CHARACTERIZATION OF DRINKING WATER QUALITY IN CHARIKAR CITY OF PARWAN PROVINCE, AFGHANISTAN

By

Abdul Basit Azami

Reg# 252-FBAS/MSES/S15

Supervisor

Dr. Islamud Din

Department of Environmental Science
Faculty of Basic and Applied Sciences
International Islamic University Islamabad
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" " - Standards and risk
Ground water quality

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Submitted for the MS Degree in Environmental science at the faculty of Basic & Applied Sciences, International Islamic University, Islamabad

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DEDICATED

To

My beloved wife , and my sweet Mother and Father, Mr. and Mrs. Abdul Hai Nasiry, my beloved brothers and beloved sisters; Mr. Abdul Samad Nasiry, Mr. Hakim Nasiry, Mr. Abdul Ghafoor Hadaf, Mr. Abdul Saboor Nasiry, Shakoor and Kabeer Nasiry, for always supporting me, and giving to me their unconditional love, and affection.

DECLARATION

I, Abdul Basit Azami s/o Abdul Hai, Registration No. 252-FBAS/MSES/S15 student of MS Environmental Science at the Department of Environmental Science, Faculty of Basic & Applied Sciences, International Islamic University Islamabad (IIUI) do hereby solemnly declare that the thesis entitled "Characterization of Drinking Water Quality in Charikar City of Parwan Province, Afghanistan" submitted by me in partial fulfillment of the requirement for the MS degree in Environmental Science, that I am the sole author of the thesis and that no part of this thesis has been published or submitted for publication.

I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright or violate any proprietary rights and that any idea, technique, quotations, or any other material from the work of otber people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices.

I declare that this is a true copy of my tbesis, including any final revisions, as approved by my thesis committee and the graduate studies office, and that this thesis has not been submitted for a higher degree to any otber university or institution.

Dated: Signature of Deponent

Acceptance by the Viva Voce Committee

Thesis Title: Characterization of Drinking Water Quality in Parwan Province, Charikar, Afghanistan

Name of Student: Abdul Basit Azami

Registration No: 252-FBAS/MSES/S15

Accepted by the Faculty of Basic and Applied Sciences, Department of Environmental Science, International Islamic University, Islamabad in partial fulfillment of the requirements for MS degree in Environmental Science.

Viva Voice Committee

Dean, FBAS	----------------------------
Chairman, DES	Dr. M. Ibrar Shinwari
Supervisor	---------------------------- (Dr. Islam ud Din)
External Examiner	Dr. Qaisar Mahmood.
Internal Examiner	---------------------------- (Prof. Dr. M. Irfan Khan)

Date:

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Finally, the errors that remain are all mine.

Date: ..../..../.../ **Abdul Basit Azami**

ABSTRACT

Charikar is the capital city of Parwan Province, located in northern Afghanistan. The main sources of water in Charikar are the Salang River, Ghorband River, springs, streams, open wells, tube wells, tanks, hand pumps and the water supply network.

Water samples were collected in triplicate from 12 sites from August to December 2016. The samples were tested for physicochemical and biological parameters and were compared with WHO and EPA standards for drinking water.

Physical parameter changes were noticed in pH, TDS, and color of water samples. There were 14 samples higher in TDS values than the recommended standards for safe drinking water collected from pump, pipe, spring, hand pump, open wells and wells. Four samples were low in pH from Parchah 5 and from open well, pipe, and pump. Only one sample from a hand pump had an abnormal color. Seventeen samples tested positive for E. coli bacteria. Six samples were positive in Parchah 5. Elevated iron (Fe) level was found in 24 samples. High SO_4 concentration was found in three samples. The most important result was the presence of E. coli in the samples. Almost 50% of the samples were positive due to the poor sanitation and sewage conditions found in Charikar. Lack of proper sanitation and little indoor plumbing leave the residents with no choice other than to use the outdoors as their toilets. Cross contamination leads to a high rate of illnesses and even death. AUWSSC and the Department of Public health, Environment, Agriculture, Energy and Water have a responsibility to provide clean, safe, potable water to all the residents of Charikar. The Municipality must properly dispose of waste and sewage to help control contamination of the water supply. Laboratory centers must be equipped for sampling and analyses of water at agricultural areas, industrial areas, WSN and all other water resources.

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ABBREVIATIONS

WSP	Water Safety Plan
EPA	Environmental Protection Agencies
WHO	World Health Organization
WQR	Water Quality Ratings
UNISCO	United Nations Educational, Scientific and Cultural Organization
WQIC	Water Quality Index Calculator
UNICEF	United Nations Children's Emergences Fund
AFNEPA	Afghanistan National Environmental Protection Agency
AUWSSC	Afghanistan Urban Water Supply and Sewage Company
USGS	United State Geological Survey
GTZ	German Technical Cooperation
AGS	Afghanistan Geological Survey
UNEP	United Nation Environmental Protection
AIMS	Afghanistan Information Management Service
DACAAR	Danish Community for Aid to Afghan Refugees
Ru-WatSIP	Rural Water Supply, Sanitation and Irrigation Program
WA	World Atlas
PMS	Preventive Maintenance Services
DWQ	Drinking Water Quality
TDS	Total Dissolved Solids
EC	Electrical Conductivity

CHAPTER 1

INTRODUCTION

1.1. CRITICAL REFLECTIONS OF WATER

Water is the most important natural resource for all living organisms on earth as they need water for their survival and growth. In the Holy Quran, it is mentioned, "We have kept alive everything from water". About 70 % of earth surface is surrounded by water out of which 97.2% water is salty while only 2.8% is fresh water in the form of glaciers, ice caps, rivers, lakes and ground water (Viman et al., 2010).

Everyone has access to water, but not all waters are clean and safe to be used. Natural sources such as open wells, and streams are contaminated by wastes (Viman et al., 2010). Contaminated water is harmful to life. People on the globe are under tremendous threat due to undesired changes in the physical, chemical, and biological characteristics of air, water, and soil (Patil & Ahmad., 2012). The health of the whole ecosystem can be threatened by chemical and physical hazards through changes in water quality and quantity.

There are 5 types of infectious diseases associated with water: 1) Water borne disease 2) Water carried diseases 3) Water wash disease 4) Water based diseases 5) Vector based water related diseases. These types of diseases have potential to cause illness and death anywhere around the world (Slack, 2014). Water causes water borne diseases which have led to the death of millions of people (Adefemi & Awokunmi, 2010). Approximately 768 million people of the world did not use an improved source of drinking water in 2011 (WHO & UNICEF, 2013).

The water quality is a term used to describe the chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose. Although scientific measurements are used to define water quality, it is not a simple thing to say that "this water is good" or "this water is bad". Water that is perfectly good to wash a car may not be good enough to serve as a drinking water. When the average person asks about water quality, they probably want to know if the water is good enough to use at home, to play in, to serve in a restaurant, etc., or if the qualities of our natural waters are suitable for aquatic plants and animal. The vulnerability of surface water and groundwater to degradation depends on a combination of natural landscape features, such as geology, topography, soil, climate and atmospheric contributions, along with human activities related to different land uses and land management practices.

1.2. SURFACE AND GROUNDWATER QUALITY

Groundwater is a vital component of the hydrological cycle and is derived from precipitation, surface water runoff, and standing bodies of water. Groundwater is mostly used for public water supply and is generally safe to drink (West & Odling, 2014).

Rain water has been condensed from the clouds. The first drop is distilled water. But when it falls as rain, it picks up germs, dust, smoke, minerals, strontium 90, lead (Pb) and many otber atmospheric chemicals. By the time rain water reaches the earth, it is so saturated with dust and pollutants it may be yellowish in color. Water is supposed to act as an atmospheric purifier. If we had no air pollution, we would have far less pollution in our drinking water. Snow water is frozen rain. Freezing does not eliminate any germs. All snowflakes have hardened mineral deposits. Melt the cleanest snow and you will find it saturated with dirt, inorganic minerals, germs and viruses.

Water is so valuable to the entire system of the human body that it is wise to use only the best, pure stream cleaned water for good health and well-being (Christopher, 2007). Surface water is taken from the lakes, rivers, waterfalls and seas. It plays the largest role in shaping the geography of the land.

