shows that most of the samples are good and 10% of them are unfit for drinking.

Table (21) water quality classification based on pH autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	1	2	
26-50	good	39	78	
51-75	poor	9	18	
76-100	Very poor	1	2	
Above 100	Unfit for drink	0	0	
total		50	100	50

The above table shows that 2 %,78 %,18% of samples are excellent, good, poor respectively and general WQI is good.

Figure (9) WQI of PH for drinking water samples autumn season

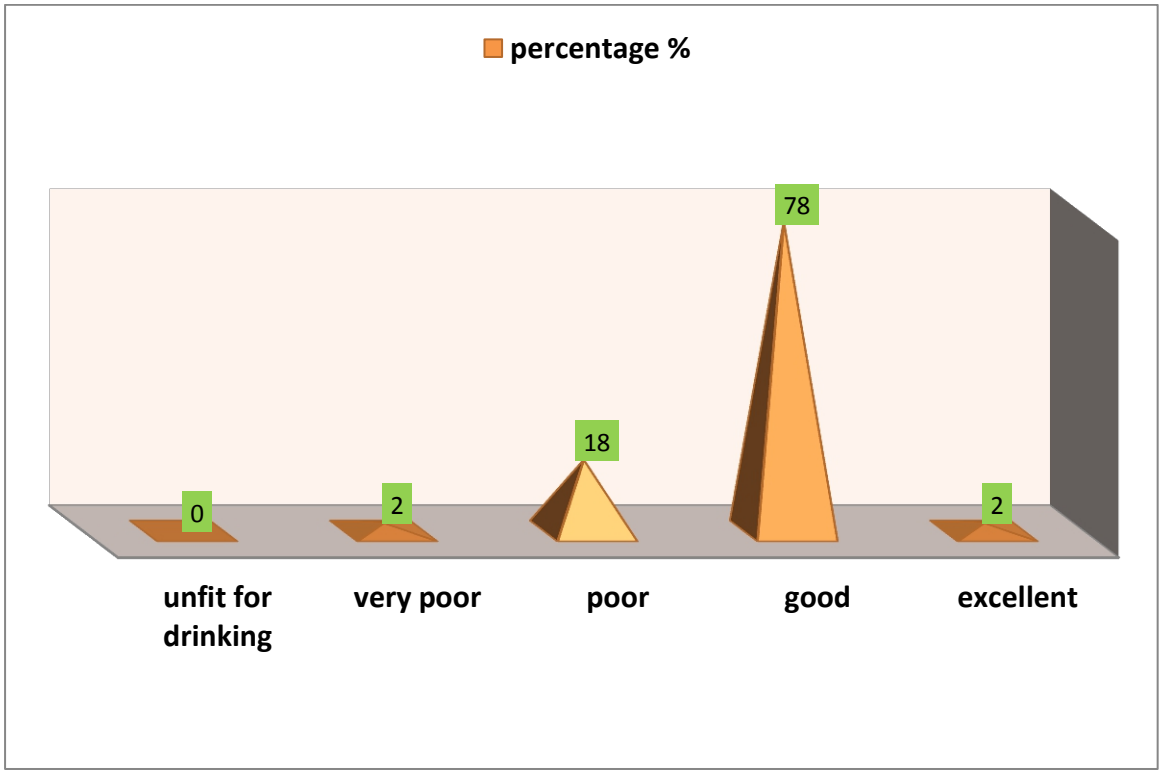


Figure (9) shows that 2%, 78%, 18% of water samples are excellent, good, poor respectively and 2% of them are very poor.

Table (22) water quality classification based on TDS autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	31	62	
26-50	good	19	38	
51-75	poor	0	0	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		50	100	22.1

The above table shows that 62 % and 38 % of samples are excellent, good respectively and general WQI is excellent.

Figure (10) WQI of TDS for drinking water samples in autumn season

Figure (10) shows that 62% of water samples are excellent and 38% of them are good.

Table (23) water quality classification based on Fluoride content autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	25	50	
26-50	good	19	33	
51-75	poor	5	10	
76-100	Very poor	1	2	
Above 100	Unfit for drink	0	0	
total		50	100	33.3

The above table shows that 50 %, 33%, and 38 % of samples are excellent, good, and poor respectively and general WQI is good.

Figure (11) WQI of fluoride for drinking water samples in autumn season

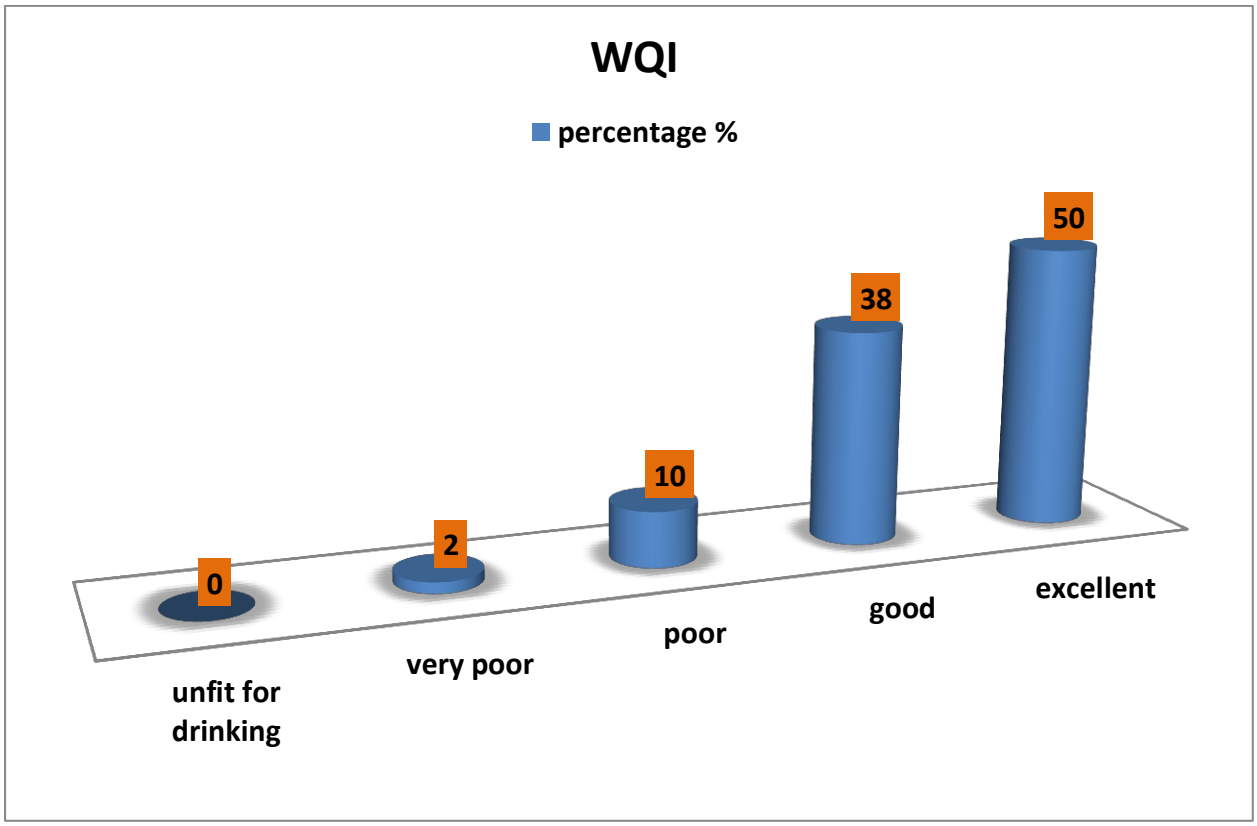


Figure (11) shows that 50%, 38%, 10% of water samples are excellent, good, poor and 2% of them are very poor.

Table (24) water quality classification based on Fe^{+2} content in autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	14	70	
26-50	good	4	20	
51-75	poor	2	10	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		20	100	19.2

The above table shows that 70%, 20% and 10% of samples are excellent, good, and poor respectively and the general WQI is excellent.

Figure (12) WQI of Fe^{+2} for drinking water samples in autumn season

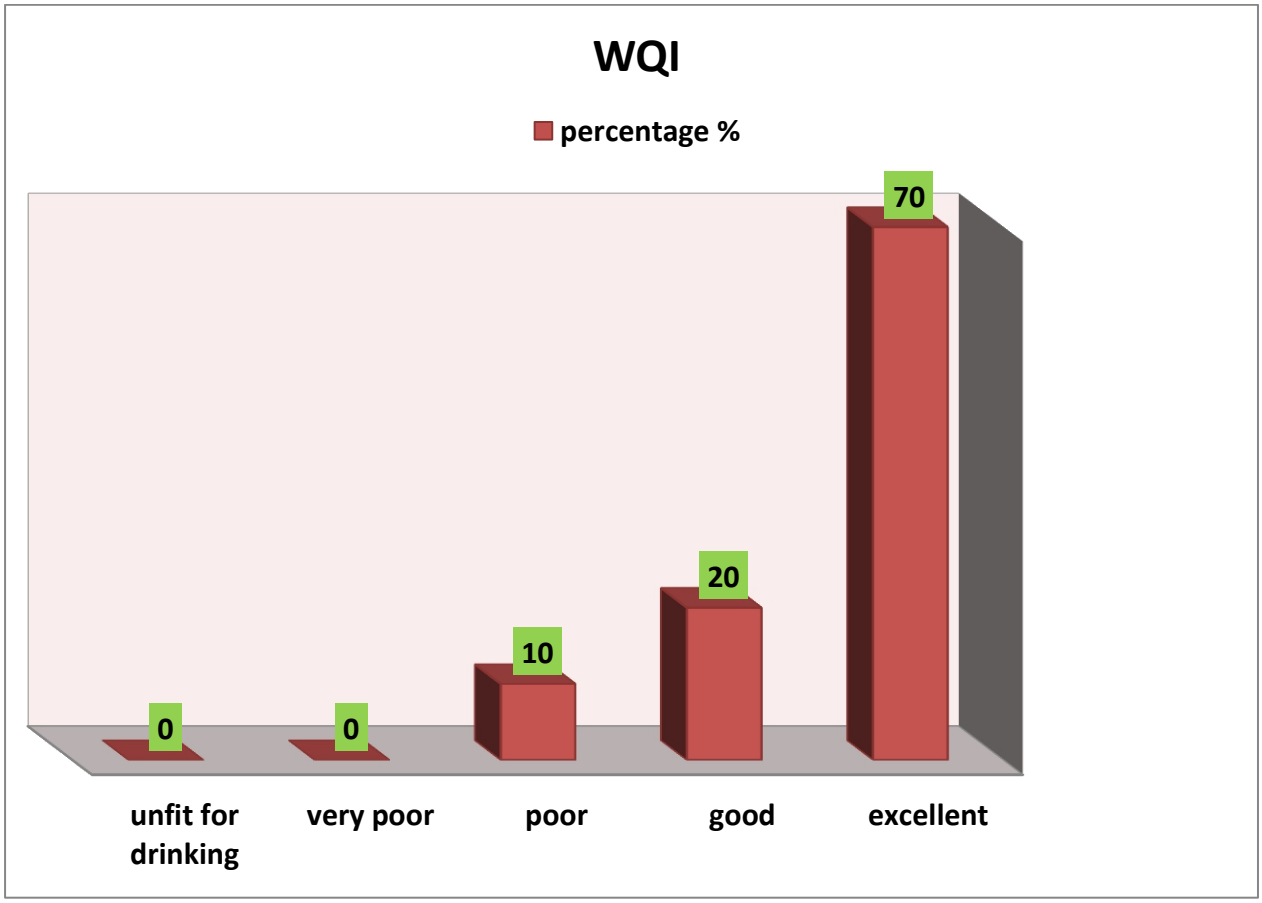


Figure (12) shows that 70%, 20%, of water samples are excellent, good, and 10% of them are poor.

Table (25) water quality classification based on SO_4 content in autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	20	100	
26-50	good	0	0	
51-75	poor	0	0	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		20	100	2.1

The above table shows that all samples are excellent and the general WQI is excellent

Figure (13) WQI of SO_4 for drinking water samples in autumn season

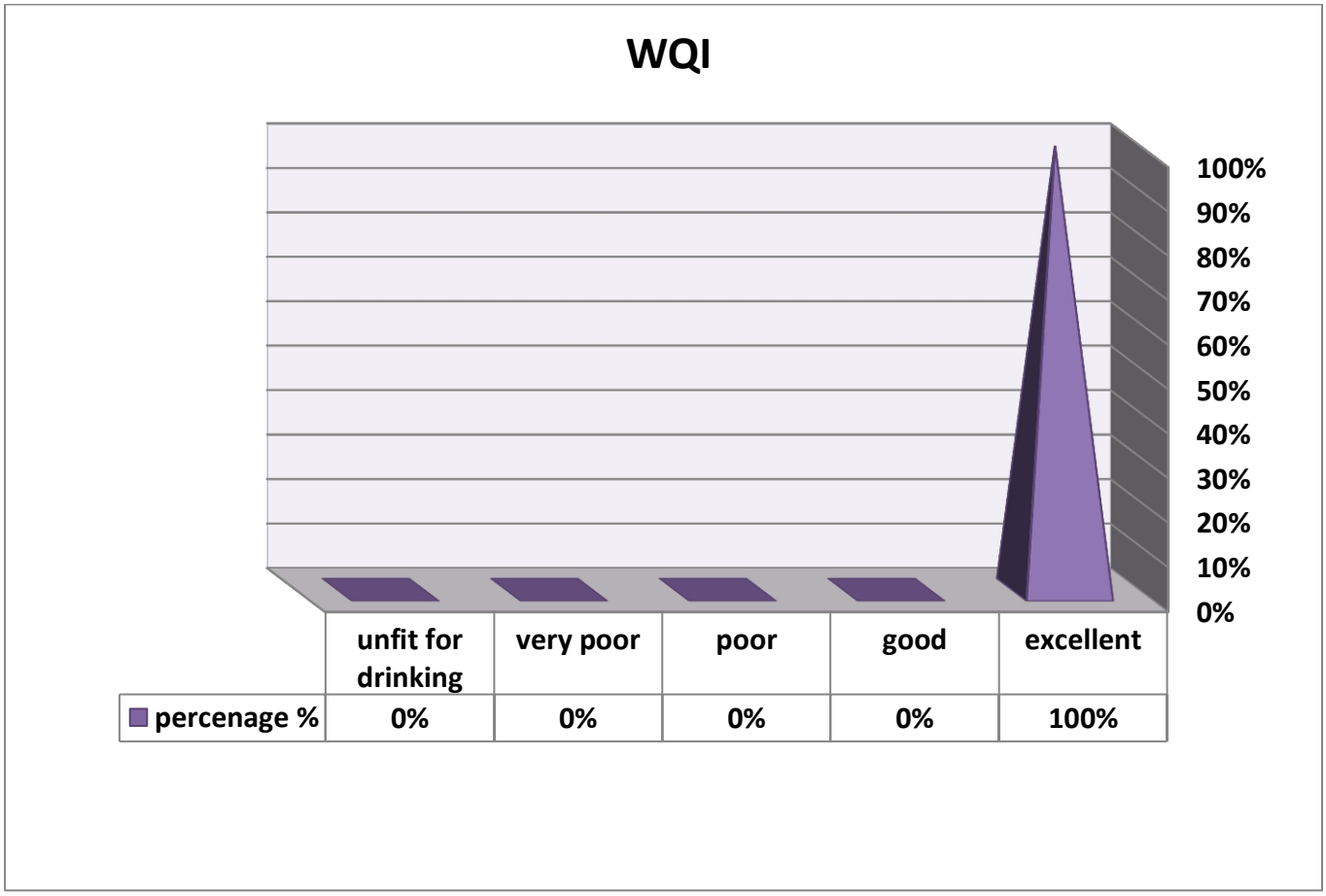


Figure (13) shows that 100%, of water samples are excellent.

Table (26) water quality classification based NO_3 content in autumn season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	19	95	
26-50	good	0	0	
51-75	poor	1	5	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		20	100	0.95

The above table shows that 95 % and 5% samples are excellent, poor and the general WQI is excellent

Figure (14) WQI of NO_3 for drinking water samples in autumn season

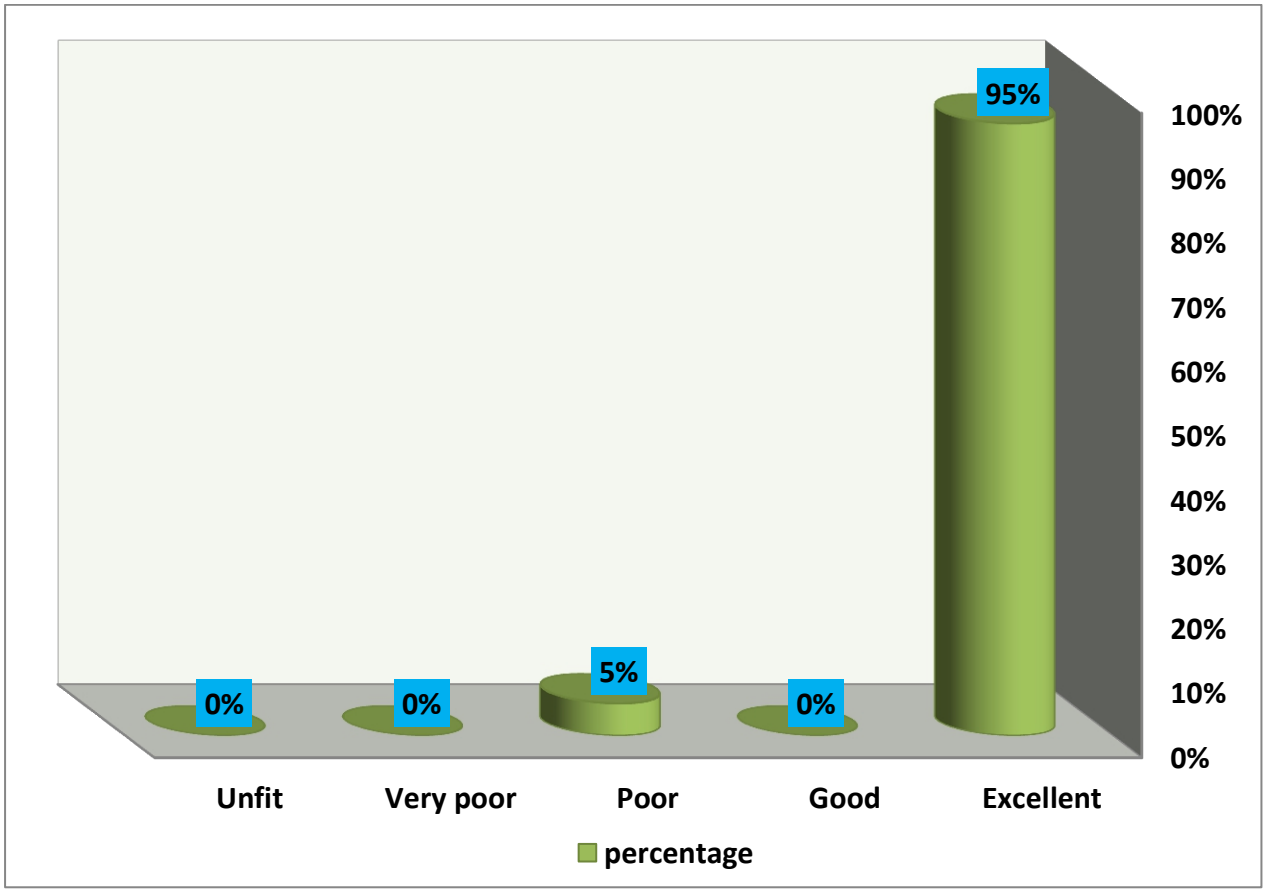


Figure (14) shows that 95 % of water samples are excellent and 5 of its poor.