It is the responsibility of a government to provide safe, clean, affordable drinking water to all its citizens. Most nations understand they have an obligation, but how to perform these duties on a wider scale can be a challenge in an environment that is lacking in trust and community relationships. If any nation wishes to have a better environment for all of its citizens, it must overcome personal biases, and issues of trust, and learn to work together to achieve these goals.

Countries will most likely implement water laws and policies and assign a governing agency to oversee the performance and the enforcement of these laws. The aim of national drinking-water laws and standards should be to ensure that the consumer enjoys safe potable water, and not to shut down deficient water supplies. The nature of each countries law will depend on the national, constitutional and many other considerations. The national regulations should apply to all water sources. Different approaches are necessary for different situations. Formal situations may require a different approach as defined by water works, a water company, or a community based program.

If a supplier is used, they are responsible for continuous, effective quality assurance and quality control to include; inspections, supervision, preventive maintenance services (PMS) and routine testing of water quality. However, the supplier is normally responsible for quality of water only up to a point; the designated property line in the distribution system and may not have responsibility for the deterioration of water quality upon the property.

Local environmental health authorities and other appointed governing agencies, often play an important role in managing water resources and drinking water supplies. This may include catchment inspection, verification of the sample, and management of formal drinking water systems by surveillance. Some rural communities rely on storage tanks and water treatment plants to supply safe drinking water to rural communities. The responsibilities of these agencies may end with treatment of the water, or this water may be potted, transported, and distributed to a specific location. Once delivered, the responsibility for contamination of the water becomes that of the consumers.

Communities have an important role to play in educating consumers where household water treatment is necessary. Management of household and small community drinking water supplies generally requires an education program. Communities must provide education about drinking water supply, water quality and contamination. Such programs should normally include; water hygiene, raising awareness on the most common methods for contamination, basic training and technology associated with drinking-water supply and management, consideration of approaches to overcoming socio-cultural barriers, acceptance of water quality interventions, motivation, mobilization, and social marketing activities of water. A list of support, follow up, and dissemination of the water quality program to achieve and maintain sustainability.

Water programs can be administered by the community, local health authorities or other entities, such as non- governmental organization (NGOs), and the private sector. If the program arises from other entities, there must be the involvement of the local health authorities in the development and implementation of water quality education and a training program is highly recommended. For more information on hygiene, and sanitation, as well as available training programs, WHO documents and websites are helpful.

Groundwater from deep and confined aquifers is usually microbial safe and chemically stable in the absence of direct contamination. However, shallow unconfined aquifers can be subject to contamination from discharges or seepages due unsafe water use methods associated with agricultural practices (pathogens, nitrates and pesticides), on-site sanitation, and sewage (pathogens and nitrates) as well as industrial wastes. Hazards and hazardous events that can have an impact on catchments and that should be taken into consideration as part of a hazard assessment include; variations in raw water quality, sewage and septic system discharge, industrial discharge, chemical use at the catchment site, chemical spills, human recreation activities, wildlife, and livestock wastes, land use, changes in land use, inadequate buffer zones, effects on vegetation, soil erosion and failure of sediment traps, storm water flows and discharges, active and closed waste disposal areas, mining, contaminated sites, hazardous waste sites, geology and naturally occurring chemicals, unconfined and shallow aquifers, inadequate wellhead protection, uncased or inadequately cased bores and unhygienic practices, climate and seasonal weather variations and natural disasters.

Further hazards and hazardous situations which can have an impact on storage reservoirs and intake areas that should be taken into consideration as part of a hazardous assessment are:

- human access/the absence of exclusion areas;
- short circuiting of reservoir areas;
- depletion of the reservoir areas;
- lack of a selective withdrawal;
- lack of alternative water sources;
- unsuitable intake area;
- the presence of Cyano-bacteria
- stratification;
- and failure of alarms and monitoring equipment.

Community management and community-managed drinking water systems, with both piped and non-piped distribution, are common worldwide in both developed and undeveloped countries. While population size or the type of supply may be appropriate, under many conditions, approaches to administration and management provide a distinction between the drinking water systems of small communities and those of larger towns and cities. Often communities rely on untrained and sometimes unpaid community members in the administration and operation of drinking water systems.

Drinking water system in peri-urban areas in developing countries, (communities surrounding major towns and cities), may also have the characteristic of community systems. Sustainable programs for the management of community drinking water quality require the active support and involvement of local communities. These communities should be involving at all stages. Such programs, including initial survey; decision on choosing a site for wells; off-takes, or establishing protection. Monitoring and surveillance of drinking water supplies; reporting faults, carring out maintenance and taking remedial corrective action. A community may already be highly organized and taking action on health or drinking water supply issues. Alternatively, it may lack a well-developed drinking- water system.

The influence of land use on water quality should be assessed as part of water resource management. This assessment is not normally undertaken by health authorities or drinking water supply agencies alone and should take into consideration the land cover changes, extraction activities, construction/upgrades of waterways, application of fertilizer, herbicides, pesticides and other chemicals, livestock density and application of manure, road construction/maintenance, various forms of recreation, urban or rural residential development, with particular attention to excreta disposal, sanitation, landfill and waste disposal; and other potentially polluting human activities such as industry, military sites etc.

Water resource management may be the responsibility of catchment management agencies or other entities controlling or affecting water resources such as industrial, navigational, agricultural and flood control entities. Regardless of the governing structure, and sector responsibilities, it is important that health authorities collaborate with managers of water resources and regulating land use in the catchment.

Establishing close collaboration between the public health authority, water supplier, and resource management agency assists recognition of the potential health hazards occurring in the system. Priority and protection of drinking water resources should be considered in decisions for land use, or regulation of contaminated water resources. This may include the involvement of other sectors and managers of agriculture, urban development, traffic and tourism. To ensure the adequate protection of drinking water sources, national authorities will normally interact with other sectors in forming national policy for integrated water resource management.

Regional and local structures will implement and setup the policy. National authorities will guide regional and local authorities by providing the necessary tools. Regional environmental and public health authorities have an important task in education of the public and participation in the preparation of the integrated water resource management plan to ensure the best available drinking water quality.

Significant and adverse health effects have been associated with inadequate plumbing systems within public and private building because of poor design, incorrect installation, secondary alterations and inadequate maintenance. Numerous factors affect the quality of water within a building piped distribution system and may result in microbial or chemical contamination of drinking water.

Outbreaks of gastrointestinal diseases can occur through fecal contamination of drinking water within buildings, arising from defects in roof storage tanks and cross-connections with waste water pipes. Poorly designed plumbing system can cause stagnation of water and provide a suitable environment for the proliferation of Legoinella, a respiratory disease caused by Legoinella bacteria.

Plumbing materials, pipes, fittings and pipe coatings can result in elevated heavy metal. Potential adverse health effects may not be confined to the individual building. Expose of other consumers to contaminants is possible through contamination of the local public distribution system. Outside the particular building, cross contamination of drinking water and back flow can occur. Reliance is therefore placed on proper installation and servicing of plumbing and for larger buildings, on specific Water Safety Plans (WSPs). To ensure the safety of drinking water supplies within the building system, plumbing practices prevent the introduction of hazards to health. This can be achieved by ensuring that:

- pipes carrying either water or wastes are airtight, durable, of smooth and unobstructed interior and protected against anticipated stresses;
- water storage systems are intact and not subject to intrusion of microbial and chemical contaminants;
- cross connection between drinking water supply and wastewater removal systems do not occur;
- hot and cold water systems are designated to minimize the proliferation of Legoinella;
- waste is discharged without contaminating drinking water;

- the system design of mulit-storey buildings minimizes pressure fluctuations;
- Plumbing systems function efficiently.

Necessary installation and servicing of plumbing systems to ensure compliance with local regulations and use only materials approved as safe for use with drinking-water. Design of the plumbing systems of new buildings should normally be approved prior to construction and be inspected by an appropriate regulatory body during construction and prior to commissioning of the buildings.

Drinking-water supplies vary large urban systems, servicing populations with tens of millions, to small community systems providing water to very small populations. In most countries, they include community sources as well as piped means of supply. Drinking-water vendors selling water to households or at collection points are common in many parts of the world where scarcity of water. Water vendors use a range of modes of transport to carry drinking-water for sale directly to the consumer, which includes trucks, wheelbarrows or trolleys and carts. There are a number of health concerns associated with water supplied to consumers by water vendors. These include adequate volumes and concerns regarding inadequate treatment, or transporting of water in inappropriate containers which can result in contamination. Water vending does not include bottled or packaged water or water sold through vending machines.

Everyone consumes water from one source or another. Consumers often play an important role in the collection, treatment and storage of water. Consumer actions may help to ensure the safety of the water they consume and may also contribute to improvement or contamination of the water consumed by others. Consumers have the responsibility for ensuring that their actions do not impact adversely on water quality. Installation and maintenance of household plumbing systems should be undertaken preferably by a licensed and authorized plumber or other persons with appropriate expertise to ensure that cross contamination or back flow vents do not result in contamination of local water supplies. In households using non-piped water supplies, appropriate efforts are needed to ensure safe collection, storage and perhaps treatment of their drinking water.

1.3. CONJUNCTIVE USE OF GROUND AND SURFACE WATER

Surface and groundwater are two separate entities, so they must be regarded as such. However, there is an ever increasing need for management of the two as they are part of an interrelated system that is paramount when the demand for water exceeds the available supply (Kinyua et al., 2016).

For public consumption (including industrial, commercial, and residential) is caused by over-pumping. Aquifers near river systems that are over-pumped have been known to deplete surface water sources as wells. Research supporting this has been found in numerous water budgets for a multitude of cities.

According to the Afghanistan mortality survey (2010), 54% of families have access drinking water and World Bank stated that 77 % of urban families have access to improved drinkable water in rural areas. This %age is about 49 % of the urban and rural populations. Only 20% of families have improved toilet facilities (APHI, 2010). Contaminated water causes many diseases. It is estimated that 26.4 % of Afghanistan children had diarrhea (Varkey et al., 2015). About 80 % of human's diseases are from contaminated water or transferred by polluted water (Royan, 2014).

With proper water resource management and access to safe drinking water, child mortality could be decreased and the average age of children would increase. In Afghanistan, access to improved water may decrease to 36 % in 2025 compared to 2004. The central statistical office information showed that 16 % of the Kochi people, 20 % rural families and 58 % urban families use safe drinking water (AFNEPA, 2012). By the end of year 2011, 89 % of people used improved potable water sources and 55 % of people enjoyed associated health benefits (WHO & UNICEF, 2013). According to Masoud (2013) 73 % of the people of Afghanistan have no access to safe drinking water. Almost 95 % have no access to sufficient hygiene.

1.4. GEOGRAPHY AND CLIMATE OF AFGHANISTAN

Afghanistan is located 37 degrees north of the great circle, it is dry and arid, and a mountainous country. The climate of Afghanistan is arid and semi-arid, generally, Afghanistan possess cold winters and hot summers. Most areas of Afghanistan are located at high altitude and receiving lower temperature all year around. The highest regions of the country summer average temperature below 15 degrees Celsius with winter average temperature below zero prevailing (Savage et al., 2008).

Heavy snow falls in the mountains. A small region in the east near Jalalabad is affected by the monsoons of southern Asia. The southern desert regions, temperature sometimes reach

120 Fahrenheit during the day to 60 degrees Fahrenheit at night. In the winter temperatures in the northern deserts occasionally drop even lower at night.

According to USAID, the average annual precipitation is sufficient to support irrigated agriculture for an expanded rural population. Afghanistan receives rain and snow equivalent to about 236 billion m3 of water in an average year. About 65 billion In3 of water flows in Afghanistan's rivers and streams. Water is one constraint to Afghanistan's rural economy in addition to other factors sucb as geography, topography, temperature, wind, and soil conditions. Other factors include: farming technology and practices, and traditional human behavior must also be taken into account in a realistic assessment of constraints. According to the Central Statistic Independent Organization, Afghanistan has almost 32 million people in 34 provinces and 8 zones. The average household has 7 members. 85% of the people, who are working, are working in agriculture, but only about 30% of the populations are employed. 45% of the population can read and write. Almost 11 million children are attending school, 41% of the children in schools are female and 59% are male. Approximately 45% of people are living in poverty. 70% of the people do not have access to clean drinking water. Afgbanistan has water, but the quality of drinking water is poor.

Under the rule of King Zahir Shah there was 20-25 liters of water per day per person available to drink from rivers, springs and melted ice from the mountains. But now, people do not have access to this amount of water. Instead now they are using different sources for drinking water, from surface waters, groundwater and water supply systems. Today, in some developed countries, people are using 500-600 liters of water per day, per person.

Afghanistan has 163 billion cubic meters of precipitation per year. From this amount 75 billion cubic meters in rivers, 18 billion cubic meters in groundwater and other the remaining water is stored in other natural resources.

In 2007, Afghanistan's cabinet passed a bill about Afghanistan Water Sector Strategy (AWSS). They divided the country water resources into 05 water basins. Afghanistan has access to 20 billion cubic meters of the 75 billion cubic meters available. There are 25 large rivers and many small rivers/streams.

USAID, World Bank, European Union, WHO, GTZ German, UNISCO, UNICEF, Japan Government, India Government, Iran, Canada Government, UK Government, Denmark Government, Norway, the Islamic Bank, USGS, and Habitat for Humanity International are working with Afghanistan to solve its water problems. Afghanistan Urban Water Supply and

Sewage Company (AUWSSC) is currently the provider for safe drinking water in Afghanistan (AUWSSC).

1.5. RIVER BASINS AND WATERSHEDS IN AFGHANISTAN

There are forty-one watersheds located within five river basins in Afghanistan. There are five none drainage areas within these forty- one watersheds. These are the five largest rivers in Afghanistan, Kabul River, Amu Darya River, Helmand River, Harrirud River, and Kunduz River.

Table 1 presents statistics for each watershed and river basin. These statistics have been prepared with data available at the AIM'S office in Kabul. These data allow comparison and classification based on major characteristics between watersheds and rivers.

Figure 1Afghanistan map showing all provinces

Table 1 Area, settlements and population by watershed

River basins	Watersheds Names	Area (Km²)	Settlements Number	Settled Population
Amu Darya	Ab-I-Rustaq	3670	231	358,749
Amu Darya	Khanabad	11994	622	668938
Amu Darya	Kokcha	22368	1344	715236
Amu Darya	Kunduz	28024	1240	1090639
Amu Darya	Panj	24637	715	134560
Amu Darya		**90693**	**4152**	**2968122**
Harirod- Murghab	Bala Murghab	25356	735	301380
Harirod- Murghab	Kushk-wa-kashan Rod	13191	501	287829
Harirod- Murghab	Lower- Hari Rod	17936	639	824456
Harirod- Murghab	Upper-Hari Rod	21124	1084	308610
Harirod- Murghab	.	**77604**	**2959**	**1722275**
Hilmand	Adraskan Rod	21266	462	186446
Hilmand	Arghistan Rod	20219	1470	208932
Hilmand	Chagay	9319	1	642
Hilmand	Dasht-i Nawur	1618	236	10987
Hilmand	Farah Rod	32809	68	381281
Hilmand	Khash Rod	21840	1029	92379
Hilmand	Khuspa Rod	9428	339	38987
Hilmand	Lower Arghandab	7300	105	732056
Hilmand	Lower Hilmand	14147	631	317275
Hilmand	Middle Hilmand	16441	246	326895
Hilmand	Sardih wa Ghazni	17252	810	1868342
Hilmand	Sistan Hilmand	21575	1922	91968
Hilmand	Tarnak Rod	9076	173	261602
Hilmand	Upper Arghandab	13170	837	316790
Hilmand	Upper Hilmand	46882	4587	1046990
Hilmand	.	**262342**	**14041**	**5881571**
Kabul	Alingar	6239	465	287089
Kabul	Chakwa Loger Rod	9968	1212	607283
Kabul	Ghorband wa Panjshir	12964	1651	1440757
Kabul	Gomal	9014	190	16316
Kabul	Kabul	12997	1628	3591820
Kabul	Kuner	11664	712	600237
Kabul	Pishin lora	4206	43	11320
Kabul	Shamal	9856	1138	630152
Kabul	.	**76908**	**7039**	**7184974**
Northern	Balkhab	28835	1662	1344202
Northern	Khulm	10230	274	259410
Northern	Saripul	16743	529	573449
Northern	Shirin Tagab	15092	504	605972
Northern	.	**70900**	**2969**	**2783033**
Non-drainage area	Dashti Murghab	8414	0	0
Non-drainage area	Dasht-i Naumed	20561	23	17441
Non-drainage area	Dasht-i Shortepa	5880	46	134187
Non-drainage area	Rejistan	26672	0	0
Non-drainage area	Rejistan-i Sedi	5829	0	0
Non-drainage area		**67356**	**69**	**151628.66**
Grand total	.	**645803**	**31229**	**20691604**

*Based on CSO 2003-04 figures. Nomadic population not included.