Table (27) Physio-chemical analysis for water samples

Sampling date	Sample NO	source	Location	TURB. NTU	TDS PPM	Conduct. µs/cm	pH	F mg/l	Hardness $CaCO_3$ mg/l
winter 2014-2015	101	storage	Block 7	6.1	87	173.5	8.1	0.3	130
	102	well	Block 4	1.5	79.4	152.7	8.1	0.0	85
	103	tap	Block 8	2.4	115	231	7.5	0.5	155
	104	well	Block 5	2.9	77.1	154.6	7.7	0.5	100
	105	storage	Block 9	4.0	167	336	8.0	1.2	105
	106	tap	Block 9	4.3	86.7	173.1	8.0	1.5	145
	107	tap	Block 13	3.1	87.5	174.2	7.6	0.1	125
	108	tap	Block 12	1.8	74.6	146.7	7.6	0.7	228
	109	tap	Block 3	0.7	75.1	150.5	7.6	0.2	166
	110	Well	Block 8	2.4	115	232	7.5	0.5	180
	111	tap	Block 5	1.6	77.5	153.1	7.9	0.8	229
	112	tap	Block 6	1.1	77.3	151.3	7.7	0.7	192
	113	storage	Block 8	3.5	114	229	7.5	0.5	150
	114	well	Block 12	1.8	74.5	152.8	7.7	0.2	317
	115	well	Block 7	5.6	85.9	171.6	7.6	1.1	125
	116	well	Block 8	0.9	132	264	7.6	0.3	160
	117	tap	Block 2	0.9	74.7	150.2	7.7	0.4	126
	118	tap	Block 7	5.1	85.9	171.4	7.5	0.7	135
	119	well	Block 5	0.3	79.3	158.6	7.9	0.5	229
	120	tap	Block 4	0.4	75.6	161.7	7.7	0.6	272
	121	tap	Block 38	0.3	92.9	184.3	7.4	0.0	130
	122	tap	Quraish	0.2	295	593	7.3	1.3	225
	123	well	Block 21	1.1	147	291	7.7	1.0	90
	124	well	Block 22	6.9	73.4	147.4	7.7	0.9	105
	125	storage	Quraish	2.6	232	462	7.5	1.2	205

Table (27) shows that the lowest values of turbidity , TDS, conductivity, pH, F and hardness are: 0.2 NTU,73.4 PPM, 147.4 µs/cm, 7.3, 0.0mg/l and 85 mg/l, also the highest values are: 6.9 NTU, 232 PPM, 462 µs/cm, 8.1, 1.5 mg/l and 317mg/l respectively.

Table (28) Physio-chemical analysis for water samples.

Sampling date	Sample NO	source	Location	TURB. NTU	TDS PPM	Conduct. µs/cm	pH	F mg/l	Hardness $CaCO_3$ mg/l
Winter 2014-2015	126	well	Quraish	0.7	210	421	7.4	0.2	275
	127	tap	Block 18	0.5	134	272	7.4	0.1	165
	128	storage	Block 18	1.1	321	644	7.8	0.0	145
	129	well	Block 29	0.2	155	316	7.6	0.2	165
	130	well	Block 14	1.0	210	425	7.9	0.0	150
	131	tap	Block 17	1.4	210	419	7.5	0.4	150
	132	tap	Block 24	0.3	220	442	7.6	0.0	145
	133	well	Block 10	1.5	173	344	7.6	0.2	100
	134	storage	Block 15	1.2	197	395	7.8	0.0	120
	135	tap	Block 16	0.5	141	284	7.7	0.0	85
	136	storage	Block 20	4.8	79.9	155.8	7.8	0.0	110
	137	well	Aldaim	0.3	199	397	7.5	0.2	140
	138	storage	Block 21	1.4	73.7	148.8	7.7	0.0	120
	139	tap	Block 14	0.6	108	215	7.5	0.0	125
	140	well	Block 20	2.5	77.9	155.4	7.6	0.1	95
	141	tap	Block 29	0.1	266	529	7.2	0.02	215
	142	well	Quraish	0.2	161	322	7.5	0.0	135
	143	well	Block 16	1.3	145	291	7.7	0.5	55
	144	storage	Quraish	0.7	295	594	7.7	0.0	195
	145	well	Block 38	0.3	185	376	7.7	0.0	95
	146	tap	Block 22	5.4	142	284	7.6	0.02	50
	147	tap	Block 19	1.3	324	638	7.7	0.0	175
	148	tap	Block 10	1.2	171	347	7.7	0.2	85
	149	tap	Block 37	1.1	185	371	7.4	0.0	100
	150	tap	Block 23	0.6	262	527	7.3	0.0	150

Table (28) shows that the lowest values of turbidity , TDS, conductivity, pH, F and hardness are: 0.1 NTU, 73.7 PPM, 155.4 µs/cm, 7.2, 0.0mg/l and 50 mg/l, also the highest values are: 5.4 NTU, 324 PPM, 644 µs/cm, 7.9, 1.3 mg/l and 275mg/l respectively.

Table (29) chemical analysis for water samples

Sampling date	Sample NO	Source	location	Fe^{+2} mg/l	SO_4 mg/l	NO_3 mg/l
winter 2014-2015	102	well	Block 4	0.1	20	13.2
	104	$Well_1$	Block 5	0.02	14	4.4
	110	well	Block 8	0.0	4	0.5
	114	well	Block 12	0. 1	19	13.2
	115	well	Block 7	0.3	4	48.4
	116	well	Block 8	0.1	0	26.4
	119	$Well_2$	Block 5	0. 2	23	0.9
	123	well	Block 21	0.01	0	4.4
	124	well	Block 22	0.03	0	0.0
	126	well	quraish	0.1	13	8.8
	129	well	Block 29	0.1	0	0
	130	well	Block 14	0.04	17	4.4
	133	well	Block 10	0.1	3	0.0
	137	well	Aldaim	0.12	0	13.2
	140	well	Block 20	0.22	0	0.5
	142	well	quraish	0.2	9	0.0
	143	well	Block 16	0.1	4	0.0
	145	well	Block 38	0.0	12	0.0
	149	well	Block 37	0.3	14	11.5
	150	$Well_3$	Block 5	0.01	16	10.2

Table (29) shows that the lowest concentrations of Fe^{+2}, SO_4, and NO_3 are: 0.0 mg/l, 0.0mg/l and 0.0 mg/l, also the highest concentrations are: 0.3mg/l, 23 mg/l and 48.4 mg/l respectively.

Table (30) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
winter 2014-2015	161	storage	Block 7	+VE	+VE	+VE
	162	well	Block 3	+VE	+VE	-VE
	163	tap	Block 4	+VE	-VE	-VE
	164	tap	Block 2	-VE	-VE	-VE
	165	storage	Block 1	+VE	+VE	- VE
	166	tap	Block 3	+VE	+VE	- VE
	167	$Well_1$	Block 5	+VE	+VE	+VE
	168	storage	Block 2	+VE	+VE	- VE
	169	well	Block 12	+VE	+VE	+VE
	170	storage	Block 3	+VE	+VE	- VE
	171	storage	Block 12	+VE	+VE	- VE
	172	well	Block 8	+VE	+VE	+VE
	173	tap	Block 17	+VE	+VE	-VE
	174	tap	Block 7	+VE	-VE	-VE
	175	storage	Block 13	-VE	-VE	-VE
	176	tab	Block 9	+VE	+VE	-VE
	177	$Well_2$	Block 5	+VE	+VE	-VE
	178	tap	Block 8	+VE	+VE	-VE
	179	well	Block 8	+VE	+VE	-VE
	180	storage	Block 9	+VE	+VE	+VE
	181	tap	Block 6	+VE	+VE	+VE
	182	tap	Block13	+VE	+VE	-VE
	183	tap	Block 1	+VE	-VE	-VE
	184	tap	Block 5	+VE	+VE	-VE
	185	tap	Block 7	+VE	+VE	+VE
	186	tap	Block 12	+VE	+VE	+VE
	187	storage	Block 5	+VE	+VE	-VE

key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (30) shows that 29.6 % of samples are indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection.

Table (31) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
winter 2014-2015	188	storage	Block 29	+VE	+VE	-VE
	189	tap	Block 23	+VE	+VE	+VE
	190	storage	Block 36	+VE	+VE	+VE
	191	storage	quraish	+VE	+VE	-VE
	192	tap	Block 24	+VE	+VE	-VE
	193	storage	Block 15	+VE	+VE	-VE
	194	well	Block 14	+VE	+VE	-VE
	195	storage	Block 19	+VE	+VE	+VE
	196	tap	Block 27	+VE	+VE	+VE
	197	tap	Block 19	+VE	+VE	-VE
	198	storage	quraish	+VE	+VE	+VE
	199	well	Block 29	+VE	+VE	+VE
	200	storage	Aldaim	+VE	+VE	-VE
	201	well	quraish	+VE	+VE	+VE
	202	well	quraish	+VE	+VE	-VE
	203	storage	Block 18	+VE	+VE	-VE
	204	tap	Block 29	+VE	+VE	+VE
	205	storage	Block 23	+VE	+VE	-VE
	206	tap	Block 18	+VE	+VE	-VE
	207	tap	Aldaim	+VE	+VE	-VE
	208	storage	Block 17	+VE	+VE	-VE
	209	storage	Block 24	+VE	+VE	+VE
	210	tap	quraish	+VE	+VE	+VE
	211	well	Aldaim	+VE	+VE	-VE
	212	tap	Block 15	+VE	+VE	+VE
	213	tap	Block 36	+VE	+VE	-VE
	214	tap	quraish	+VE	-VE	-VE

Key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (31) shows that 40.7 % of samples are indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection

Table (32) bacteriological analysis for water samples

Sampling date	Sample NO	source	location	Coliform test/ lauryl	Thermo tolerant test/ BGB	E. coli Test/ EMB
winter 2014-2015	215	well	Block 18	+VE	+VE	+VE
	216	storage	Block 11	+VE	-VE	-VE
	217	storage	Block 37	+VE	+VE	+VE
	218	tap	Block 14	+VE	+VE	-VE
	219	tap	Block 20	+VE	+VE	+VE
	220	well	Block 20	+VE	+VE	-VE
	221	storage	Block 16	+VE	+VE	-VE
	222	tap	Block 10	+VE	+VE	-VE
	223	tap	Block 22	+VE	+VE	-VE
	224	tap	Block 21	+VE	+VE	+VE
	225	well	Block 22	+VE	-VE	-VE
	226	storage	Block 1	+VE	-VE	-VE
	227	storage	Block 14	+VE	+VE	-VE
	228	well	Block 38	+VE	+VE	-VE
	229	tap	Block 11	+VE	+VE	+VE
	230	well	Block 10	+VE	+VE	-VE
	231	tap	Block 37	+VE	+VE	+VE
	232	tap	Block 21	+VE	+VE	+VE
	233	storage	Block 22	+VE	+VE	-VE
	234	storage	Block 38	+VE	+VE	-VE
	235	tap	Block 16	+VE	+VE	+VE
	236	storage	Block 10	+VE	+VE	+VE
	237	tap	Block 11	+VE	+VE	+VE
	238	tap	Block 38	+VE	+VE	-VE
	239	well	Block 1	+VE	+VE	-VE
	240	storage	Block 20	+VE	+VE	-VE

key	
+VE	-VE
Positive / Presence	Negative /Absence

Table (32) shows that 38.5% of samples are indicated presence of feacal pollution

- Note: all samples were received at laboratory within six hours from time of collection.

Table (33) water quality classification based on turbidity in winter season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	26	52	
26-50	good	12	24	
51-75	poor	4	8	
76-100	Very poor	3	6	
Above 100	Unfit for drink	5	10	
total		50	100	36.68

The above table shows 52%, 24%, 8% of samples are excellent, good, poor respectively and 10% of them unfit for drinking, the general WQI is good.

Figure (15) WQI of turbidity for drinking water samples winter season

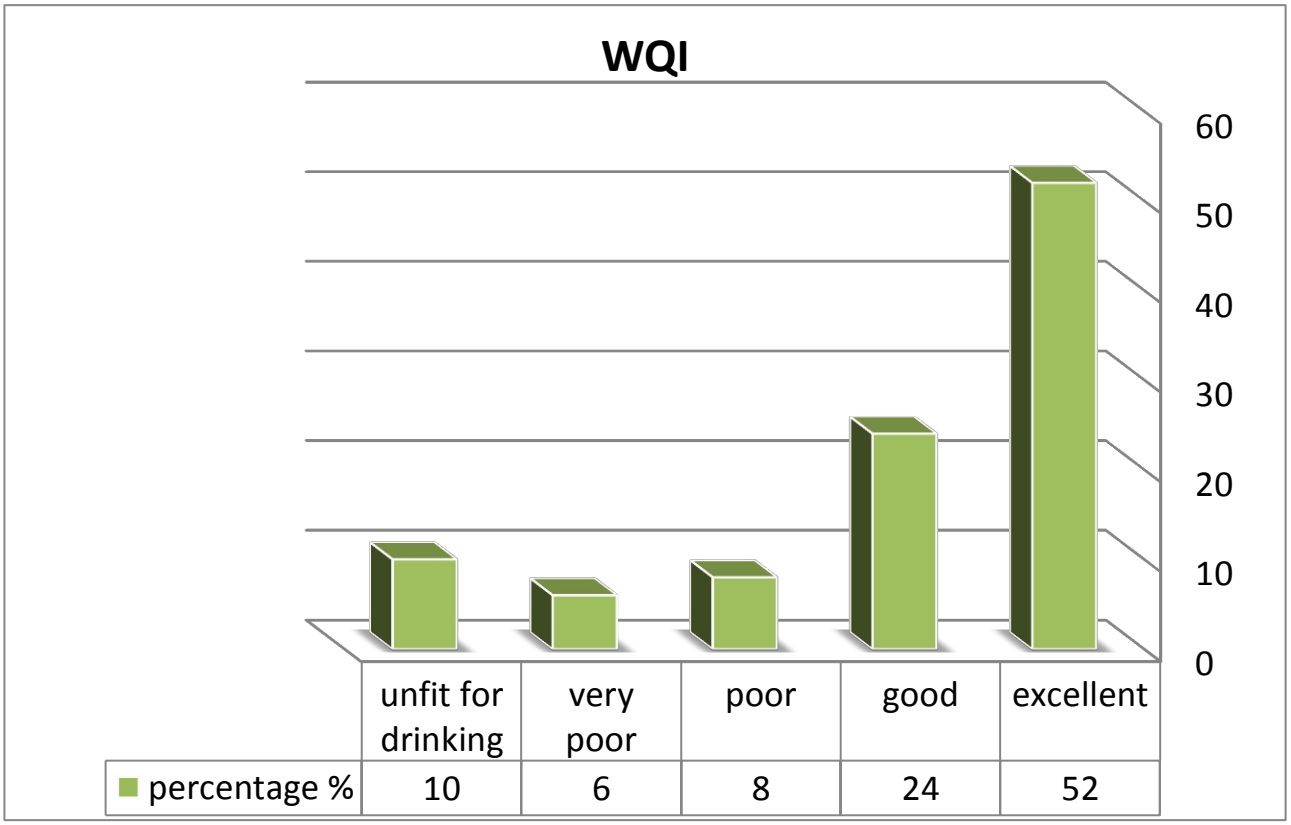


Figure (15) shows that 52%, 24%, 6% of samples are excellent, good, very poor respectively and 10% of them unfit for drinking.

Table (34) water quality classification based on pH in winter season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	3	6	
26-50	good	37	74	
51-75	poor	10	20	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		50	100	56.66

The above table shows 6 %, 74 %,20% of samples are excellent, good, poor respectively and general WQI is poor.

Figure (16) WQI of pH for drinking water samples winter season

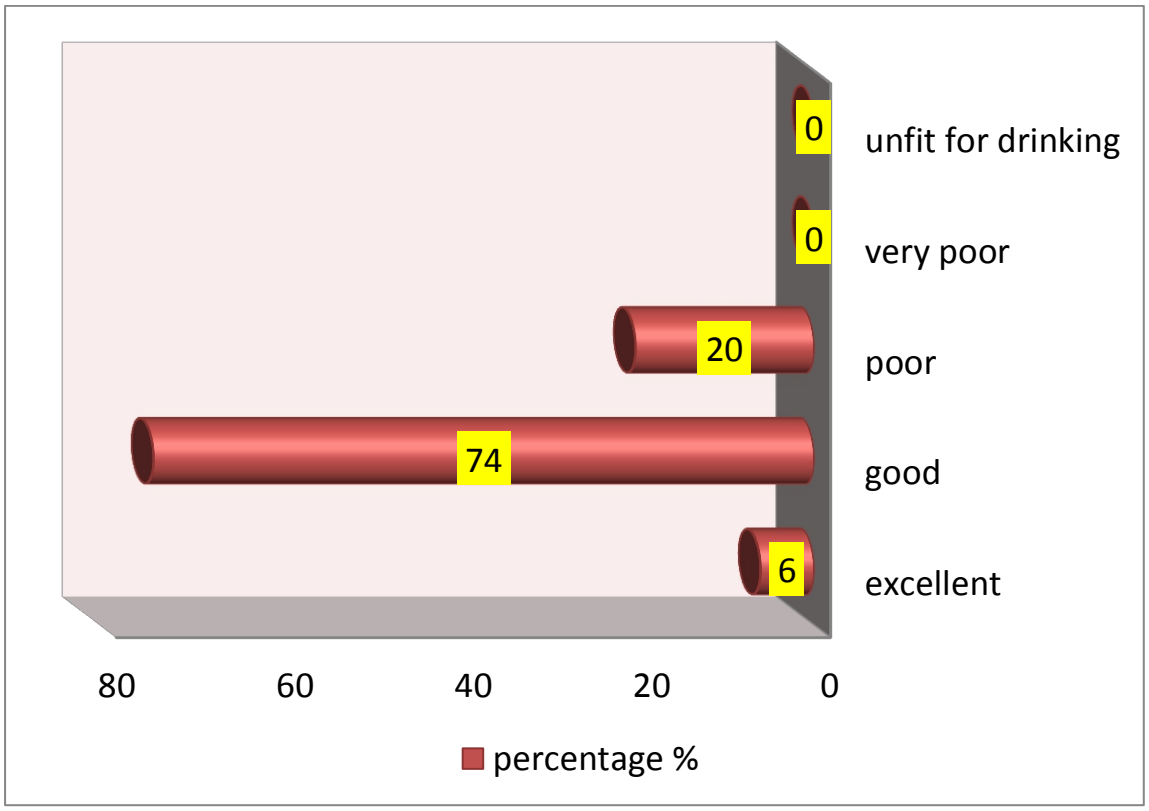


Figure (16) shows that 6%, 74%, 20% of water samples are excellent, good, and poor respectively.