According to Afghanistan Information Management Service (AIMS) Upper Hilmand is the largest watershed in Afghanistan, covering 46,882 Km^2, while the smallest watershed is Dasht-i Nawur, which covers 1,618 Km^2. Graphs 1 illustrate the area by each watershed in

Afghanistan. However, Graph 2 shows that the largest number of people is found in the Kabul, Sardih wa Ghazni, Ghorband we Panjshir (Shomali plain) and Balkhab watersheds.

Four main river systems flow down from Afghanistan's mountainous center, across its lowlands, and into deserts or adjoining counties. Regions above 14,000 ft (which receive heavy snow) and those above 4,000 ft (which receive a combination of snow and rain) supply most sections of the country with water during the spring and early summer months. Badakhshan, Kunar, and Takhar provinces in northeast Afghanistan contain regions of glaciations. The glaciers are a long-term benefit that can stabilize water supply within and between years. The glaciers lend a steadiness to stream flows in Afghanistan levels of precipitation vary substantially from year to year in Afghanistan. Most of the water from the glaciers rushes downstream in torrents instead of being retained. Man-made irrigation systems are used to capture water for agriculture in all inhabited regions of Afghanistan, canal systems are mostly use in the North. South of the Hindu Kush, canals are also utilized, as well as simple diversion channels form small streams, rivers, and of Karezes, hand-dug subterranean channels directing water from permanent water tables under mountains or hills to the surface adjacent to fields and villages. Large irrigation projects are located in the Helmand and Nangarhar valleys, and in regions close to Herat and Kunduz, in Kahul and larger cities, urban water and sanitation systems are provided.

1.6. GEOGRAPHICAL LOCATION OF PARWAN

Parwan province is located in northern Afghanistan at 35.0 degrees E and borders Baghlan, Panjshir, Kapisa, Kabul, Wardak and Bamyan provinces. It is approximately 5,974 Km^2 and has 11 districts: Bagram, Charikar, Ghorband, Jabal Saraj, Kohi Safi, Salang, Sayed Khel, Shekh Ali, Shinwari, Siah Gerd, and Surkhi Parsa. The capital city of Parwan is Charikar. Most of the province is mountainous and part of the Hindu Kush range. The Salang Pass splits the mountains in the north and connects Parwan to its northern neighbor, Baghlan. The Salang River flows southward through Parwan beginning in the mountainous north. Parwan climate is highland, semi-arid (Royan, 2014).

Parwan Province's potential for economic growth is good, mainly due to its proximity to, and good infrastructure links with Kabul. It is has good quality irrigated farmland and a diverse agriculture with a vast amount of horticulture and plenty of livestock production. These sectors in particular attract investment. Factional fighting is continuous in some districts but has had limited effects on the economy.

70% of Charikar residents are currently without water. The residents of Charikar are facing serious life threatening conditions due to lack of clean drinking water. DACCAR, an NGO made a little progress in extending water resources. Despite more than 30 years efforts, its greatest accomplishment remains producing a hand pump. This pump was installed on shallow wells and tube wells through a water supply project.

India is investing 09 million dollars in a new water project which will benefit Charikar city. It involves two water reservoirs, each with a 6000 gallon per day capacity (Ru-WatSIP, 2003-2013). This project should be completed in December 2016 but unfortunately still it is under construction.

Table 2 Water Supply Network (WSN)

Charikar Center	Shallow well	Digging	1	12934	175	Completed
Charikar Center	Latrine	Construction	2	35357	400	Completed
Charikar Center	Shallow well	Digging	13	55346	2275	Completed
Charikar Center	Latrine	Construction	3	53036	600	Completed
Charikar Center	Shallow well	Digging	1	4704	300	Ongoing
Charikar Center	Latrine	Construction	3	30966	600	Ongoing
Charikar Center	Shallow well	Digging	1	47000	250	Completed
Charikar Center	Shallow well	Digging	1	32062	200	Completed
Charikar Center	Shallow well	Digging	1	4461	170	Completed
Charikar Center	Shallow well	Digging	1	5024	170	Completed
Charikar Center	Deep Well	Digging	1	45726	500	Ongoing
Charikar	WSN	Construction	1	29871	1500	Ongoing
Charikar	Shallow well	Digging	2	6195	350	Ongoing

Charikar is the capital city of Parwan Province and according to Afghanistan Culture, it is the main town of the Kondaman Valley, located in northern Afghanistan. It is also the largest city in Parwan province. Charikar is located at 35.01 degrees latitude and 69.17 degrees longitude and is 1554 meters above sea level. The city population of Charikar is 96, 039. Residential dwellings in Charikar number 10,671. There are 4 police (Nahias) districts with a total land area of 3.025 hectare land area. Charikar city is located 69 Km from Kabul city. Despite its proximity to Kabul, more than half of the land lies low. The highland of Charikar, about 37% is residential and vacant plots are about 32%. The roads of Charikar occupied about 19% of the built up land area. Charikar is the gateway to Panjshir valley where Shamilli plains meet the bottom of the Hindu Kush Mountains.

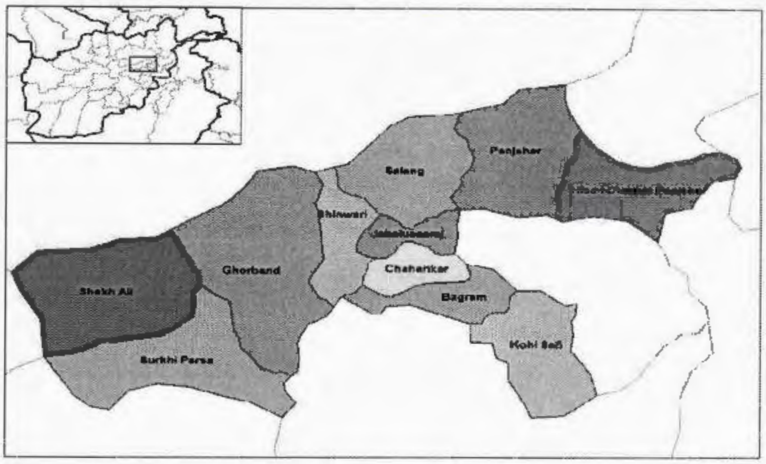

Figure 2 Parwan province map showing all districts

1.7. NATURAL RESOURCES OF PARWAN

Water: snowmelt runoffs from a mountain range of more than 400 km feed through side valleys into the central Kabul River, which carries perennial water. Especially the area around the canal head therefore, has sufficient water supply for irrigation.

Soil: River plains are highly fertile areas. Small areas of land in the plains experience lower productivity levels due to water logging or high salinity. The soft-rolling loess covered hillsides are depleted of soil nutrients and are of low pasture quality. The high mountains of the central highland range in the north features slopes with high porosity, scarce vegetation and permeability.

Biomass: Natural vegetation is restricted to some meager Juniper shrub zones in the higher altitude of the central high range. There is potential for the rehabilitation of forests in places where people recall the existence and profitability of pistachio or mixed forests. In the river plains, farmers cultivate the traditional Poplar/Willow hedges for subsistence. Herbs and grasses are scarce in the rangeland areas where invasive plants like thistles dominate. The rehabilitation of pastureland is possible through reseeding combined with rotational grazing or other methods to protect the land from over grazing.

Minerals: Parwan has a cement factory and iron (Fe) was previously exploited in the North. Parwan has 15 kinds of natural resources, such as: coal, gems, zinc (Zn), lead (Pb), copper (Cu), iron (Fe), chromites.

Parwan Province is one of the largest provinces of the country, with the highest water demand (Lashkaripour & Hussaini, 2008). Parwan Province never had a proper universal water supply system, but rather several local systems, fed hy largely independent sources. Thc first water supply system (Gulbahar Water Supply Network) of Parwan Province was designed and constructed more than fifty years ago in 1966. Karez in the Gulhahar district was the source of water, located about 16 Km from Parwan. Water flowed under gravity through about 18 Km long cast iron pipe to Parwan urban area. This water was distributed to the Royal Palace as well as to main government buildings and houses in urban areas. Presently that water supply networks nonfunctional. It is estimated that 50-60 % of the network was damaged during the past 20 years post Soviet- Civil war time. Only 25% of the people of the Parwan Province have direct access to potable water (AUWSSC).

Diseases: Parwan urban areas have the bighest diarrhea widespread rates of about 34%. Diarrhea diseases are transmitted by polluted water, soil, and food. There is no system for disposal of waste. Parwan's residences utilize 53% of water from wells for drinking and other purposes. The winter of 2005 was lengthy and had the heaviest snow recorded on the Hindu Kush in decades. The result was floods and sewerage around the country (Kakar *et al.*, 2008).

1.8. OBJECTIVES

- Pbysicochemical characterization of drinking water sources in Charikar city of Parwan province.
- To estimate microbial contamination (E. coli) in drinking water samples.
- Contaminated water impacts on peoples' health in the study area

CHAPTER 2

LITERATURE REVIEW

Shar *et al.,* (2010) performed a study to assess the concentration of heterotrophic plate count (HPC), E. coli, and total coliform in groundwater and surface water from Rohri city, Sindh. Total 96 samples of ground and surface water were collected. The finding results from all 96 samples were found to be contaminated with total coliform and E. coli. The pre-storage groundwater samples hands pumps were found to be less contaminated with total coliform (25%) and E. coli (12.5%) compared to post storage groundwater samples contaminated with total coliform 100% and E. coli 41.6. Total coliform and E. coli counts per 100ml were found to increase above tbe WHO standards.

Pavendan, *et al.,* (2011) analyzed the physiochemical and microbial properties of drinking water from alternative water sources of Tiruchirappalli district of south India. Tbe index for healthy society is water quality. There are some factors that quantitatively and qualitatively influence water resources such as industrialization, modern agriculture practices, and urbanization. 60 water samples were collected from three different sources such as (open wells, bore wells, and corporation water of the study area). The assessment showed that open wells water is very contaminated and had the high value of total dissolved solids, total hardness and total alkalinity. The fluoride (F^-) presence in bore wells water crossed the WHO limit for drinking water, recorded the microbial contamination up to 12% of bore wells, 11.1% of open wells and 6.3% of corporation water samples.

Chrysanthus, (2014) assessed the bacterial quality of different water sources in bambui and bambili residential areas, north-west region, Cameroon. In this assessment estimated the bacterial quality of well water and spring water sources. Because this water sources fulfill their daily needs for water. 18 water samples were randomly collected for this analysis in sterilized bottles and the samples were transported at 4C in ice container. In this assessment multiple tube fermentation technique was used. Therefore they need pure water and free of microbes and otber organisms which are harmful to human beings. This study exhibited that 95% well water samples bave the low value of microbiological quality and it does not match to the WHO standards for drinking water.

Al-Bayatti *et al.,* (2012) studied the physiochemical and bacterial parameters of Tigris River which is near to water purification stations in Baghdad Iraq. The water samples for bacterial analysis were collected in 250 ml sterilized glass bottles and for physiochemical analysis collection of water samples done with I litter glass bottles. They analyzed some physiochemical characteristic such as Ph , temperature, EC, DO, TDS, BOD, and salinity, total coliform, fecal coliform, E. coli, were analyzed as well. The result carried out from this study showed that counts of Total coliform and E. coli are over the WHO standards in all stations and at all seasons. Therefore must try to avoid contaminants discharged into Tigris River.

Ahmad, *et al.*, (2015) investigated some physiochemical and bacterial characteristics of drinking water and its potential health impacts in academic institution of Abbottabad, Pakistan. According to their assessment, 63.5% of the samples were beyond the permissible limits of WHO standards for drinking water. Coliforms were found in 66.6% of total water samples and suggested proper monitoring and purification of the water.

Oladipo and Adeboye (2015) performed physiochemical and bacterial analysis of well water used for drinking and domestic purposes in Ogbomosho, Nigeria. They analyzed the water for Turbidity, ph, total hardness, TDS, TSS, Chloride contents, biological oxygen demand (BOD) and chemical oxygen demand (COD) as well as total bacterial counts. The result showed that the water were contaminated and needed treatment before use.

Digha and Ekanem (2015) assessed the water quality and affects of population density on water in Calabar Municipality Cross River State, Nigeria. The samples were collected from 06 boreholes and investigated color, turbidity, EC, and temperature, calcium, magnesium, potassium, sodium, total hardness, nitrate (NO_3), Fe, Pb, Cu and zing in the water. The study showed that groundwater was suitable for irrigation but water samples collected around Ediba, Essien town; Ilok Omin and Ikot Iffanga were not suitable for drinking purposes.

Danish and Rajesh (2013) studied some physiochemical characteristic of drinking water sources in the Amravati district of India. Physiochemical parameters determined such as Ph, EC, total hardness, temperature BOD, COD, calcium, magnesium, and alkalinity. The bottles were treated with dilute mineral acid solutions for two days before sampling. Most of the parameters were found in excess of the allowed limits.

Matre and Zodpe (2014) assessed the bacterial and physiochemical parameters of drinking water in Akola district, India. Some physiochemical parameters such bas color, odor, pH, alkalinity, TDS, turbidity, hardness, Fe, and NO_3 were studied by following standards methods. Samples from hand pumps, tap water, bore wells; tube wells and open wells were collected. According to their findings the water was contaminated and needed treatment before use.

Olukemi (2013) analyzed the effect of Moringa oliefera seeds on bacterial quality and physicochemical characteristics of drinking water in rural communities of Ondo southwestern of Nigeria and used the pour plate technique to conclude the existence of bacterial pathogens. In this study analyzed some physicochemical patterns such as odor, color, temperature, pH turbidity, chloride and NO_3. From various steams at different locations in rural communities samples were collected within the three local government areas (Ile Oluji/Oke Igbo, Odigbo and Ondo East) in the state. In these rural communities the main sources of drinking water were these steams. The study showed that the water had law quality.

Babatuyi *et al.*, (2014) examined the bacterial and physicochemical analysis of Ochaja natural spring water. Water samples were collected in sterilized bottles. The serial dilution and plating on nutrient agar (NA) determined the total viable count of bacteria. For determination of total and fecal coliform they used pour plate and spread plate methods. The total viable organisms and fecal coliform range was form 2.3*10 cfu/ml and 1.25*10 cfu/ml. the fecal coliform and total viable counts were no consequential distinguish ($p<0.05$). There was low level of turbidity and NO_3, also had the high level of phosphorus. The findings of the physicochemical characteristics were within the satisfactory limit of WHO.

Onojah *et al.*, (2013) investigated physicochemical and bacterial assay of sachet water samples marketed in kogi state of university compound, anyigha, for this study they used sachet water samples and these samples were collected from five different sources in 100 ml amount sterilized plastic disposable bottles. Bacterial examination of samples revealed the presence of pathogens such as years, color, tested, E coli, Bacillus species etc. Chemical analysis revealed the presence of metals ranging from Pb, Fe and Cr, the study showed that the water not suitable for drinking.