Table (35) water quality classification based on TDS in winter season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	44	88	
26-50	good	6	12	
51-75	poor	0	0	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		50	100	9.38

The above table shows 88 % and 12 % of samples are excellent, good respectively and the general WQI is excellent.

Figure (17) WQI of TDS for drinking water samples in winter season

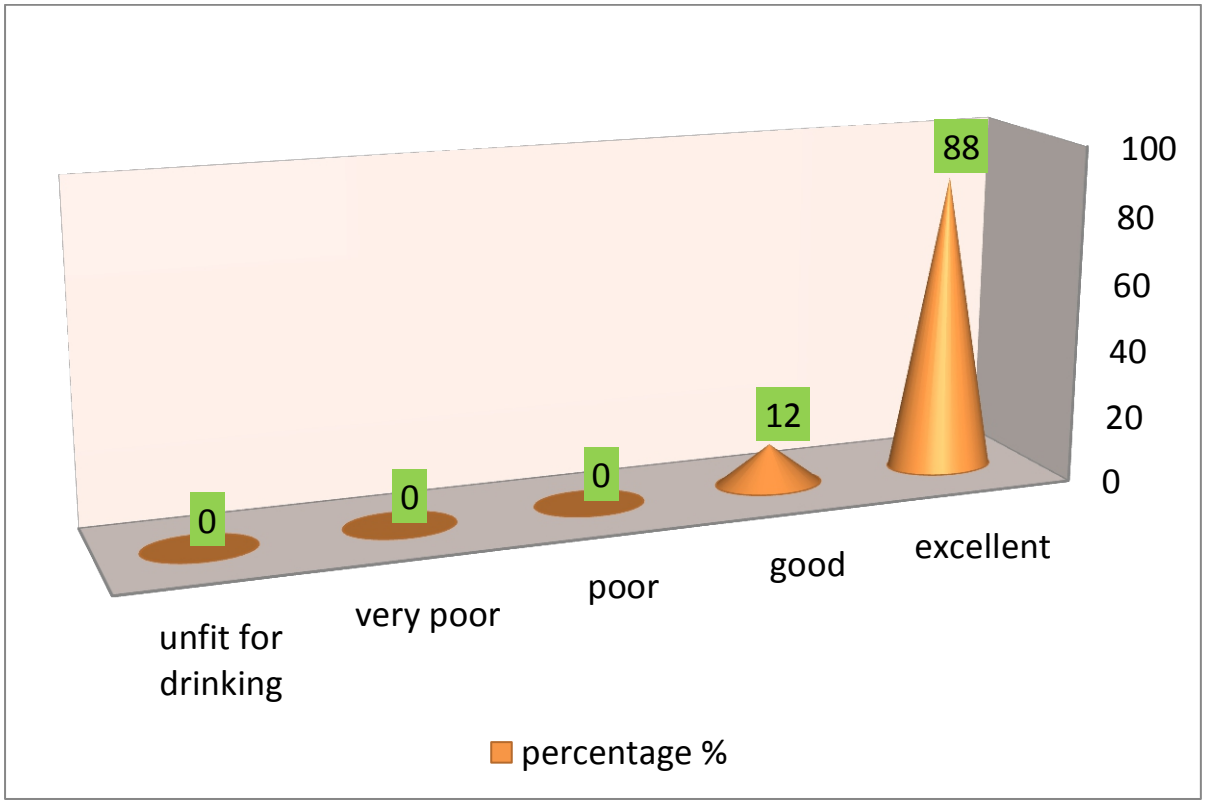


Figure (17) shows that 88% of water samples are excellent and 12% of them are good.

Table (36) water quality classification based on Fluoride content in winter season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	31	62	
26-50	good	12	24	
51-75	poor	3	6	
76-100	Very poor	4	8	
Above 100	Unfit for drink	0	0	
total		50	100	21.66

The above table shows that 62 %, 24%, and 8 % of samples are excellent, good, very poor respectively and the general WQI is excellent.

Figure (18) WQI of fluoride for drinking water samples in winter season

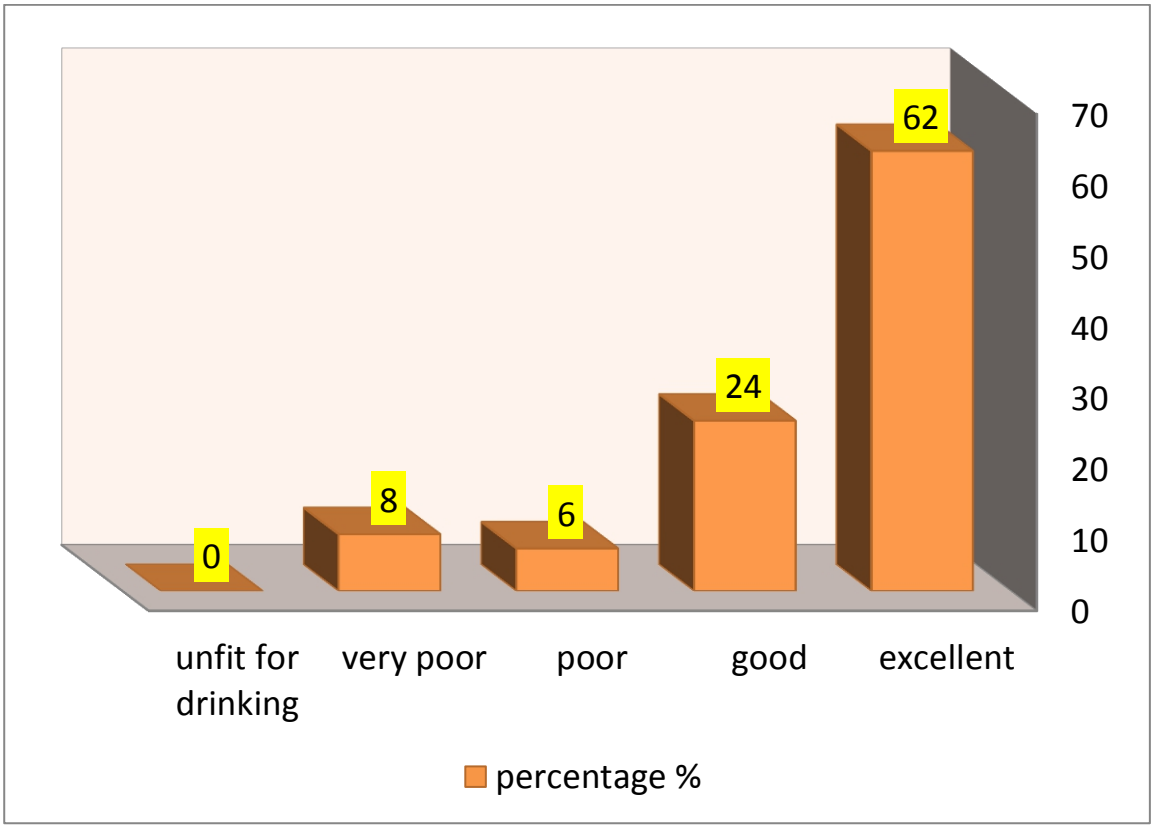


Figure (18) shows that 62%, 24%, 6% of water samples are excellent, good, poor and 8% of them are very poor.

Table (37) water quality classification based on Fe^{+2} content in winter season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	7	35	
26-50	good	8	40	
51-75	poor	3	15	
76-100	Very poor	2	10	
Above 100	Unfit for drink	0	0	
total		20	100	18.33

The above table shows that 35%, 40% and 10% of samples are excellent, good, and very poor respectively and the general WQI is excellent.

Figure (19) WQI of Fe^{+2} for drinking water samples in winter season

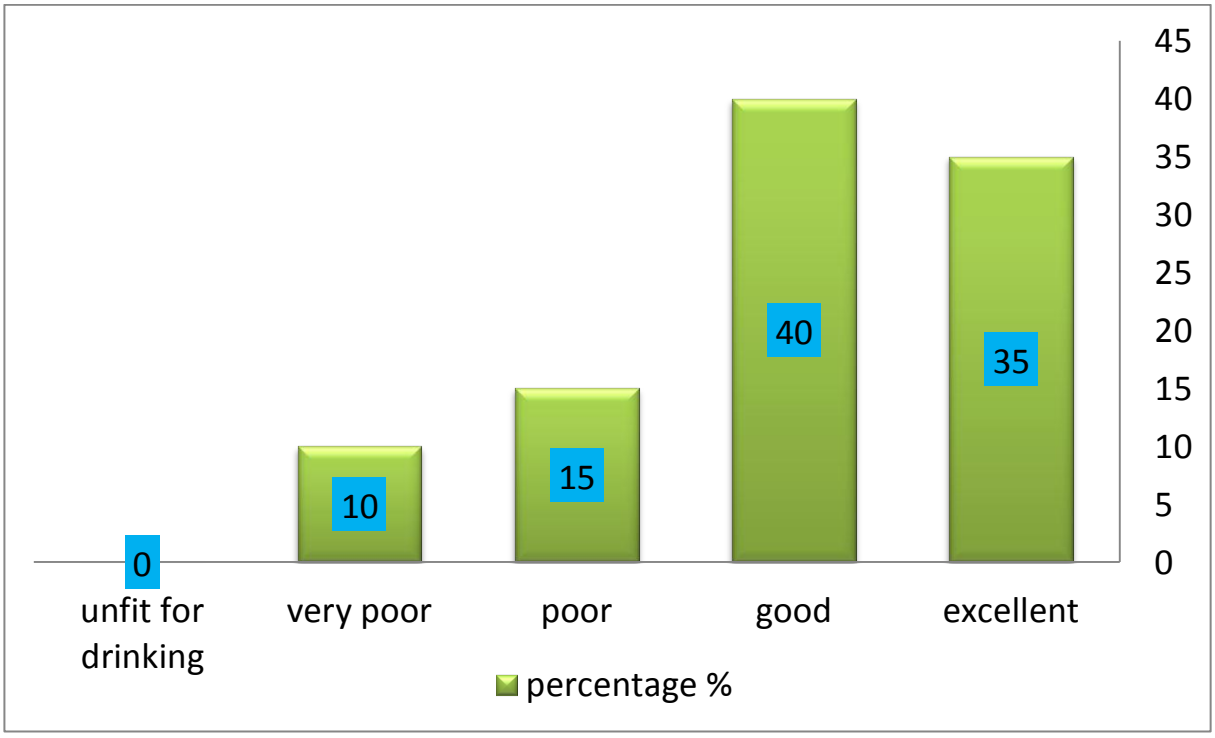


Figure (19) shows that 35%, 40%, 15% of water samples are excellent, good, poor and 10% of them are very poor respectively .

Table (38) water quality classification based on SO_4 content in winter season

WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	20	100	
26-50	good	0	0	
51-75	poor	0	0	
76-100	Very poor	0	0	
Above 100	Unfit for drink	0	0	
total		20	100	5.7

The above table shows that all samples are excellent and the general WQI is excellent

Figure (20) WQI of SO_4 for drinking water samples winter season

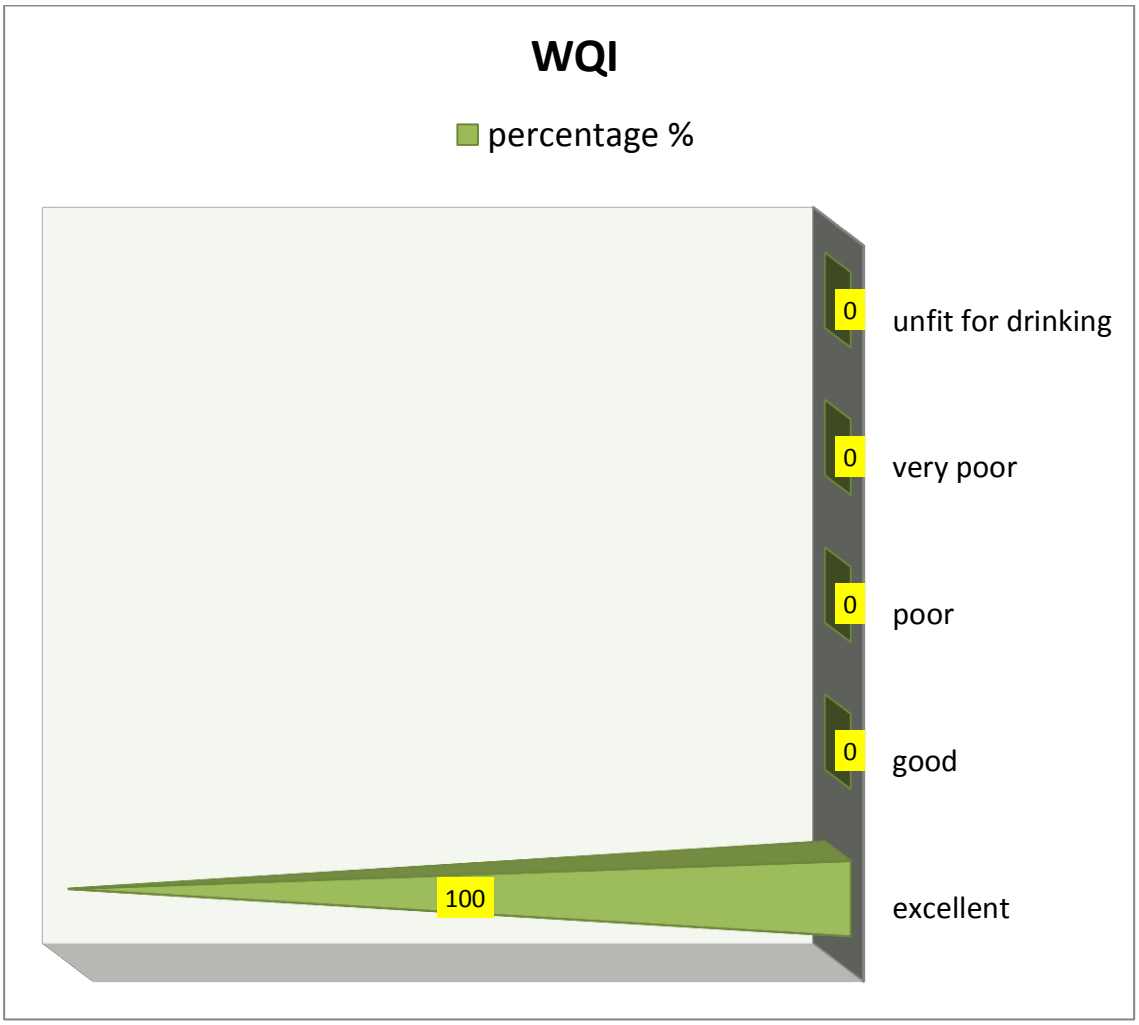


Figure (20) shows that 100%, of water samples are excellent.

Table (39) water quality classification based on NO_3 content in winter season

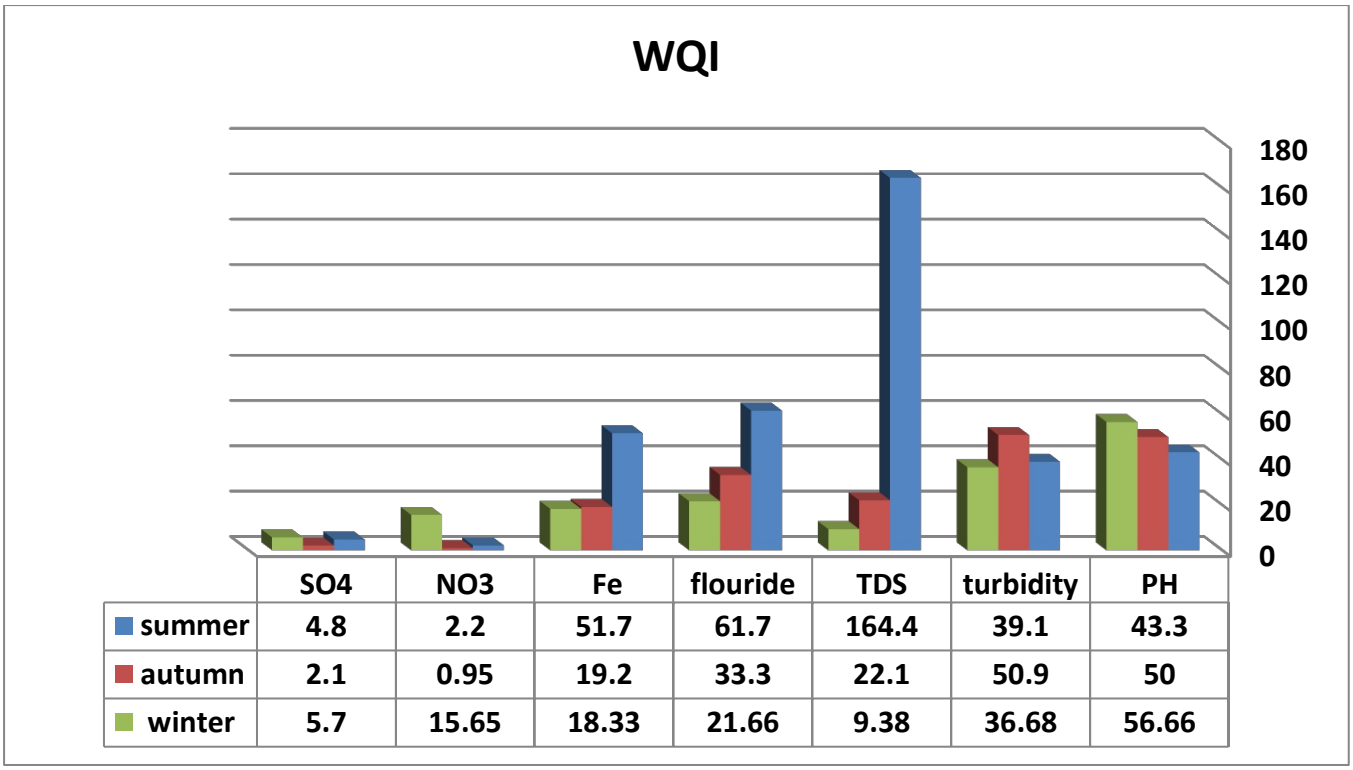
WQI value rate	Water quality	NO of samples	Percentage %	General WQI
0-25	excellent	15	75	
26-50	good	3	15	
51-75	poor	1	5	
76-100	Very poor	1	5	
Above 100	Unfit for drink	0	0	
total		20	100	15.65

The above table shows that 75 %, 15% ,5% of samples are excellent, good, poor and the general WQI is excellent

Figure (21) WQI of NO_3 for drinking water samples in winter season

Figure (21) shows that 75 % of water samples are excellent and 15%,5% of them are good, poor/very poor respectively.