Sabae *et al.*, (2014) analyzed the seasonal and regional variation of physiochemical and bacterial parameters of surface water in El-bahr El-pherony, Menoufia, Egypt, and 28 samples were collected for analysis during January- September 2013. Physicochemical parameters i.e., pH, Temperature dissolved oxygen (DO) turbidity and BOD as well as total coliform, E-coli, fecal coliform, fecal streptococci (FS) and some pathogenic bacteria were analyzed. For bacterial analysis spread plate method was used. The result showed sewage pollution and suggested regular monitoring for bacterial contamination of the water.

Naji *et al.,* (2011) analyzed the physiochemical and bacterial parameters of drinking water collected samples in Hilla city, Iraq. They collected water samples for bacterial analysis according to APHA (1998) and using sterile borosilicate glass bottles for water sampling. They used various culture media for isolation of bacteria such as Mac conkey agar (Hi- media) for coliform count, nutrient agar (Oxide) for total aerobic bacterial count and brain- heart infusion agar (Hi-media) for fecal streptococci count.

Hamid *et al.,* (2013) investigated the intensive report of total analyses of drinking water in Lahore, Pakistan. Investigation conducted by collected water samples from tube wells and taps water from various locations/ towns of Lahore. In this study some physicochemical parameters of water were analyzed such pH, temperature, color, turbidity, TSS, total hardness, TDS, EC, chloride, F-, NO_3, As and Pb and from this assessment curried out that physicochemical properties of drinking water are appropriate to the WHO standard for drinking water in Pakistan.

Diya'uddeen *et al.,* (2014) assessed the physicochemical and bacterial quality of river Galma around Dakace industrial estate, Zaria of Nigeria. They used plastic bottles for water sampling and those bottles were prewashed. For microbiological analysis they used spread plate method. Temperature and pH was determined on in situ. Assessment showed that the water is not suitable for agriculture and domestic use, without some physical and chemical purification. Because of the total coliform and total heterotrophic bacteria (THB) crossed the WHO standard of drinking water. In this analysis sample collected from four locations during four months.

Alfa and Ajaye (2014) analyzed spring water of Osan-Ekiti, Nigeria for knowing its physicochemical and bacterial characteristic, this analysis performed on five collected samples of spring water from several sites; sterilized bottles were used for water sampling. pH and EC were measured with the help of conductivity meter. From hygienic point of view the result of this study showed that spring water have the trend to cause disease and spring water is not suitable for human used.

Omoigberale *et al.,* (2013) has studied the seasonal variation in bacterial quality of Ebutte River in ehor community EDO state. Nigeria in this study they used the basic microbiological technique. 30 samples from 5 different locations were collected monthly during six months in rainy seasons. Pour plate method was used for total coliform bacteria analysis fecal coliform bacteria analyzed with most probable number (MPN) method. Study showed that the major sources of water pollution are animal. Human and agricultural activities. The result showed that Ebutte river water is not appropriate directly for human use, because it cause a many diseases to human health.

Saxena *et al.,* (2011) analyzed the water quality under different environmental condition and its physicochemical and bacterial parameters in Ahmadabad, Gujarat, India, such as pH. COD, BOD, TDS, and DO. The study also conducted to assess the changes in initial characteristics in the water samples over a significant period of time, under several environmental conditions composed unusual materials, study showed that several environmental conditions such as sunlight causes the elimination of microbes from water due to photo-degradation process.

Okoye and adiele (2014) carried out from physicochemical and bacterial study of groundwater of Ezinihittle Mbaise local government area of Imo state; Nigeria water samples from eleven boreholes of various towns were collected. For determination of heavy metals the samples preserved by adding 5 ml HNO_3, to prevent from adhering metals to the walls of containers. Water samples were collected in 2 litters prewashed polyethylene containers. Several standard methods were used for the analysis of gravimetric method for TDS, total alkalinity by potentiometric titration, total acidity by potentiometric titration, and total hardness (TH) calcium and magnesium were analyzed with EDTA titration method. Chloride was determined by mohr's argent-o-metric method, NO_3 was analyzed by cadmium (Cd) reduction method, sulfate (SO_4) was determined by turbid-metric method and phosphate was analyzed by reactive (ortho) phosphate ascorbic acid method. Trace metals such as (Cd, Cr, Cu, Fe, Ni, Pb, and Zn) determined using atomic absorption spectrophotometer (AAS). At eight boreholes water was impaired by growth of bacteria, the study showed that water must boiled before drinking.

Omarzai (2016) assessed the physicochemical and bacterial characterization of drinking water quality in Kabul city, Afghanistan. He analyzed some physiochemical and bacterial parameters such as Color, Odor, Ph, Temperature, Turbidity, Electrical Conductivity, Coli form, Total Coli form, Fecal Coli form and Escherichia coli. The total 85 water samples were collected in 500 ml and 100 ml clean bottles from three different sources such as deep wells, water storage tanks and water distribution networks or house connections from selected areas of Kabul city. The result carried out from this study showed that counts of Electrical

Conductivity, Turbidity, that 31 out of 85 samples EC values exceeded the permeability limits of WHO standards and the result from Total coliform and Fecal coli are in first zone free from fecal coli form , only one water sample contained total coli form colonies (4CFU/100Ml). In zone two free from fecal colifom but total coli form bacteria were found in range of 63-150 CFU/100Ml. In zone three no coliforms found in water samples.

CHAPTER 3

MATERIALS AND METHODS

3.1. STUDY AREA

Charikar Parwan is the capital city of Parwan Province and is the main town of the Kondaman Valley, located in northern Afghanistan. It is also the largest city in Parwan province. Charikar is located at 35.01 degrees latitude and 69.17 degrees longitude and is 1554 meters above sea level. The city population of Charikar is 96, 039. Residential dwellings in Charikar number 10,671. There are 4 police (Nahias) districts with a total land area of 3.025 hectare land area. Charikar city is located 69 Km from Kabul city. Despite its proximity to Kabul, more than half of the land lies low. The highland of Charikar, about 37% is residential and vacant plots are about 32%. The roads of Charikar occupy about 19% of the built up land area. Charikar is the gateway to Panjshir valley where Shamilli plains meet the bottom of the Hindu Kush Mountains. Charikar is known for producing pottery high quality grapes. 70% of Charikar residents are currently without water.

AUWSSC is responsible for production, conduction and distribution of potable water from various sources to the people. The sources of the water are: Salang River, Ghorband River, springs, two small streams, plus 13 tube wells, tanks, open wells, pipes, hand pumps and the WSN, Water Supply Network.

3.2. WATER SAMPLING SITES AND PROCEDURES

A preliminary visit was taken to choose the testing sites. 12 sites were chosen and three samples were taken from each site. Sites were listed (Parchahs 1-12) and labeled as PP 1-PP40. Samples were collected from August 2016 to December 2016.

Prior to collection of samples 40 polyurethane bottles of 100 ml size were cleaned and sterilized. After completely drying, bottles were labeled with date, time, location and sample number. A log for data and conditions at the time of sampling was also prepared along with a cooler which was filled with ice for transport to testing laboratory.