Figure (22) comparison of WQI per seasons



	SO4	NO3	Fe	flouride	TDS	turbidity	PH
summer	4.8	2.2	51.7	61.7	164.4	39.1	43.3
autumn	2.1	0.95	19.2	33.3	22.1	50.9	50
winter	5.7	15.65	18.33	21.66	9.38	36.68	56.66

Figure (22) shows that the WQI was affected by seasonal variations.

Figure (23) comparison of polluted samples per season

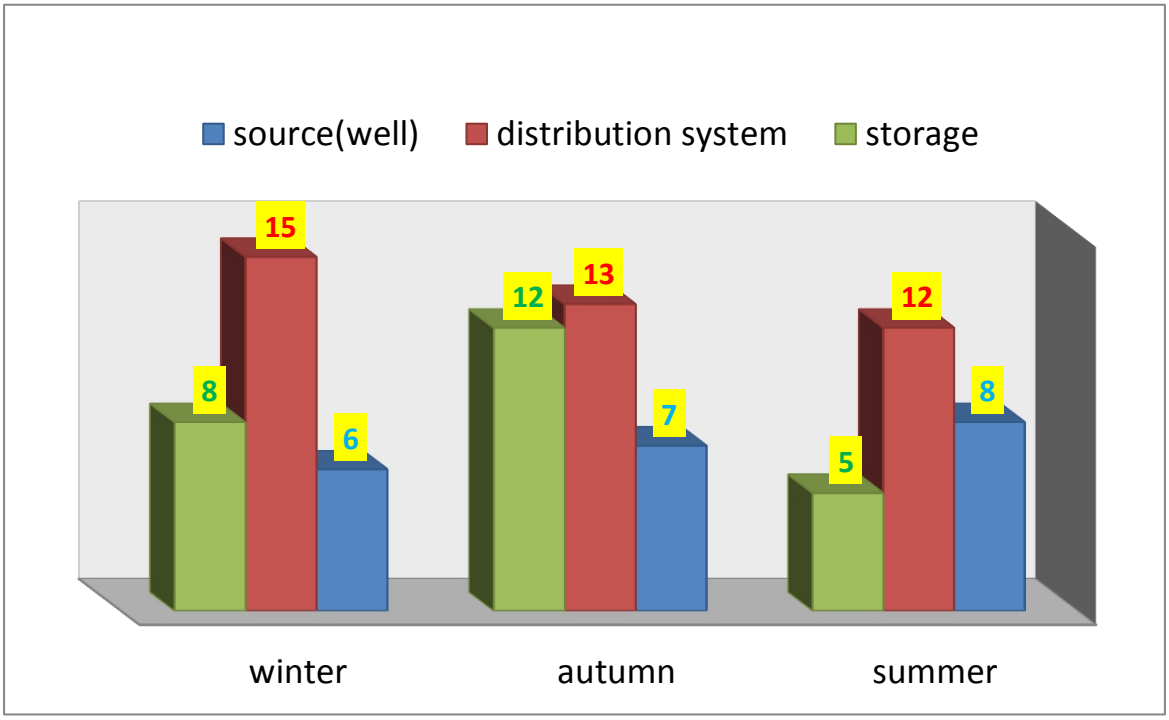


Figure (23) shows that the highest pollution in autumn season and also distribution system has higher pollution than other sources.

Table (40) bacteriological quality for drinking water samples per seasons

season	NO of tested samples	E. coli positive	Percentage %
Summer	80	25	31.3
Autumn	80	32	40
Winter	80	29	36.3
Total	240	86	35.8

Table (40) shows that the highest pollution in autumn season 40% and then in winter season 36.3%

Figure (24) comparison of E. coli presence per seasons

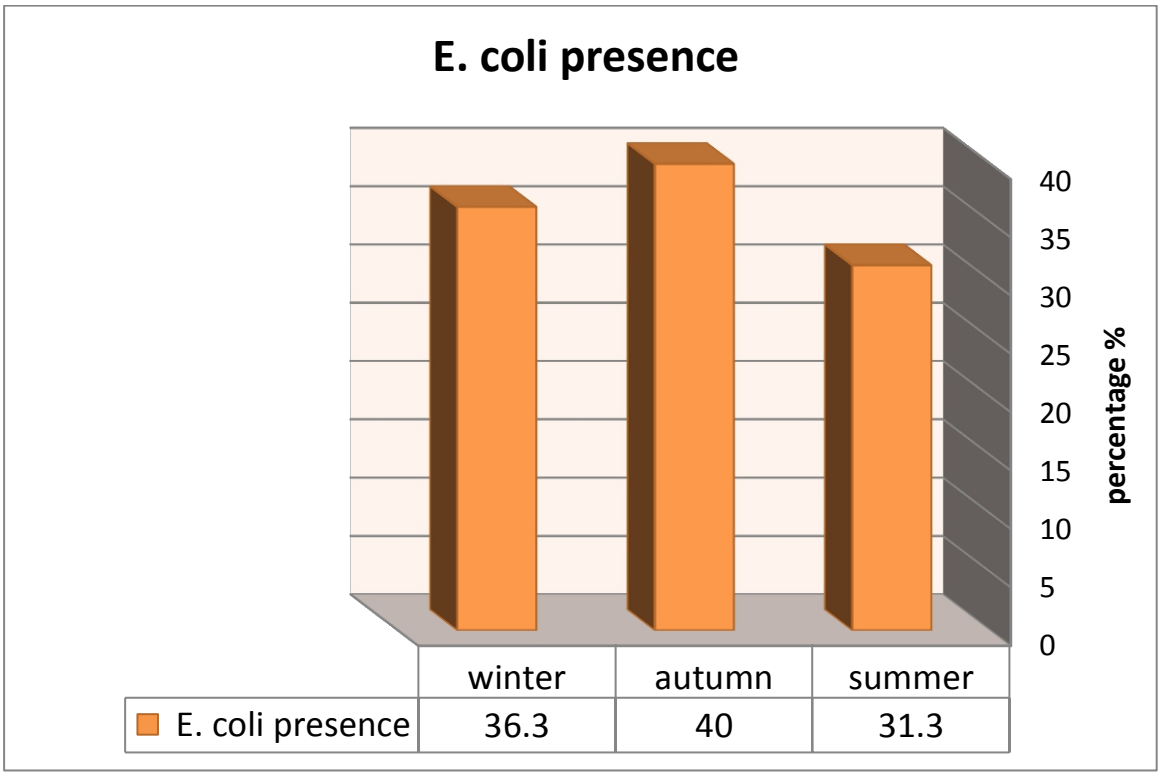
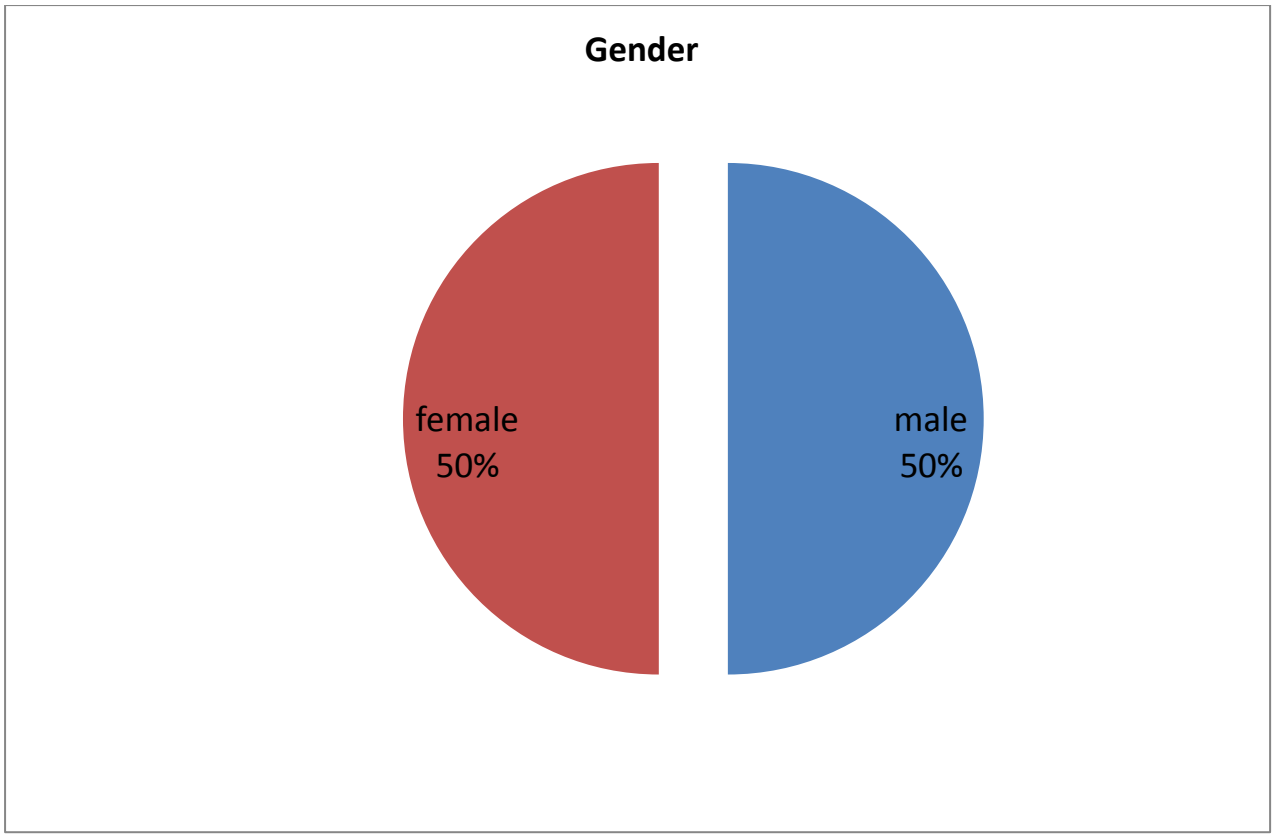


Figure (24) shows that 36.3%, 40%, 31.3% of tested samples are E. coli positive and the highest ratio in autumn season (40%).

Figure (25) Gender



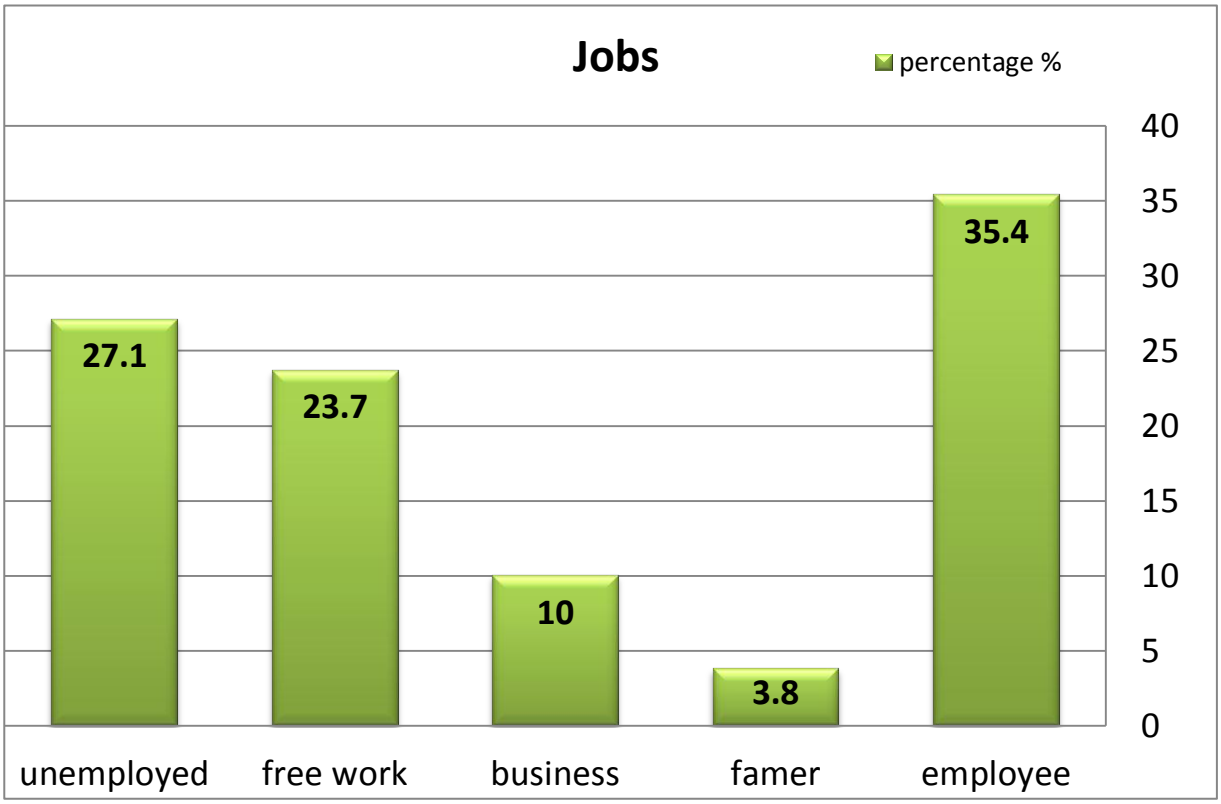
The above figure shows that 50% of study populations are males and the same are females.

Table (41) age distribution

Age/ year	frequency	Percent %
20-25	61	25.4
26-30	48	20.0
31-35	43	17.9
36-40	47	19.6
Above 40	41	17.1
total	240	100

The above table shows that 25.4% , 17.9% and 17.1% of study populations, their ages ranged 20-25, 31-35and more than 40 years of age respectively.

Figure (26) occupations



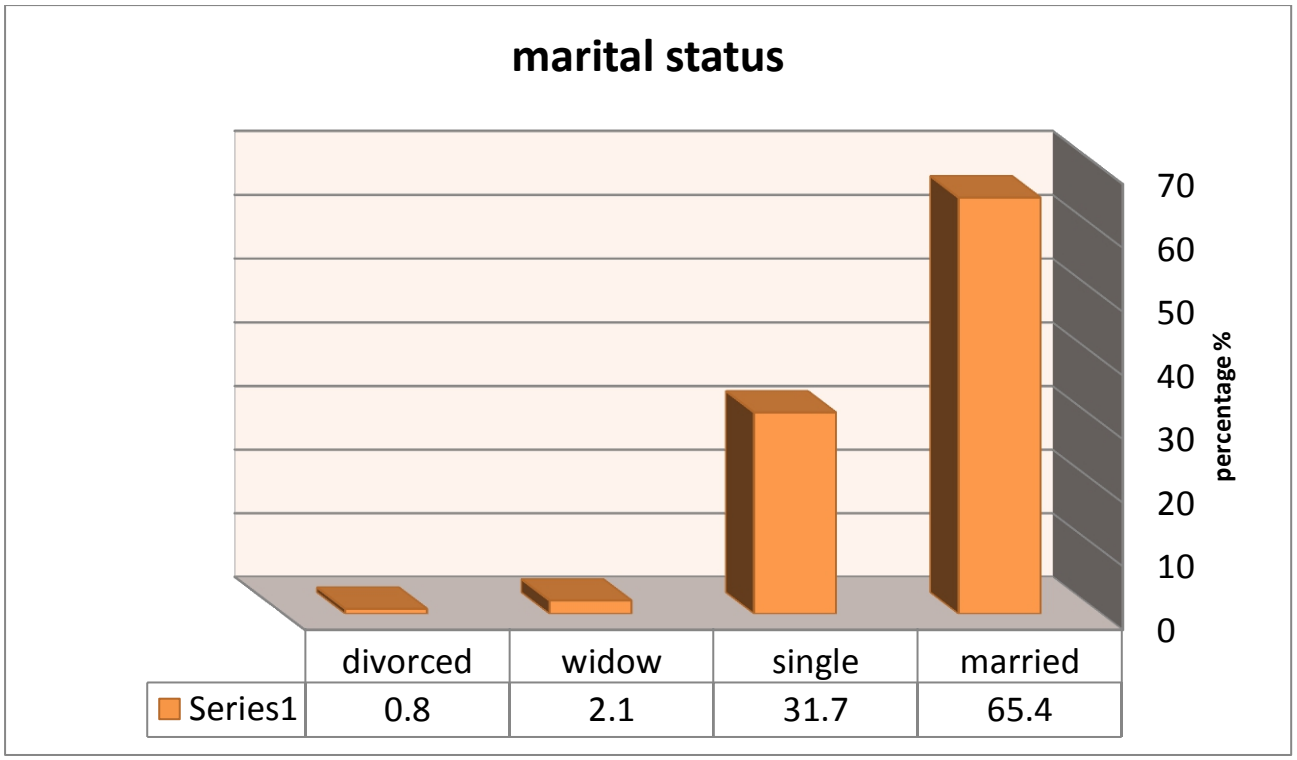
The above figure shows that 35.4%, 27.1% and 3.8% of study populations are employees, unemployed and farmers respectively.

Table (42) educational level

level	frequency	Percent %
illiterate	15	6.2
basic	27	11.3
intermediate	27	11.3
secondary	67	27.9
university	92	38.3
postgraduate	12	5.0
total	240	100

The above table shows that for 38.3% of study populations the education level is university and 6.2%, 11.2% of them are illiterate, basic and intermediate levels respectively.

Figure (27) marital status



The above figure shows that 65.4%, 31.7% and 0.8 of study populations are married, single and divorced respectively.

Table (43) family size

Range/person	frequency	Percent %
2-4	93	38.8
5-7	110	45.8
8-10	34	14.2
Above 10	3	1.2
total	240	100

The above table shows that 38.8%, 45.8% of study populations have family size ranged 2-4, 5-7 persons respectively and 1.2% of them are having more than 10 persons.

Table (44) source of drinking water

source	frequency	Percent %
ground	230	95.8
surface	10	4.2
rain	0	0.0
total	240	100

The above table shows that 95.8% of study populations depend on ground water and 4.2% of them depend on surface water.

Table (45) method of obtaining on water

method	frequency	Percent %
Network	233	97.1
Tanker or carro	4	1.7
Private well	3	1.2
total	240	100

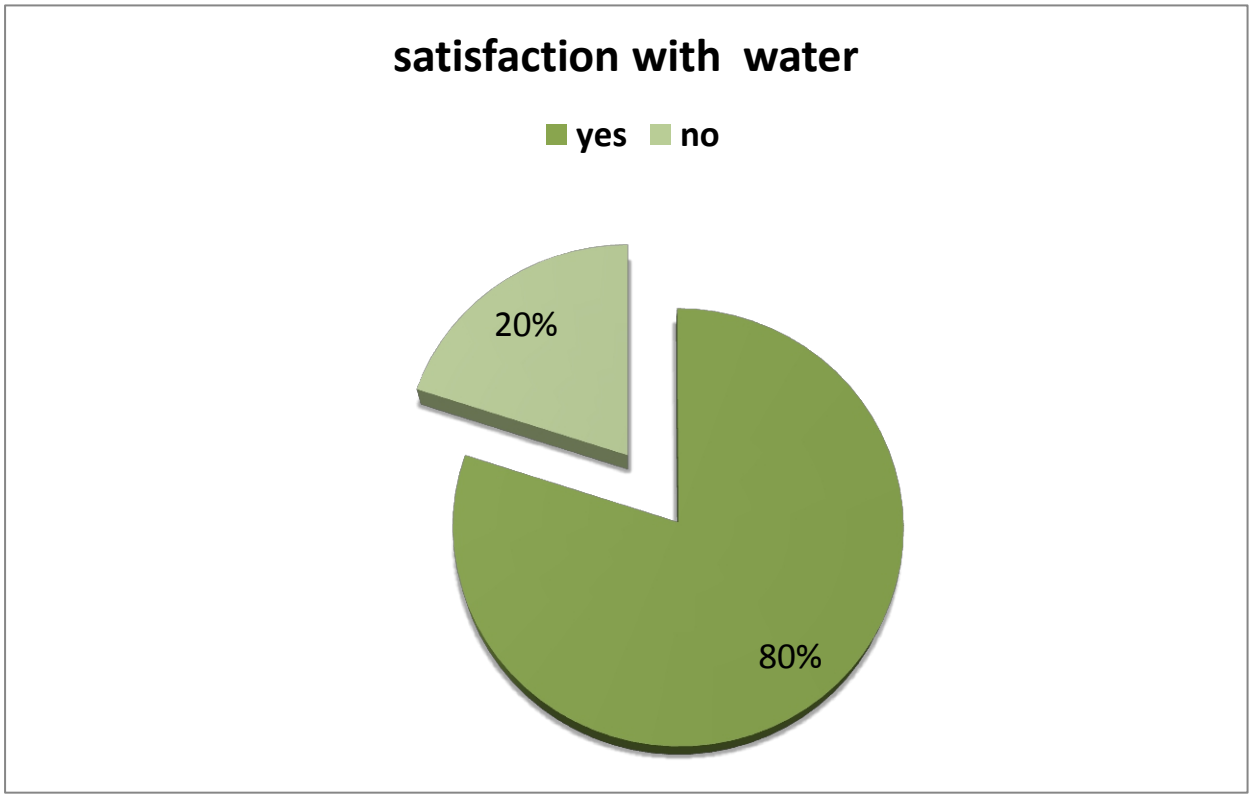
The above table shows that 97.1% of the study population obtain water through network and 1.7% of them obtain it by tanker or carro.

Table (46) duration of water supply

Period/hrs	frequency	Percent %
No connect	5	2.1
Less than 4hrs	26	10.8
5-12hrs	62	25.8
More than 12hrs	147	61.3
total	240	100

The above table shows that 61.2%,25.8% of the study populations have water supply for more than 12hrs.,5-12 hrs. Daily respectively and 2.1% of them are not connected to the network.

Figure (28) satisfaction with water supply



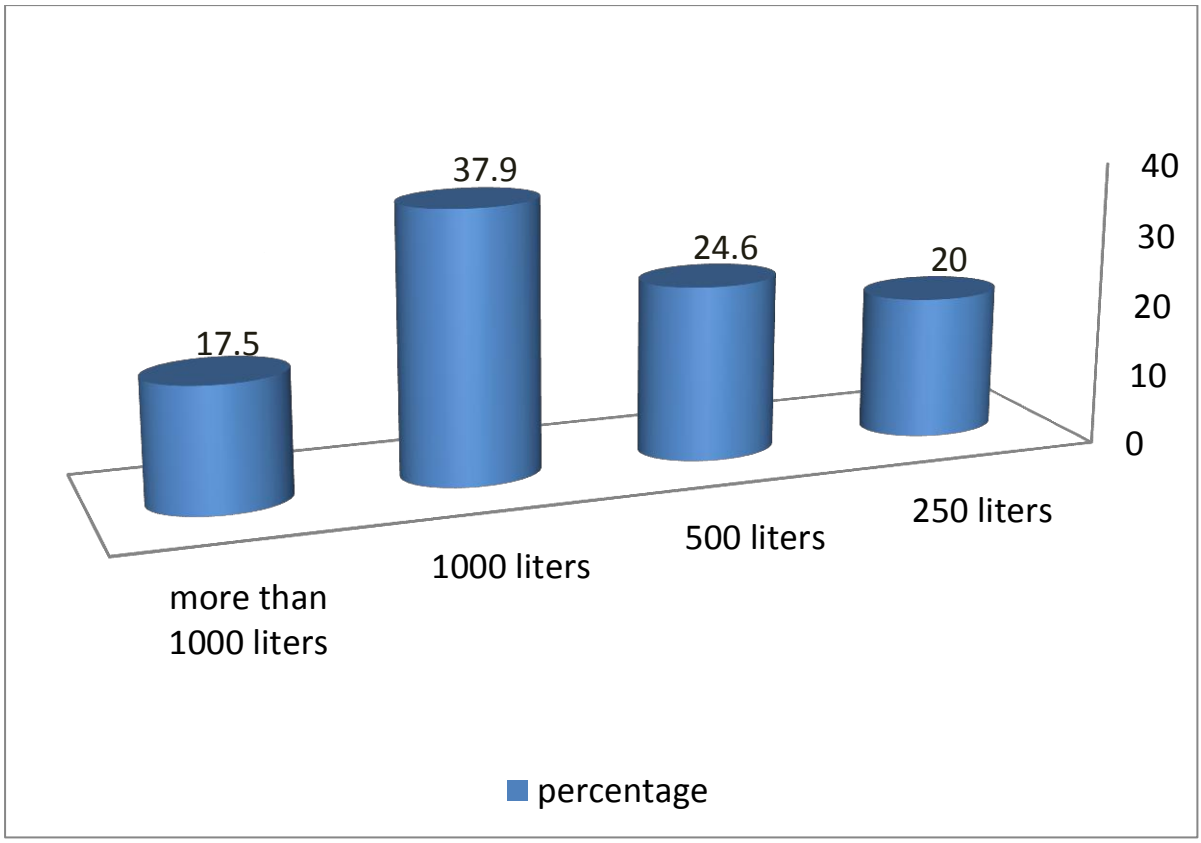
The above figure shows that 80% of the study populations said that they are satisfied and 20% of them said do not satisfied.

Table (47) increasing of water consumption per season

season	frequency	Percent %
autumn	5	2.1
winter	5	2.1
summer	230	95.8
total	240	100

The above table shows that 95.8% of the study populations said that the consumption of water is increasing in summer and 2.1% of them mentioned that in autumn and winter.

Figure (29) storage capacity of water



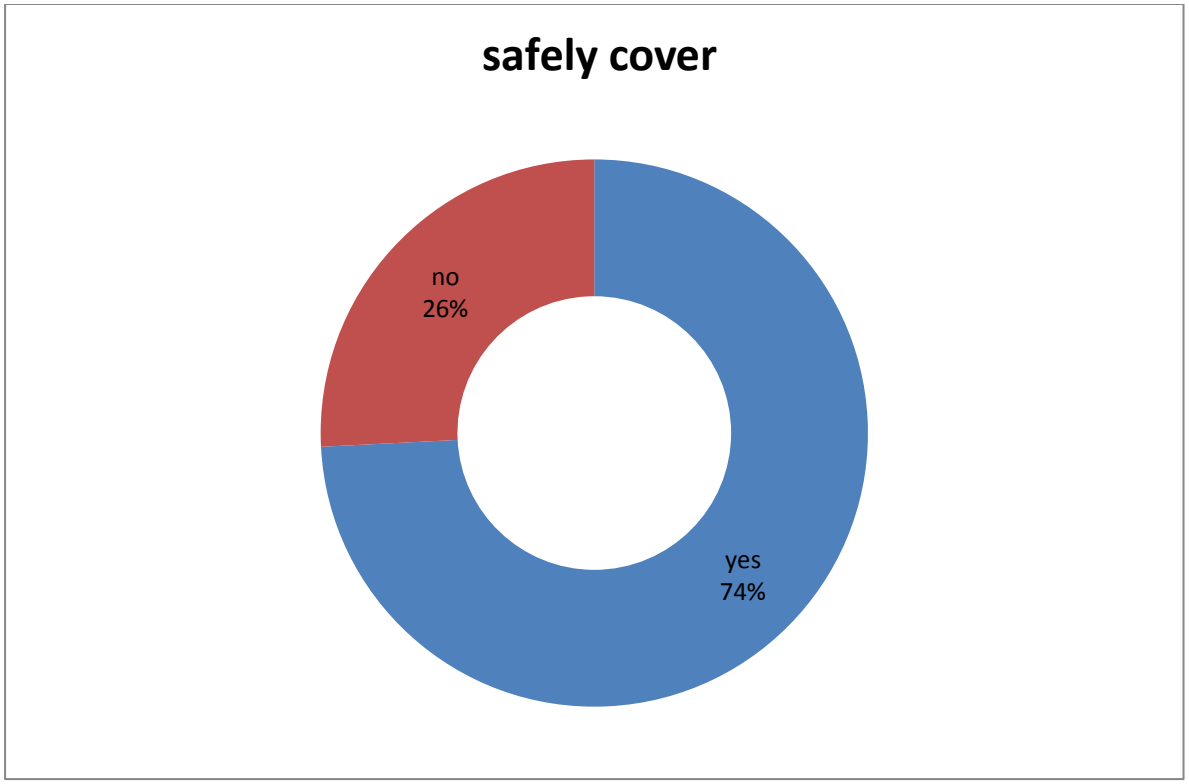
The above figure shows that 24.6%, 37.9% of the study populations have storage capacities of 500, 1000liters respectively and 17.5% of them have more than 1000 liters.

Table (48) keeping of drinking water separated

separation	frequency	Percent %
yes	159	66.2
NO	81	33.8
total	240	100

The above table shows that 66.2% of the study populations keep drinking water separated and 33.8% of them do not keep it separated.

Figure (30) show the percentage of safely cover of water containers



The above figure shows that 74.2% of drinking water containers have safe cover and 25.8% of them have no safe cover.

Table (49) method of taking drinking water from storage facility

mean	frequency	Percent %
poured	114	47.5
cup	59	24.6
other	67	27.9
total	240	100

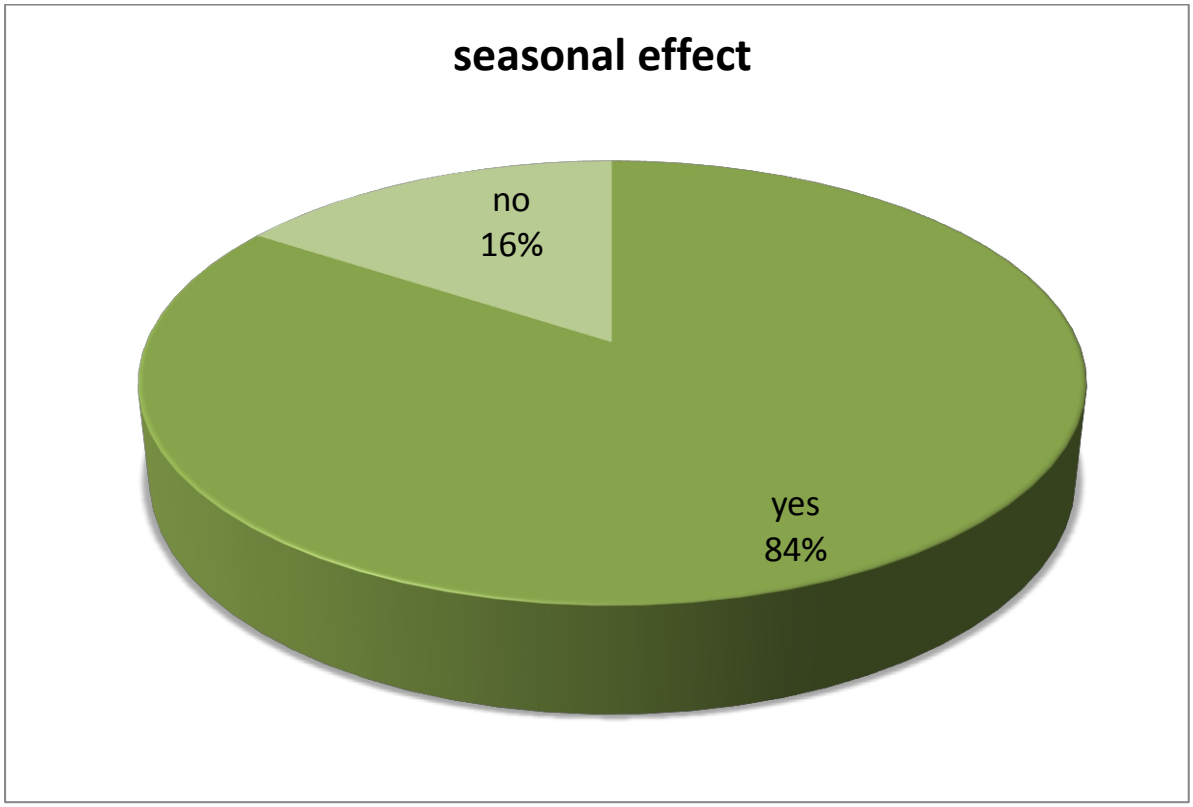
The above table shows that 47.5% and 24.6 of the study populations take drinking water from storage mean by poured and cup respectively.

Table (50) frequency of cleaning the storage container

time	frequency	Percent %
daily	53	22.1
weekly	100	41.7
monthly	36	15.0
rarely	29	21.1
never	22	9.1
total	240	100

The above table shows that 22.1%, 41.7% and 15% of the study population clean water containers daily, weekly and monthly respectively and 9.1% of them never clean their water containers.

Figure (31) effect of seasonal variation on drinking water



The above figure shows that 84.2 % of the study populations said that the seasonal variations have effect on water quality and 15.8% of them mentioned that no effect.

Table (51) water quality

quality	frequency	Percent %
excellent	13	5.4
good	88	36.7
acceptable	99	41.2
unacceptable	40	16.7
total	240	100

The above table shows that 5.4%, 36.7 and 16.7% of the study populations said that drinking water quality is excellent, good and unacceptable respectively.

Table (52) paying of fees for drinking water

paying	frequency	Percent %
yes	230	95.8
NO	10	4.2
total	240	100

The above table shows that 95.8 % of study populations paid fees for water and 4.2% of them did no pay.

Table (53) amount of monthly fees

Fees /SDG	frequency	Percent %
20SDG	119	51.7
25SDG	49	21.3
30SDG	47	20.4
More than 30SDG	15	6.6
total	230	100

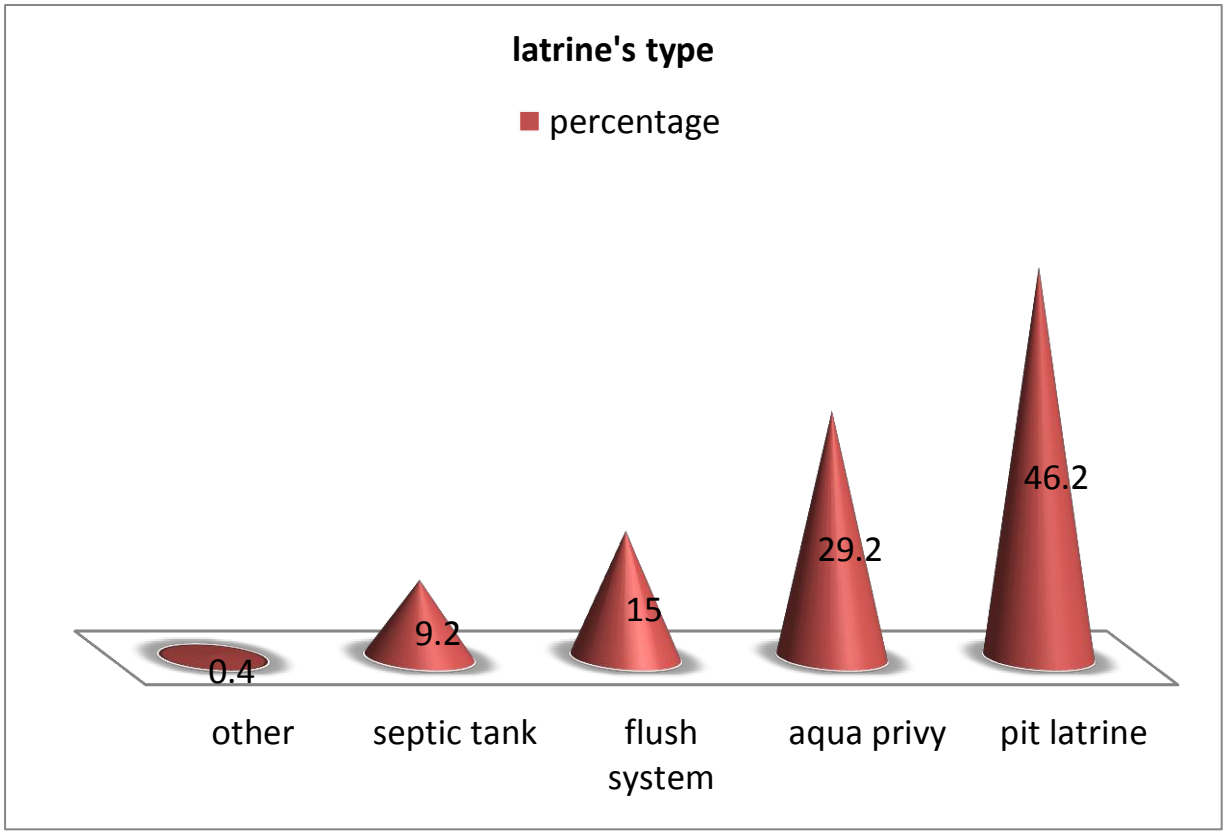
The above table shows that 51.7%, 20.4 and 6.6% of citizens are pay 20SDG, 30SDG and more than30SDG respectively.