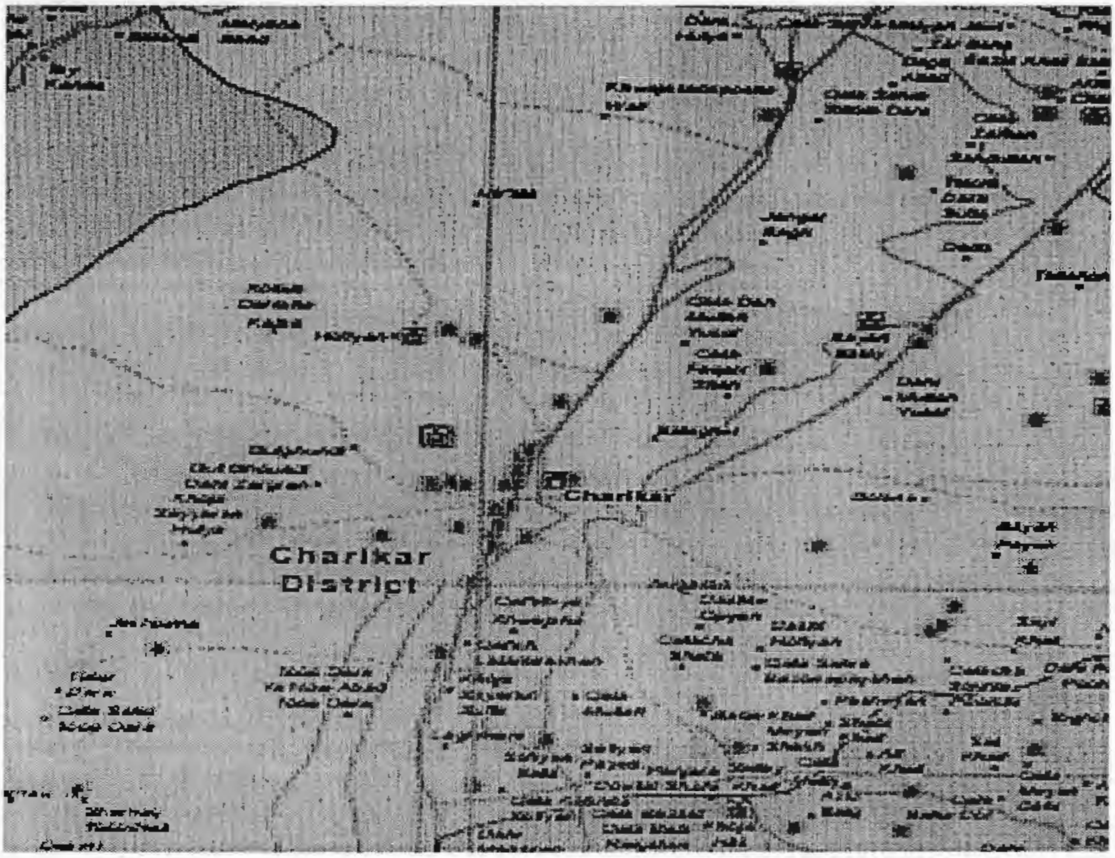

Figure 3 Study area map showing sampling sites in Charikar City

Collections were made in accordance with standard sampling techniques for all water sources along with standard precautionary measures for sampling drinking water listed in the WHO standards for water sampling.

Polyurethane bottles were filled from tap water taking care not to contaminate the sample. Each bottle was then placed in the ice box for transportation.

Collection from piped springs was made in a similar manner. Because the spring was constantly running, clearing of the water was not necessary. Samples were collected from midstream filling containers with air tight and no empty space.

Wells, open bore wells, and hand pumps were taken in similar way. They were flushed before the sampling to remove stagnant water. Then the sample was collected directly into the sample bottles. Collected samples were transported in ice box to the laboratories and tested within 48 hours of collection.

During sampling of water for bacterial analysis precautions were taken to ensure the representativeness of the samples and to prevent any change or contamination of the samples during collection. Bacterial samples were collected in sterilized bottle.

3.3. PHYSICOCHEMICAL ANALYSES

Odor, color, temperature, D.O., pH of the water samples were measured on the spot using physical senses and respective electrodes by following standard procedures for water analyses (APHA, 2000). All other physicochemical parameters were examined in the National Environmental Protection Agency Laboratory Kabul and Kabul University Laboratory.

Other chemical parameters such as NO_3, SO_4, Fe, Arsenic, hardness, chlorides (Cl^-), ammonia (NH_3) and chlorine (Cl_2) were analyzed according to the standard methods.

3.4. BACTERIAL ANALYSIS

Bacterial analysis of the samples was performed in the Department of Public Health Laboratory Kabul.

Water samples were tested for the presence of E. coli bacteria. Analyses were done by using multiple-tube method, membrane-filtration method and H_2S strip field testing method. Tests were made to determine the presence of E.coli in the drinking water consistent with organisms that produce hydrogen sulfide (H_2S). Water sample (10ml) was added to a media containing hottle and incubated at 37°C for 24 hours and was extended up to 48 hours for observable results in case of negative results.

Inoculation was performed using a 50ml portion of water sample into 50ml double strength MacConkey broth and five 10ml portion of water into each of the five 10ml double strength MacConkey broth. Then the samples were incubated at 37°C for 48 hour

Table 3 Water Sampling in Charikar, Parwan Province

Sample code	Villages	Source Type	Static Water Level	Depth
C1	Parchah 1	Pump	5m	30 m
C2	Parchah 1	Pipe	3m	
C3	Parchah 1	Spring	100 m	2 m
C4	Parchah 1	H. Pump	1 m	0.5 m
C5	Parchah 1	Spring	0.5 m	40 m
C6	Parchah2	Pipe	2 m	54 m
C7	Parchah2	H. Pump	2 m	2 m
C8	Parchah2	Well	1 m	2 m
C9	Parchah3	WSN	1 m	2 m
C10	Parchah3	H. Pump	1.5 m	2.3m
C11	Parchah3	H. Pump	3 m	0.5 m
C12	Parchah3	WSN	0.5 m	0.15 m
C13	Parchah3	Well	0.5 m	8 m
C14	Parchah3	Well	3 m	1 m
C15	Parchah4	Well	3 m	2 m
C16	Parchah 4	H. Pump	1 m	150 m
C17	Parchah 5	Spring	4 m	0.5 m
C18	Parchah 5	H. Pump	0.4 m	40m
C19	Parchah 5	D. Well	100 m	45 m
C20	Parchah 5	Pipe	5 m	
C21	Parchah 5	Pump	100 m	70 m
C22	Parchah 5	O.Well	3 m	1.5 m
C23	Parchah 5	O.Well	100 m	85 m
C24	Parchah 6	O.Well	3 m	70 m
C25	Parchah 6	H. Pump	2 m	1.8 m
C26	Parchah 7	H. Pump	1 m	0.4 m
C27	Parchah 7	Pipe	0.5 m	1.9 m
C28	Parchah 7	Well	1 m	9m
C29	Parchah 8	Well	100 m	7m
C30	Parchah 8	WSN	3 m	75 m
C31	Parchah 8	Well	2 m	5m
C32	Parchah 8	Pipe	3 m	
C33	Parchah 9	Pipe	100 m	2.1 m
C34	Parchah 9	H. Pump	1 m	2 m
C35	Parchah 10	WSN	1 m	
C36	Parchah 10	S. Spring	100 m	0.7m
C37	Parchah 10	Spring	100 m	0.5m
C38	Parchah 11	Pump	5 m	23m
C39	Parchah 12	Pump	2 m	27m
C40	Parchah 12	Well	2 m	4m

CHAPTER 4

RESULTS AND DISCUSSION

In the physical parameters changes were noticed in the pH, TDS and color of water samples. In fourteen samples TDS values were in excess of the recommended standards for safe drinking water. Parchah 1 had four samples with high values, the remaining high values were found in Parchah 2, 3, 4, 5, 7, and 8. The sources were pump, pipe, spring, hand pump, well, and open wells. Five hand pumps and four pipes were found to have higher TDS values. The pH was low in four samples all located within Parchah 5 where the sources were open well, pipe, and pump. One sample from hand pump showed an abnormal color in Parchah 5. The abnormal color found in sample PP18 is likely to be caused by the presence of particulate matter. High TDS values in fourteen samples were likely caused by a combination of soil particles from the surrounding environment as well as partially decomposed organic matter. In addition, dissolved waste materials were found in the samples testing positive for E. coli, (in the 17 samples from Parchahs 1, 2, 3, 4, 5, 7 and 8).

In the biological and chemical parameters many of the samples tested exceeded limits set by the WHO and EPA standards. High Fe levels were found in 24 samples. The highest level of Fe was 0.39 mg/L taken at Parchah 5 from a hand pump. E. coli tests were positive in 17 samples. Parchah 5 testing positive for E. coli in 6 samples. Parchah 1, 2, 3, 4, 7, and Parchah 8. NO_3 at level 11.8 mg/L was found in Parchah 7 at a well. Chloride levels exceeding the limits ranged from 600 to 295mg/L. 7 samples exceeded the limits for hardness. The range of harness was from 1810 to 700 mg/L. Parchahs 1, 5, and 7 had 2 samples each. SO4 tests exceeded limits in 3 samples. Two samples limit at 270 mg/L and one at 285mg/L, from pump, pipe and spring. Parchah1 had 2 samples and Parchah 5 had 1.