Table (54) paying of additional fees

pay	frequency	Percent %
Yes	74	30.8
NO	166	69.2
total	240	100

The above table shows that 30.8%, of citizens have willing to pay additional fees and 69.2 of them have no interest to pay more for water.

Figure (32) type of latrines



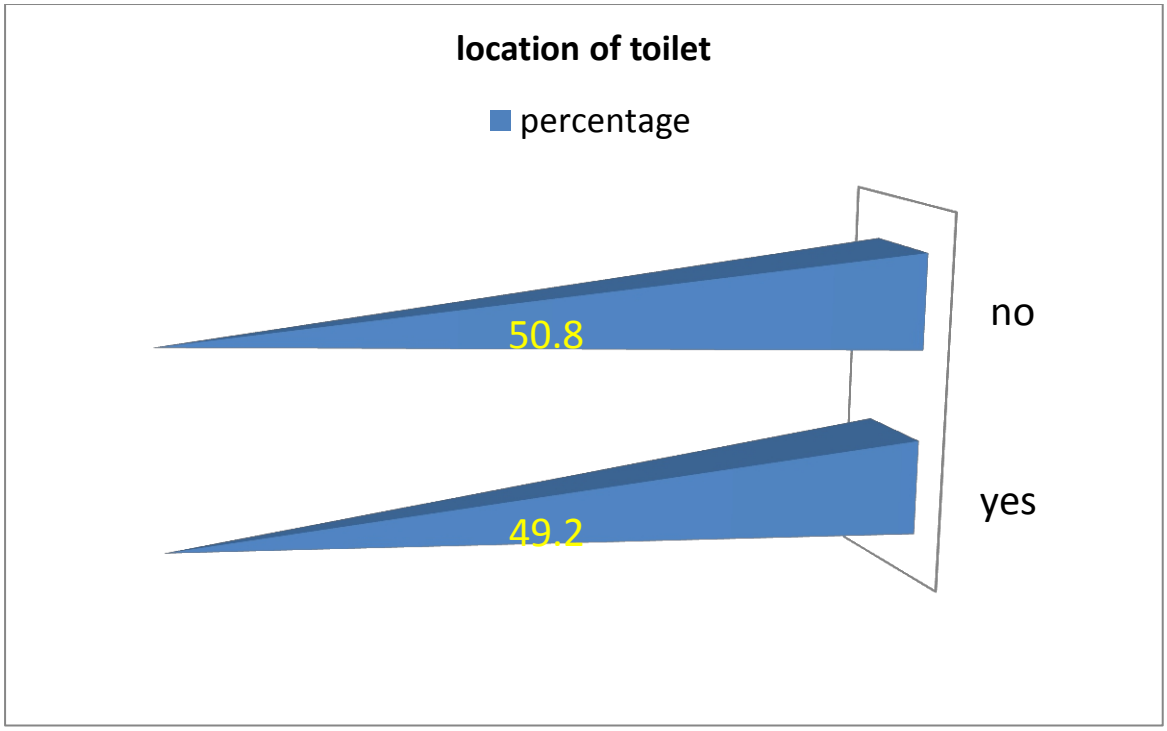
The above figure shows that 46.2%, 15% and 9.2% of the study populations have type of latrine are pit, flush latrines and septic tank respectively.

Table (55) presecure of sewerage system in the Twon

presecure	frequency	Percent %
Yes	32	13.3
NO	208	86.7
total	240	100

The above table shows that 86.7 % of the study populations said sewerage system is not found in shendi Town and 13.3% of them mentioned that it is found.

Figure (33) position of toilet within 10 meters from water source



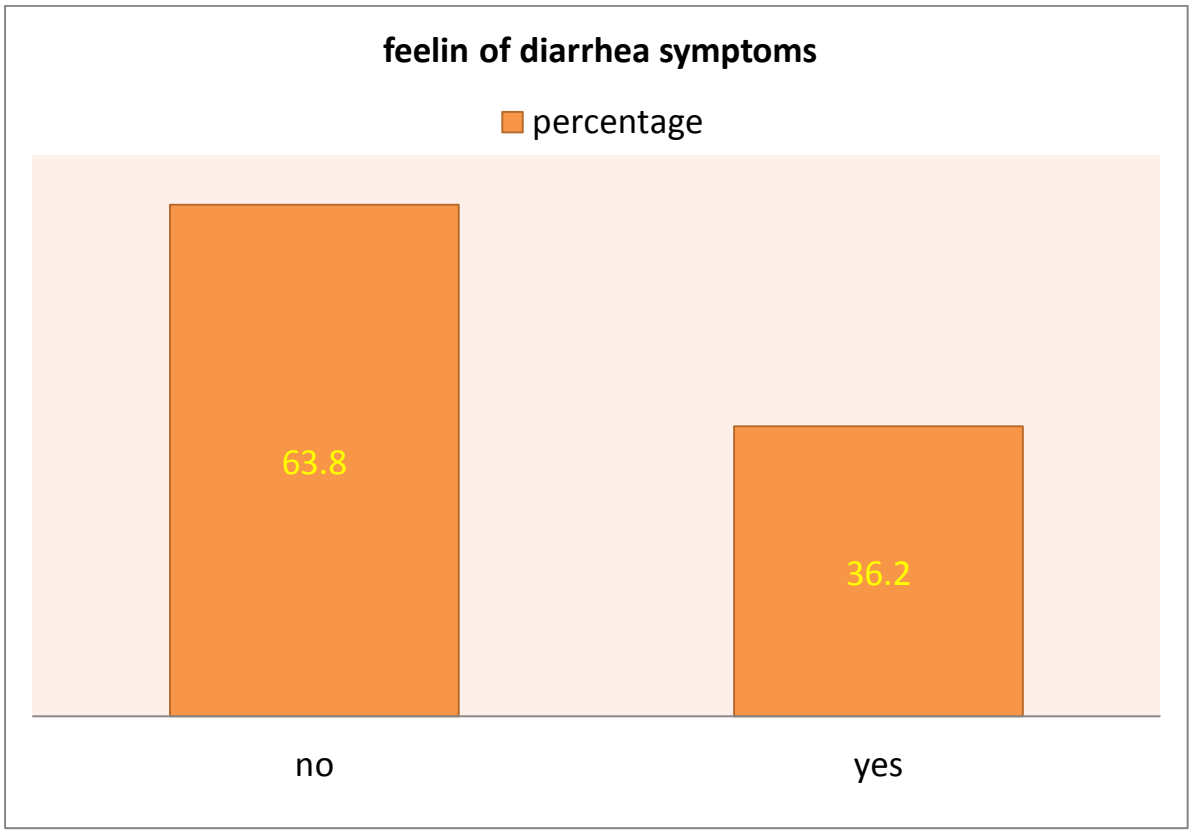
The above figure shows that 49.2 % of the study populations the position of toilet is in correct distance and 50.8% of them are not in right position.

Table (56) washing of hands by soap

Time of washing	frequency	Percent %
At prayer	2	0.8
Before eating	68	28.3
After eating	99	41.2
Before bed	1	0.4
Before cooking	9	3.8
After toilet	61	25.5
total	240	100

The above table shows that 28.3%, 41.2% and 25.4% of the study populations wash their hands by soap before eating, after eating and after using of toilet respectively.

Figure (34) feeling of diarrhea symptoms



The above figure shows that 36.2 % of study populations are complained from diarrhea symptoms and 63.8% of them do no.

Table (57) visiting health units

visiting	frequency	Percent %
Yes	73	83.9
NO	14	16.1
total	87	100

The above table shows that 83.9 % of those complained from diarrhea symptoms had gone to health units for diagnosis and 16.1% of them do no go.

Table (58) result of diagnosis at health units

Time of washing	frequency	Percent %
dysentery	28	32.3
typhoid	39	44.8
amoebaisis	7	8
giardiasis	6	6.9
Hepatitis A	3	3.4
Hepatitis E	1	1.2
helminthes	3	3.4
total	87	100

The above table shows that results of diagnosis 32.3%, 44.8%, 8%, 6.9% and 3.4% are dysentery, typhoid, amoebaisis, giardiasis and hepatitis A, helminthes respectively.

Table (59) prevalence of water-borne diseases per seasons

season	frequency	Percent %
autumn	211	87.9
winter	2	0.8
summer	27	11.3
total	240	100

The above table shows that 87.9 % of the study populations are said that the prevalence of water borne-diseases is increasing in autumn and 11.3% of them mentioned that in summer.

Figure (35) confirmed water-borne diseases cases from health units

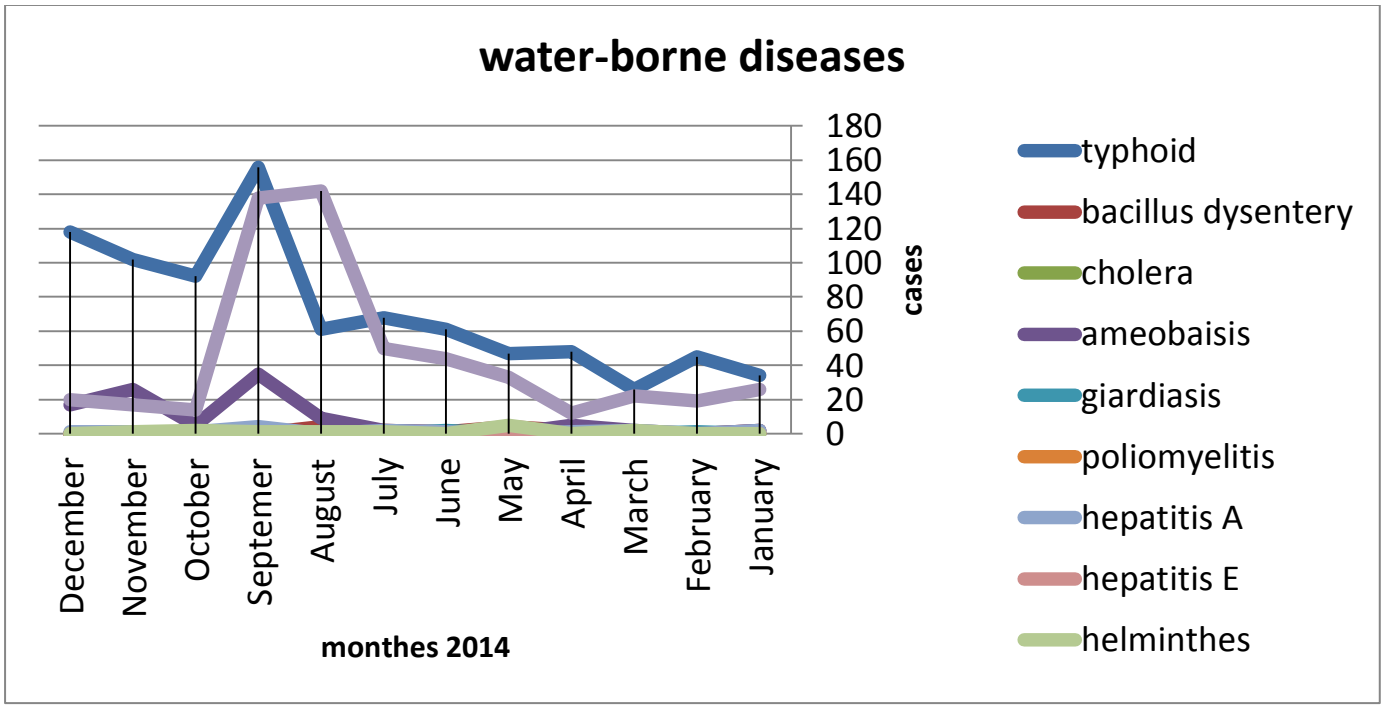


Figure (35) shows that the more incidences of water-borne diseases are typhoid and diarrhea respectively.

Figure (36) comparison of water-borne disease cases per seasons

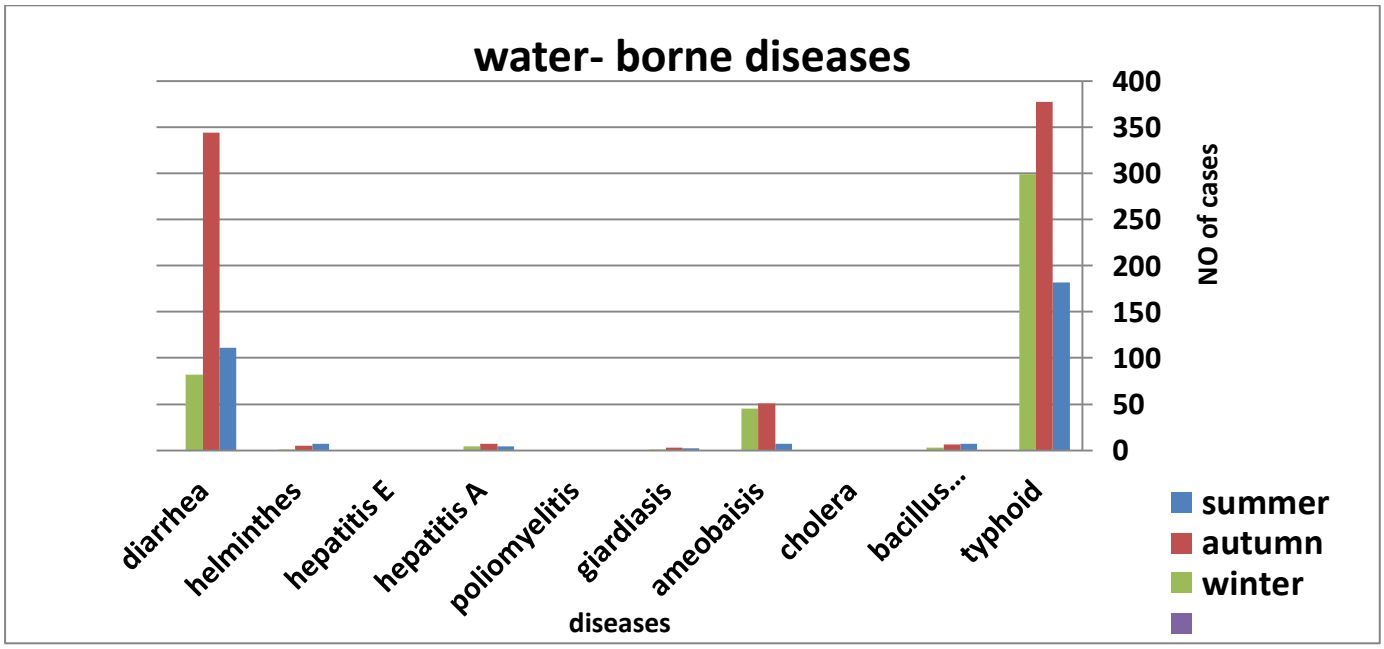


Figure (36) shows that the prevalence of water-borne diseases increases in autumn, winter and summer respectively

5.1 Discussion

Unsafe drinking water is the one of the basic health problems in the Sudan. This study aims to assess drinking water quality per seasons and also aims to identify water supply system in Shendi Town.

The study revealed that the distribution system of drinking water at Shendi town is looped, in spite of this system (looped) has no pipe dead ends but there are many dis advantages or problems such are : more complex than branched type because it's combination of loops and branches with lots of interconnected pipes that required many valves and special parts ,also in the cases appearance of pollution in water many of consumers are affected by the health hazard due to water that can be supplied from more than one direction, as connecting of all network or distribution system together in form of loops. Most of residents in Shendi town are not satisfied with drinking water supply system, 41.2 % and 16.7% of them said that water quality is acceptable and unacceptable respectively, while just 5.4 % of populations are satisfied (table 51).

The study showed that there are little seasonal variation in all samples of turbidity (tables 1, 2, 14, 15, 27, 28). Turbidity can promote growth of pathogens in distribution system and lead to water borne diseases (EPA , 1999). Also turbidity in ground water doesn't indicate pathogens presence but provides on general water quality and is an indicator of surface influence on ground water quality (Martin , Allen et al. , 2008). Turbidity can serve to signal potential contamination problem. Distribution system turbidity can be an indicative of microbiological problems (CDW, 2012).

The present study pointed that the values of pH in all samples is complied with the standards of WHO and SSMO, one of the best control of microbial growth is pH , whereas most microorganisms cannot survive at low pH . So observed all values of pH of drinking water were within acceptable limits according to WHO and Sudanese standards for drinking water quality (tables 1, 2, 14, 15, 27, 28).

However WQI pointed that quality of drinking water is good in summer and autumn, while in winter it's poor (figures 2, 9, 16).

The present study showed that 40%, 30% and 22% of water samples indicated that drinking water is moderately hard, hard and very hard respectively in summer season (tables 1, 2). Also pointed that 26%, 58% and 16% of water samples are moderately hard, hard and very hard respectively in autumn (tables 14, 15). While in winter season 28% , 46% and 22% 0f water samples are showed that drinking water is moderately hard, hard and very hard (tables 27, 28). Hard water produce serious health problems like urolithosis , cardiovascular disorders , according to past studies and inverse relationship between the hardness of drinking water and cardiovascular diseases has been reported by Simith and Crombic(2008), other diseases like anencephaly and cancer also caused by hardness of water (meena, kl. et al. 2011). According to the present findings drinking water in study area is hard so we expect some health problems due to hardness of drinking water.

The study revealed that there are low concentrations of fluoride in drinking water , presence of fluoride in drinking water is very beneficial for health of teeth . Samples indicated that concentrations of fluoride ranged between (0.0 – 1.3 mg/l) ,(0.0- 0.8 mg /l) and (0.0- 1.5 mg/l) in summer , autumn and winter respectively (tables 1, 2, 14, 15, 27, 28). Concentrations of fluoride from (1.0 – 1.2 mg/l) are considered as the optimal beneficial for dental protection (CDC, 2014). in previous study done by Ramadan and Hilmi (2014), to determine the maximum safe limit for fluoride in potable water in Khartoum state according to climate conditions of the Sudan , they found that the optimal concentration of fluoride in potable water must be in range 0.32- 0.35 mg/l according to Sudanese conditions.

WQI pointed that quality of drinking water based on fluoride concentration is excellent, good and poor in winter, autumn and summer respectively (tables 10, 23, 36). According to the present results we observe lack of fluoride concentration in

drinking water because many of tested samples were showed nil fluoride and also below permissible concentration that determined by WHO and SSMO (1.5 mg/l). So according to these results, dental decay in next generations may be occurring if completely depending on drinking water as the main source of fluoride.

The present study revealed that no expected health problems due to Fe^{+2} , NO_3^- and SO_4 because all tested samples indicated that contents of all these parameters are within guidelines of WHO and Sudanese standards (SSMO), (Tables 3, 16, 29). But the study showed that there are some seasonal variations in Fe^{+2} content(figure, 5) , while in NO_3 and SO_4 WQI indicated that quality of water is excellent in all seasons figures (6, 7) .

The current study showed that TDS in drinking water in winter and autumn is acceptable because content of it below 500ml/l, less than WHO and SSMO guidelines (tables 14, 15, 27, 28). While contents of TDS are above permissible limits in summer (tables 1, 2), this may be due to levels of temperature. the temperature has effect in solubility of substances , high values of TDS in ground water generally are not harmful to human beings , but high content of TDS affect persons who suffer from kidney and heart diseases (Dave et al. 2011). WQI of TDS pointed that drinking water quality is excellent in winter and autumn (figures 10, 17). However it's indicated that water quality is unfit for drinking purposes in summer (figure 3).

The study revealed that there are relation between family size and consumption of water per season (P. value = 0.033 < 0.05) (table 60) , this means rate of water consumption is different from one family to another depending on number of persons, also the study found that highly statistical significance between rate of water flow or time of water supply and capacity of storage at household level, also there are correlation between keeping of drinking water safely , found of safely cover, and the correct method of water taking (P. values = 0.000 < 0.05) (tables 63,64,65) . i e capacity of storage is increasing due to increasing of water supply time and

continuous water flow within the day, and also decreasing result with decline of water supply duration .

Current study showed that no relationship between type of latrine and appearance of symptoms of water-borne diseases , also no correlation between presence of sewerage system and increase of water borne disease (P. values. = > 0.05) (tables 67,69). However water associated diseases caused by insufficient safe water supplies coupled with poor sanitation (UNICEF, 2008). In a previous study carried by Mohammed (2012), in Kosti town, he found that there are statistically significant correlation between education level and knowledge of water-borne diseases.

The Present study revealed that there is no relation between educational level and knowledge of seasonal variations of drinking water quality , also no correlation between educational level and washing of hands by soap before eating (P. value = >0.05 (tables 66, 68), in spite of that education plays great role in provision information and awareness . in a past study conducted by Hamza (2011), in north Kordofan (elobeit town) he revealed that there are weakness in hygiene awareness among the study population , this typically as the result found by this study.

The study showed that no relationship between ages of study population and going into health institutions for diagnosis in case of infection by water borne diseases, also the study revealed that neither correlation between gender and type of water borne diseases (P. value = 0.112 > 0.05) (tables 69, 70) . This means water borne diseases are not infecting certain age or gender but are wide spread among all ages and infect both gender.

The study revealed that the bacteriological quality of drinking water varied from season to another, where 31.3% of tested samples indicated feacal pollution in summer season , (tables 4, 5, 6). And 40% of samples pointed to E. coli bacteria presence in autumn, (tables 17, 18, 19). While 36% of samples were indicated E. coli

positive in winter (tables 30, 31, and 32). All indicators of bacteriological quality are above guidelines of WHO and SSMO, all water intended for drinking E. coli or thermo tolerant coli form must not detectable in any 100 mg /l sample, treated water entering distribution system E. coli , thermo tolerant coli form bacteria must not be detectable in any 100mg/ sample , in case of large supplies system when sufficient samples were examined E. coli bacteria must not be detectable in 95% of samples (SSMO). So according to these results the quality of water is not suitable for drinking without appropriate treatment process.

The present study showed that feacal pollution was found in all seasons but in autumn is higher than other seasons, (Figure 24), this may be due to absence of sewerage system in Shendi Town and run off during rainfall, also raise of level of water in aquifer or water table , especially during the period of study in 2014 heavy rains were precipitated in the study area. In a previous study conducted by Amera and Saad (2012), in north kordofan state to identify seasonal variation effects on drinking water quality , they found that bacteriological quality of water is very poor with very high level of E. coli and feacal coli form count in most seasons. With peak in rainy season. Also in other past study conducted by Mohammed (2009), to assess bacteriological quality of drinking water in west kordofan state , they revealed that all samples pointed extreme high level of total coli forms were detected at each sample . The researchers revealed that the highest count of pollution was seen in autumn compared to other seasons , this is typically as the results that revealed by the present study. While in another previous study done by Hamza (2011), in Elobiet Town , he found that there are bacteriological contamination in water supply system in all three seasons but the highest one in summer season and then autumn , where 94%, 81% and 23.6% of tested samples were positive coli forms , thermo tolerant and E. coli respectively . Also in another past study conducted by Mohmmed (2012), in Kosti Town , he showed that high growth of total coli forms bacteria , in all samples 100% were positive for coli forms and thermo tolerant bacteria, the study pointed that

seasonal variations with regard E coli presence , where 89.7% , 76.9% and 66.7% off samples were positive in summer, rainy and winter respectively .

Current study showed that seasonal variations or changes had a great effect on drinking water quality , specially bacterial quality , this is clear through the results revealed from analysis of samples at laboratory and also through information collected from the study population , where 84.2% of them said that seasonal changes have effect on water quality figure (31).

The present study showed that drinking water pollution was detected in all sites of sampling (well, distribution system and storage facilities) while it is more in samples of distribution system (figure 23) so distribution system in Shendi Town needs to urgent interventions from related authorities . these results are in agreement with Eltigani (2007) in a previous study conducted in Shendi locality to investigate bacteriological quality in drinking water, he found that thirteen of 48 (27.1%) samples collected from different sources of drinking water were contaminated with E. coli bacteria, the highest contamination with to regard E. coli presence in distribution system, storage facilities then shallow well and surface sources respectively. In a previous study done by Othman, Hamid and Ali (2010), to assess bacteriological quality of ground water in west Omdurman area in eight sites ,they found that presence of feacal coli forms bacteria in seven sites, the researchers said the reason return to public sanitation system , Hago and Nadia (2012) in El Gazeera state (Al butana area) , they found that none of the wells water samples taken directly from well source showed any positive results (total coli forms bacteria absence).

This study revealed that typhoid disease is the more spread among populations than other water-borne diseases and then diarrhea illness (figure 35) this results typically as information that collected from citizens through questionnaire (table 58). Also the study showed that seasonal variations had a great effect in prevalence of water borne diseases, where the highest prevalence rate of water borne diseases is in

autumn compared with other seasons (figure 36). In a previous study done by Hamza (2011) in El- Obiet Town , he found that the highest prevalence of water associated diseases is giardiasis , while in another previous study conducted by Mohammed (2012) in kosti Town he revealed that dysentery and diarrhea are more prevalence than other water – borne diseases.

The Present study showed that there is lack of awareness about drinking water quality and its health risks , where 41.2% of study population washing their hands with soap after eating not before it(table 56) this behavior may lead to spread of water- borne diseases. These findings are the same as results in previous studies conducted by Hamza (2011) and Mohammed (2012) they found that there are lower levels of awareness among the citizens to wards water and its relation to health and personal hygiene. Also these results are in agreement with past study done by Eltigani (2007) in Shendi locality, he reported that: (high illiteracy, lack of awareness and weak community involvement in supervision and management of their drinking water sources).

5.2 Conclusion

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

- Ninety five point eight percent (95.8%) of Shendi population depend on ground water as the main source for drinking water.
- Distribution system of water is looped, and the network is very old,
- No sewerage system in Shendi town and 40.2% of residents use pit latrines as sanitation method.
- Bacteriological quality of drinking water is poor, and the indicator of pollution exceeds the admissible level of WHO and Sudanese standards for drinking water in all seasons.
- pH of drinking water is acceptable and within the guidelines of WHO and SSMO.
- Contents of Fe^{+2}, NO_3 , SO_4 in drinking water are below permissible limits of WHO / SSMO guidelines.
- Low of fluoride concentration in drinking water, where all majority of examined water samples are shown lack of fluoride contents (below guidelines) and some of them are shown nil of fluoride.
- Hardness of drinking water varied from season to another, where 30%, 46% and 58% of examined samples are shown water quality is hard in summer, winter and autumn season respectively.
- Seasonal variations had effects on drinking water quality, where all tested parameters are varied from season to another.
- Typhoid disease is the more spread than other water- borne diseases and, it's prevalence rate in autumn is higher than other seasons as shown in health institutions records.
- Weakness of knowledge among study population about drinking water quality and water- borne diseases.

5.3 Recommendations

For healthy living, potable safe water is absolutely essential. It is a basic need for all human beings to get adequate supply and pure drinking water. So based on findings of this study and conclusion, the thesis recommends related authorities by the following:-

- Civil Water Corporation should be improve the quality of currently drinking water by subjecting it to treatment processes, and must be establish surface drinking water treatment plant as soon as possible.
- Health authority of locality should be establish closed surveillance system to follow up quality of drinking water according to WHO guidelines and set closed plan for water –borne diseases control for intervention in suitable time.
- Engineering affair of locality should be establish sewerage system in Shendi Town as soon as possible to avoid pollution of drinking water by human waste.
- Residents of Shendi Town should be commit by monthly fees and pay more to participate in improvement of drinking water quality and must be use simple methods of drinking water treatment at household level.
- Shendi University coordination with faculty of public health should be raise and spread awareness about importance of safely and adequate drinking water, also must be create , encourage and support more studies about drinking water quality and other water associated diseases.

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5.5 Appendices

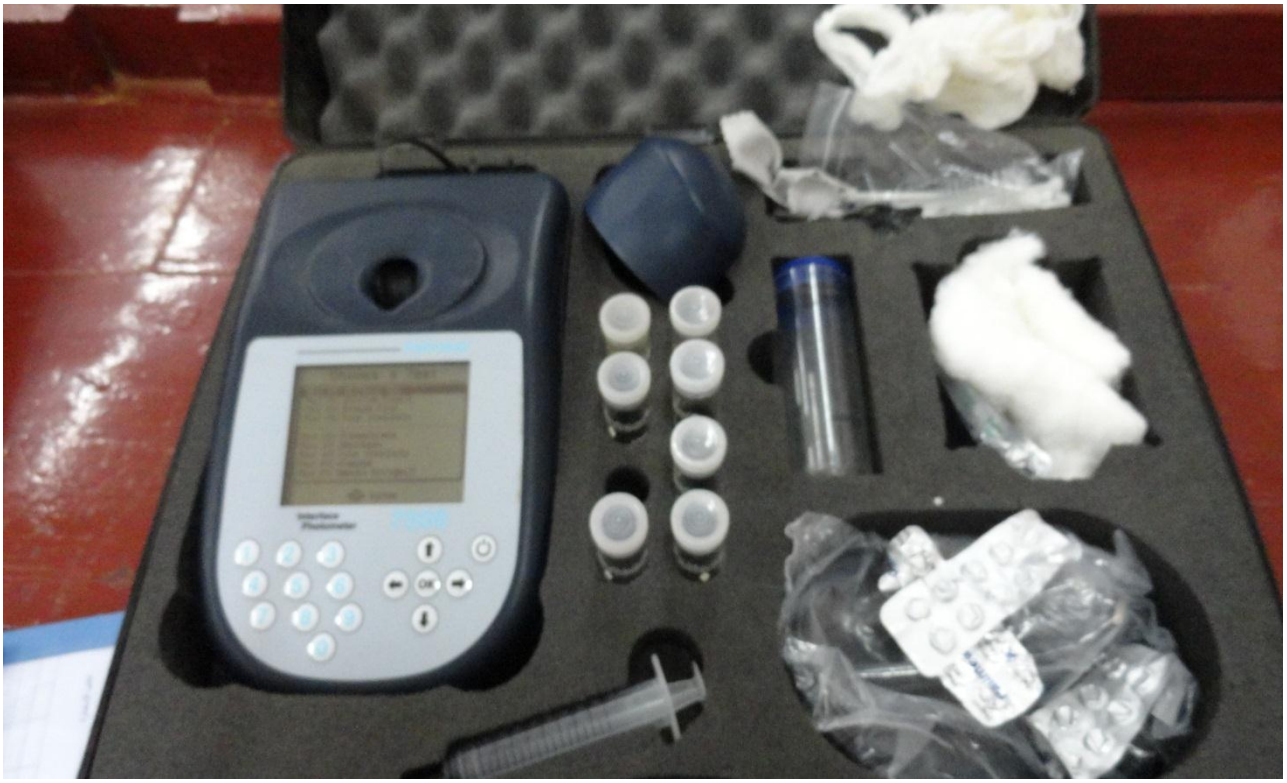

Plate (1) Photo meter that used in chemical tests.

Plate (2) conduct/ TDS meter used in measurement of conductivity/ TDS of water. **of**

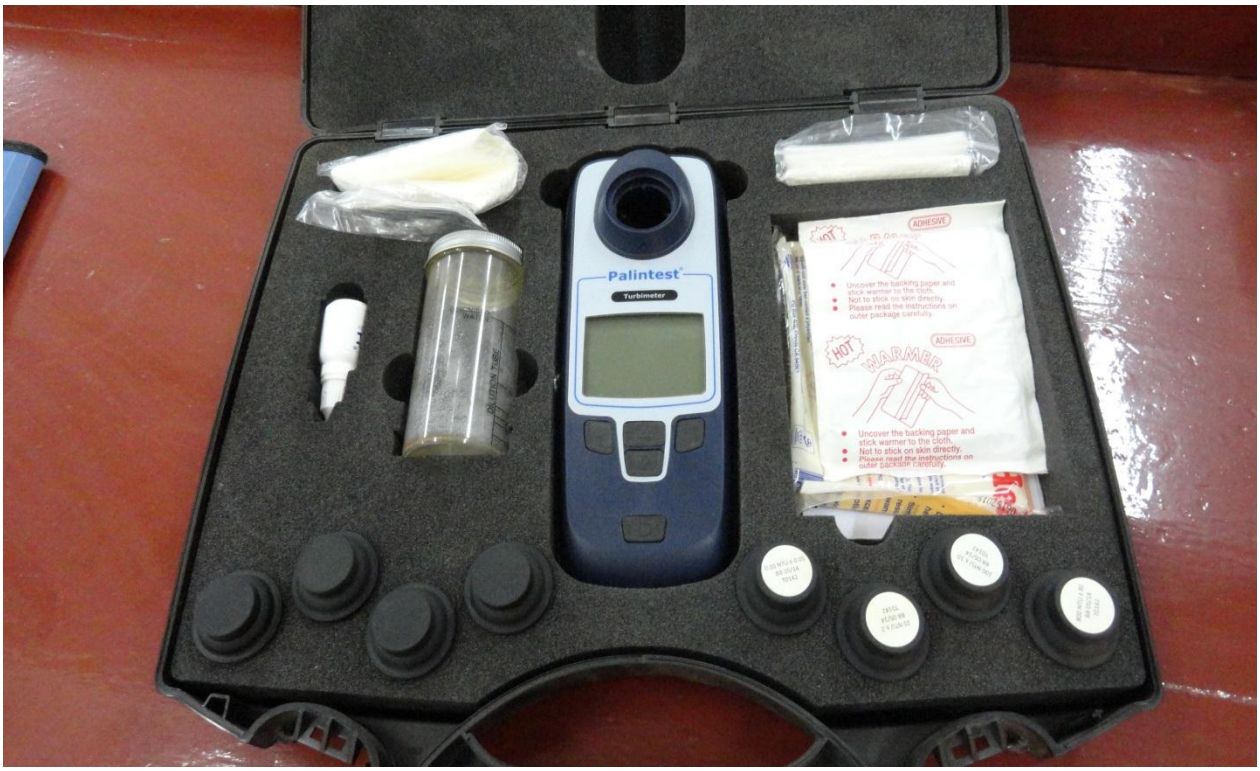

Plate (3) Turbimeter used in measurement of water turbidity.

Plate (4) sterilized glass bottles used in collection of samples for bacteriological examinations.

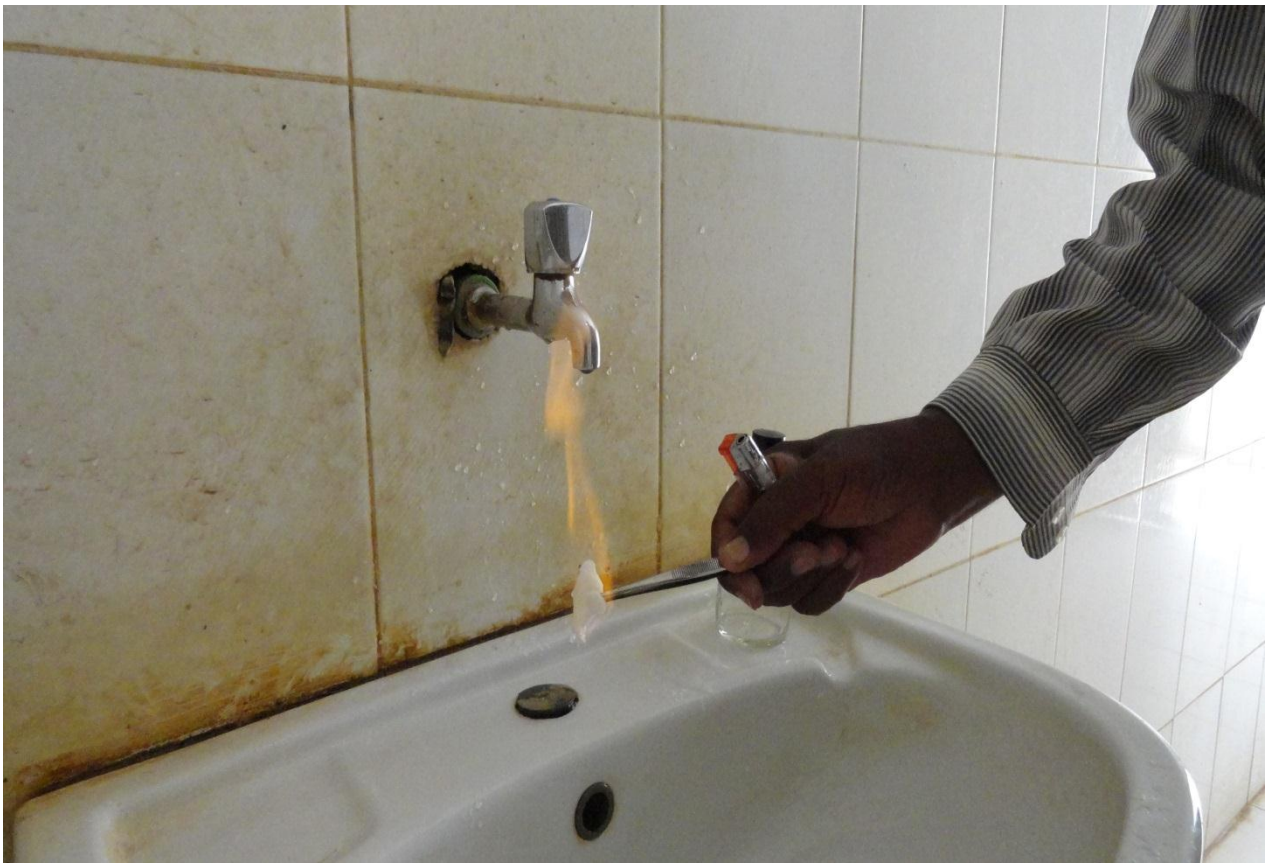

Plate (5) sterilization process of tap before bacteriological sampling.

Plate (6) preparation process of media at laboratory before culturing or testing

Plate (7) positive results of coli form bacteria at BGB media.

Plate(8) negative results of coli form bacteria at BGB media.

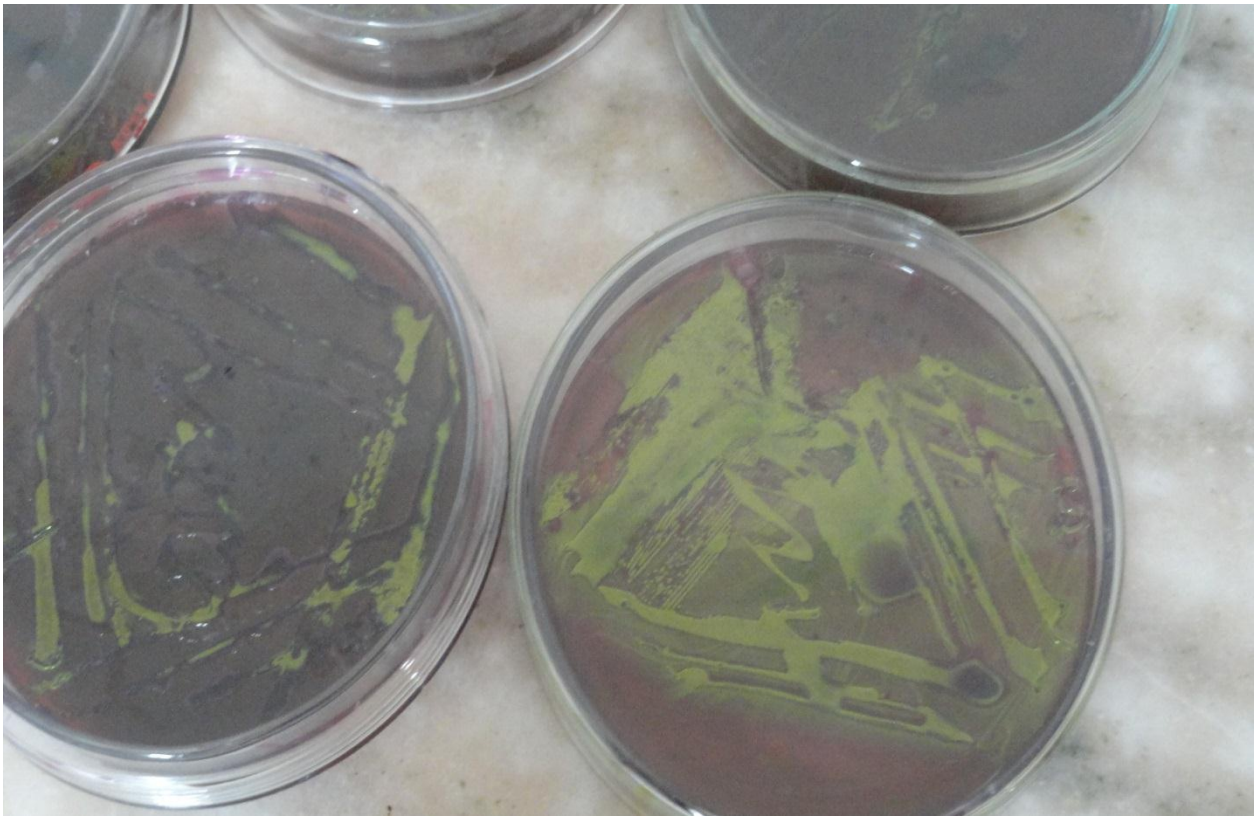

Plate (9) positive results of E. coli bacteria at EMB media.

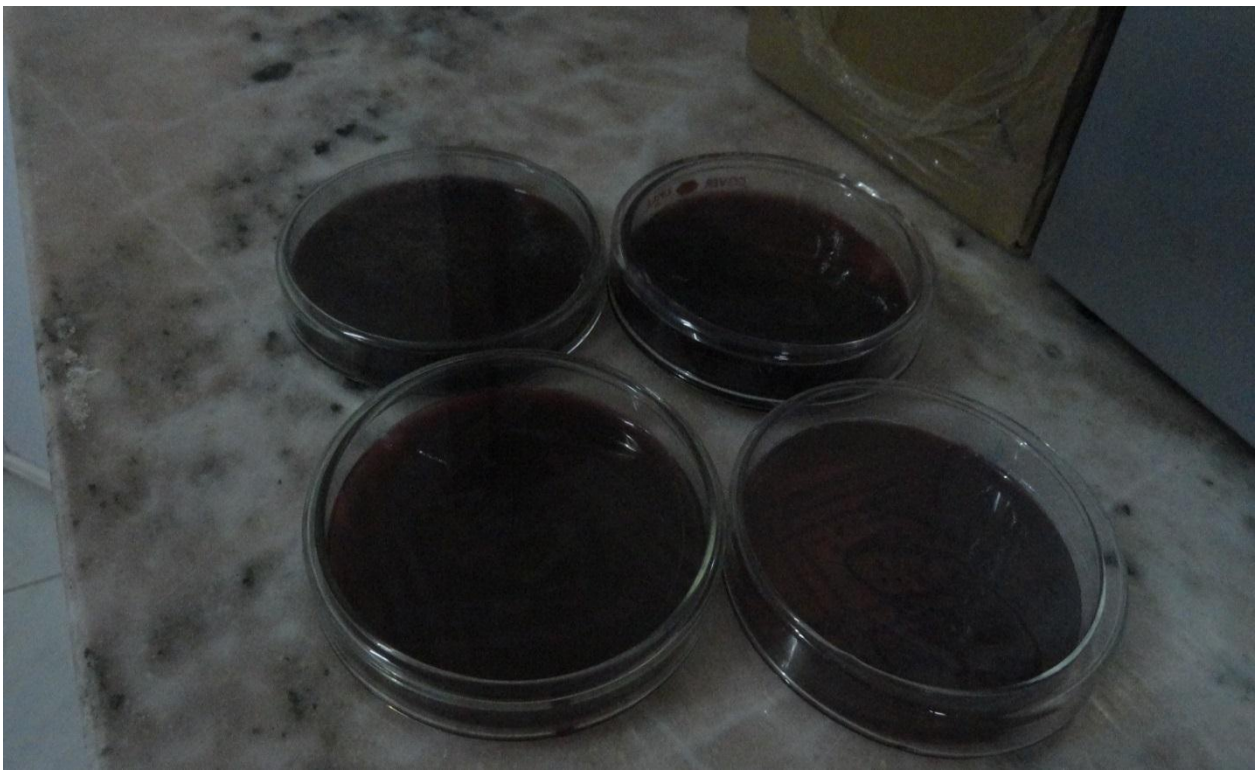

Plate (10) negative results of E. coli bacteria at EMB media.

Plate (11) reading of results of bacteriological tests at laboratory.

Plate (12) process of searching about water borne-diseases cases from records in health institutions.

Shendi University

Faculty of postgraduate studies

Form of samples collection

Date ……...time……

Locality……. Town……block No……...

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

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

Name of collector……..

Name of sending lablotary……

Date & time of receive sample at lab……

Name of receiver……...

بسم الله الرحمن الرحيم

Shendi University

Faculty of postgraduate studies

Form of samples collection

Date ……...time……

Locality……. Town……block NO…….

Type of source……. Site of sampling…….

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

Name of collector……..

Name of sending lablotary……

Date & time of receive sample at lab……

Name of receiver……...

بسم الله الرحمن الرحيم

ShendiUniversity

Faculty of postgraduate studies

Form of water-borne diseases

Health unit name: ……

Month…….

disease	No. of cases	remark
Typhoid		
Bacillus dysentery		
Cholera		
Amoebiasis		
Giardiasis		
Poliomyelitis		
Hepatitis A		
Hepatitis E		
Helminthes		
Diarrhea		

Name of medical director……

Signature of medical director…….

Shendi University

graduate studies and scientific research Faculty of

Questionnaire about drinking water quality addressed to residents in Shendi town

Block NO: (1)

Name: - 2)(

Sex: - (a) male ☐ (b) female **(3)** ☐

(4) Age:-

(a) 20-25 years ☐ (b) 26-30 years ☐ (c) 31-35 years ☐ (d)36-40 year ☐
(e) more than 40 years ☐

(5**) Educational level: -**

(a) Illiterate ☐ (b) basic ☐ (c) intermediate ☐ (d) secondary ☐
(e) university ☐ (f) post graduate ☐

(6) Work or occupation:

(a) Employee ☐ (b) farmer ☐ (c) commercial ☐ (d) free works ☐
(e) Un employee ☐

Marital status: - (7)

(a) Married ☐ (b) single ☐ (c) widow ☐ (d) divorce ☐

(8) Family size: -

(a) 2-4 persons ☐ (b) 5-7 persons ☐ (c) 8-10 persons ☐
(d) more than 10 persons ☐

(9) What the main source of drinking water for your house hold?

(a) Rain water ☐ (b) surface water ☐ (d) ground water ☐

(10) How to obtain on drinking water for household?

(a) Municipal network ☐ (b) tanker delivery ☐ (c) free aid from ☐ humanitarian (d) private well ☐

(11) How often does household have running water from the network?

(a) Not connected ☐ (b) less than 4 hours daily ☐ (c) 5-12 hours daily ☐ (d) more than 12 hours daily ☐

(12) Is the water you are receiving satisfying your needs?

(a) Yes ☐ (b) No ☐

(13) Which season you consume more quantity of water?

(a)Autumn ☐ (b) winter ☐ (c) Summer ☐

(14) How many liters of drinking water storage capacity do you have?

(a) 250liter ☐ (b) 500liters ☐ (c) 1000liters ☐ (d) more than1000liters ☐

(15) Do you keep drinking water in separate container or tank?

(a) Yes ☐ (b) No ☐

(16) Does water container have a narrow mouth or opening?

(a) Yes ☐ (b) No ☐

(17) Is drinking water container or tank has algid or cover?

(a) Yes ☐ (b) No ☐

(18) How the water is taken from the container or tank?

(a) Poured ☐ (b) cup ☐ (c) other ☐ utensil

(19) How often is the container cleaned?

(a)every day ☐ (b)every week ☐ (c) every month ☐ (d) rarely ☐ (e)never ☐

(20) Do you think that seasonal variations have effect on drinking water quality and quantity?

(a) Yes ☐ (b) No ☐

(21) What is your view about drinking water quality?

(a) Excellent ☐ (b) good ☐ (c) acceptable ☐ (d) unacceptable ☐

(22) Are you paying fees for drinking water?

(a) Yes ☐ (b) No ☐

(23) How much did you pay for drinking water last month?

(a) 20 SDG ☐ (b) 25SDG ☐ (d) more than 30 SDG ☐ (c)30 SDG ☐

(24) Do you mind to pay additional fees for improving the quality of drinking water?

(a) Yes ☐ (b) No ☐

(25) What sort of the toilet do you have?

(a) Pit latrine ☐ (b) aqua privy ☐ (c) flush latrine ☐ (d) septic tank ☐

(e) other ☐

(26) Do you have Stagnant or sewerage system near your house ?

(a) Yes ☐ (b) No ☐

(27) Is the position of toilet in a house within 10 meters from any source of water or tap stands?

(a) Yes ☐ (b) No ☐

(28) When do you usually wash your hands with soap? More than answer is possible.

(a) at prayer times ☐ (b) before eating times ☐ (c) after meal times ☐

(d)before bed ☐ (e)before cooking ☐ (f) after using the toilet ☐

(29) Has anyone in your house had unusual diarrhea symptoms in the last few weeks?

(a) Yes ☐ (b) No ☐

(30) In the case of the answer by yes in above question did the infected person go to health unit?

(a) Yes ☐ (b) No ☐

(31) In the case of the answer by yes in above question what the result of diagnosis?

(a)cholera ☐ (b) bacillary dysentery ☐ (c) typhoid ☐

(d)amoebic dysentery ☐ (e) Giardiasis ☐ (f) hepatitis A ☐

(g) hepatitis E ☐ (h) poliomyetis ☐ (i) helminthes ☐ (j) other ☐

(32) In which season there is increase rate of water-borne diseases?

(a) Autumn ☐ (b) winter ☐ (c) summer ☐

Ethical considerations

The ethical considerations of this study as the following:

- Permission had been taken from Civil Water Corporation represented by manager of corporation to permit for take water samples from water supply system for purposes of study.
- Agreement had been taken from manager of drinking water safety and manager of distance in Shendi Town to obtain on certain required information for study.
- Permission had been taken from managers of health institutions and health centers in Shendi Town to search in records to find confirmed cases of water-borne diseases.
- Agreement had been taken from Ministry of Health River Nile State , represented by manager of public health laboratory to use laboratory and it's facilities for analyzed the water samples.
- Permission had been taken from populations of Shendi Town to take water samples from household and filling the questionnaire with them, to obtain on information about quality and quantity of drinking water also to collect data about water-borne diseases.

River Nile state
Ministry Of Health
Public Health Laboratory

بسم الله الرحمن الرحيم

ولايـــة نهـــر النيـــل
وزارة الصـحـــــة
معـمـــل الصـحـــة العـامة

Food & water examination

الاسم : محلية شندى مسئول جمع العينة:

Date of samplin7\6\2014
Date of Examination7\6\2014-18\6\2014

NO	اسم المصدر	CHOLIFORM TEST LAURYL	THERMOTOLERANT CHOLIFORM TEST B.G.B	CULTURE E.M.B	INDOL TEST
12		+VE	+VE	E.coli -VE	-VE
13		+VE	+VE	E.coli +VE	+VE
14		+VE	-VE	E.coli -VE	-VE
15		+VE	-VE	E.coli -VE	-VE
16		+VE	+VE	E.coli -VE	-VE
17		+VE	+VE	E.coli -VE	-VE
18		+VE	+VE	E.coli -VE	-VE
19		+VE	-VE	E.coli -VE	-VE
20		+VE	+VE	E.coli -VE	-VE
21		+VE	-VE	E.coli -VE	-VE
22		+VE	-VE	E.coli -VE	-VE

- نسخة للسيد \ مدير إدارة صحة البيئة بوزارة الصحة .
- نسخة للسيد \ معمل الصحة العامة .

- Dat18\6\2014

ولاية نهر النيل - وزارة الصحة
التاريخ
معمل الصحة العامة

River Nile state
Ministry Of Health
Public Health Laboratory

بسم الله الرحمن الرحيم

ولايـــة نهـــر النيـــل
وزارة الصـــحـــة
معمـــل الصـــحـــة العـامة

Food & water examination

الاسم : محلية شندى مسئول جمع العينة:

Date of sampling3\10\2014
Date of Examination3\10\2014-7\10\2014

NO	اسم المصدر	CHOLIFORM TEST LAURYL	THERMOTOLERANT CHOLIFORM TEST B.G.B	CULTURE E.M.B
100		+VE	+VE	E.coli -VE
101		+VE	+VE	E.coli-VE
102		+VE	+VE	E.coli -VE
103		+VE	-VE	E.coli -VE
104		+VE	+VE	E.coli+VE
105		+VE	+VE	E.coli +VE
106		+VE	+VE	E.coli -VE
107		+VE	+VE	E.coli -VE
108		+VE	+VE	E.coli -VE
109		+VE	+VE	E.coli -VE
110		+VE	+VE	E.coli +VE

- نسخة للسيد \ مدير إدارة صحة البيئة بوزارة الصحة .
- نسخة للسيد \ معمل الصحة العامة .

- **Dat7\10\2014**

هنان إدريس
أخصائي أحمد أحمر
أول مصطفى

ولاية نهر النيل - وزارة الصحة
معمل الصحة العامة

River Nile state
Ministry Of Health
Public Health Laboratory

بسم الله الرحمن الرحيم

ولايـــة نهـــر النيـــل
وزارة الصـــحـــة
معـمـــل الصـحـــة العـامة

Food & water examination

الاسم : محلية شندى مسئول جمع العينة:

Date of sampling15\2\2015
Date of Examination15\2\2015—19\2\2015

NO	اسم المصدر	CHOLIFORM TEST LAURYL	THERMOTOLERANT CHOLIFORM TEST B.G.B	CULTURE E.M.B
199		+VE	+VE	E.coli+VE
200		+VE	+VE	E.coli-VE
201		+VE	+VE	E.coli+VE
203		+VE	+VE	E.coli -VE
204		+VE	+VE	E.coli +VE
205		+VE	+VE	E.coli -VE
206		+VE	+VE	E.coli-VE
207		+VE	+VE	E.coli -VE
208		+VE	+VE	E.coli -VE
209		+VE	+VE	E.coli+VE
210		+VE	+VE	E.coli +VE

- نسخة للسيد \ مدير إدارة صحة البيئة بوزارة الصحة .
- نسخة للسيد \ معمل الصحة العامة .

ولاية نهر النيل - وزارة الصحة
التاريخ
معمل الصحة العامة

Study area map (Shendi Town)