In Parchah 7, the well having a NO_3 level at 11.8 mg/L may be caused an excess of NH_3. This could be caused by seepage from the surrounding land as most of this area is surrounded by land used in farming and agriculture. There were 3 samples found to have high chloride samples coming from Parchahs 5 and 7. This chloride present might likely come from sewage, most of the people living in this area use the land as a place for disposal of human wastes. Excessive levels of Fe were found in 24 samples. In Charikar there is an open Museum from the history of Military operations which were brought from all over Afghanistan and are kept as an exhibit for people to see. This mostly Fe material sits on an elevated area. When the rains and spring waters come the leaching from this material flows downhill into the surrounding soils. The river from the Ghorband district has an Fe mine located North in Bamian Province. The by products from mining can easily flow downstream into the Parwan Province area. These two things alone can greatly affect the drinking water for Charikar city. SO_4 in three samples from Parchah 1 and 5, with levels 270-285 mg/L, can be explained by the nearby industrial area of Jabal Saraj, a cement factory along with many other small factories which crush rock and make gravel packs. This combined with the natural rains which provide oxidation to the magnesium, plus carbon provided naturally and added to the soils by the annual spring rains.

Lastly and maybe the most important of all is the presence of E. coli in nearly half of all samples. There is no doubt where this E. coli comes from. Found in nearly all types of sources sampled, this leads to the conclusion the most likely source for contribution of this waste is human. Lack of sanitation in this area leaves these people with little option than to use the outdoor areas as their public toilet. After defecation, more than likely these same people will use the same stream to wash their hands in and then take home in containers to be used for potable drinking water. This is one of the leading causes of illnesses and deaths in this area.

Much of ill health and parasitic disease found in humans and animals can be traced to contaminated drinking water. Water intended for human consumption must be free from chemicals and pathogens to be considered safe for drinking. This study focused on the WHO and EPA standards set for safe potable water as a means to judge the drinkability of a source.

Table 4 Physicochemical Parameter Results Charikar City, Parwan Province 2016

No.	Color	Odor	Taste	pH	TDS (mg/L)	EC (mS/cm)	Temp. °C	Turb (NTU)
C1	Normal	Normal	Normal	7.3	961	1551	16	<5
C2	Normal	Normal	Normal	7.2	952	1535	16	<5
C3	Normal	Normal	Normal	7.4	536	865	13	<5
C4	Normal	Normal	Normal	7.8	530	854	15	<5
C5	Normal	Normal	Normal	8	514	830	17	<5
C6	Normal	Normal	Normal	7.8	527	850	16.8	<5
C7	Normal	Normal	Normal	7	370	595	15.8	<5
C8	Normal	Normal	Normal	7.1	363	580	16	<5
C9	Normal	Normal	Normal	7.3	418	585	15	<5
C10	Normal	Normal	Normal	7.5	502	676	16	<5
C11	Normal	Normal	Normal	7.5	326	810	17	<5
C12	Normal	Normal	Normal	8	223	526	15	<5
C13	Normal	Normal	Normal	7.6	357	366	15.8	<5
C14	Normal	Normal	Normal	7.4	330	576	15.2	<5
C15	Normal	Normal	Normal	7.3	526	54	16	<5
C16	Normal	Normal	Normal	7.2	799	853	12	<5
C17	Normal	Normal	Normal	7.1	364	1289	13.7	<5
C18	Abnormal	Normal	Normal	7.5	1170	587	13.9	<5
C19	Normal	Normal	Normal	5.14	496	1882	12	<5
C20	Normal	Normal	Normal	5.5	417	800	15	<5
C21	Normal	Normal	Normal	5.3	122	673	13	<5
C22	Normal	Normal	Normal	5.12	403	197	11	<5
C23	Normal	Normal	Normal	7.9	416	651	14	<5
C24	Normal	Normal	Normal	8.27	953	672	15	<5
C25	Normal	Normal	Normal	8	355	1537	13.9	<5
C26	Normal	Normal	Normal	7.1	1668	572	14.3	<5
C27	Normal	Normal	Normal	7.6	1940	2690	13	<5
C28	Normal	Normal	Normal	7.4	521	3130	14.5	<5
C29	Normal	Normal	Normal	7.1	398	844	12	<5
C30	Normal	Normal	Normal	8	350	642	12.9	<5
C31	Normal	Normal	Normal	.2	355	565	13.	<5
C32	Normal	Normal	Normal	7.6	520	572	13	<5
C33	Normal	Normal	Normal	8.16	319	839	12.5	<5
C34	Normal	Normal	Normal	7.26	134	515	11	<5
C35	Normal	Normal	Normal	7.4	288	216	10	<5
C36	Normal	Normal	Normal	7.4	276	466	0.5	<5
C37	Normal	Normal	Normal	7.5	302	460	9	<5
C38	Normal	Normal	Normal	7.8	300	503	9.8	<5
C39	Normal	Normal	Normal	8	255	484	10.8	<5
C40	Normal	Normal	Normal	6.8	301	432	11	<5

Table 5 Biological and Chemical Results Charikar City, Parwan Province

No.	NO_3	F	Fe	SO_4	Chloride	E. coli	Hardness	Cl_2/NH_3 As
C1	1.9	0.8	0.05	270	199	-ve	880	0
C2	1.8	0.74	0.05	270	197	+ve	920	0
C3	5.3	0.34	0.03	80	44	-ve	490	0
C4	5.3	0.35	0.03	75	40	-ve	480	0
C5	5.2	0.32	0.03	65	37	-ve	460	0
C6	5.3	0.33	0.04	70	37	+ve	450	0
C7	5.7	0.3	0.03	45	20	+ve	311	0
C8	5.8	0.3	0.02	40	20	+ve	290	0
C9	4.4	0.6	0.03	\50	30	-ve	380	0
C10	7.09	0.3	0.04	75	39	+ve	470	0
C11	6.5	0.31	0.04	40	15	+ve	280	0
C12	2	0.1	0.02	40	15	+ve	159	0
C13	3.7	0.17	0.03	48	17	-ve	280	0
C14	2	0.15	0.06	41	35	-ve	260	0
C15	1.9	0.16	0.05	45	65	+ve	450	0
C16	2.1	0.31	0.06	200	122	+ve	700	0
C17	2.8	0.21	0.03	285	42	+ve	310	0
C18	3.8	0.21	0.39	40	295	-ve	1091	0
C19	3.4	0.25	0.06	40	60	+ve	420	0
C20	2.6	0.5	0.04	50	38	+ve	380	0
C21	1.4	0.06	0.07	30	12	+ve	90	0
C22	2.2	0.13	0.04	45	15	+ve	370	0
C23	4.3	0.26	0.04	95	17	+ve	380	0
C24	.	02	0.16	9	178	-ve	870	0
C25	5.5	0.2	0.03	60	20	-ve	291	0
C26	2.4	0.22	0.04	88	386	-ve	1500	0
C27	3.1	0.31	0.05	115	600	-ve	1810	0
C28	11.8	0.28	0.05	90	55	+ve	480	0
C29	3	0.2	0.04	45	17	+ve	310	0
C30	4.2	0.28	0.05	43	16	-ve	290	0
C31	3.6	0.45	0.04	45	20	+ve	280	0
C32	4.5	0.38	0.06	215	25	-ve	270	0
C33	5.8	0.25	0.03	30	17	-ve	260	0
C34	2.9	0.1	0.02	10	12.1	-ve	130	0
C35	6.2	0.2	0.03	25	17.5	-ve	200	0
C36	6.8	0.21	0.03	20	15	-ve	270	0
C37	6.3	0.3	0.04	25	10	-ve	260	0
C38	8.2	0.38	0.03	30	17.5	-ve	260	0
C39	5.2	0.25	0.03	25	12.5	-ve	200	0
C40	6.2	0.2	0.03	25	15.2	-ve	255	0

4.1. pH

Analysis of the pH data showed a mean level of 7.29 and all were within the normal limits. The lowest pH level was 5.12, in fact four levels were below 6.5, and is a more clear indicator of how there are fluctuations in the Charikar city's water.

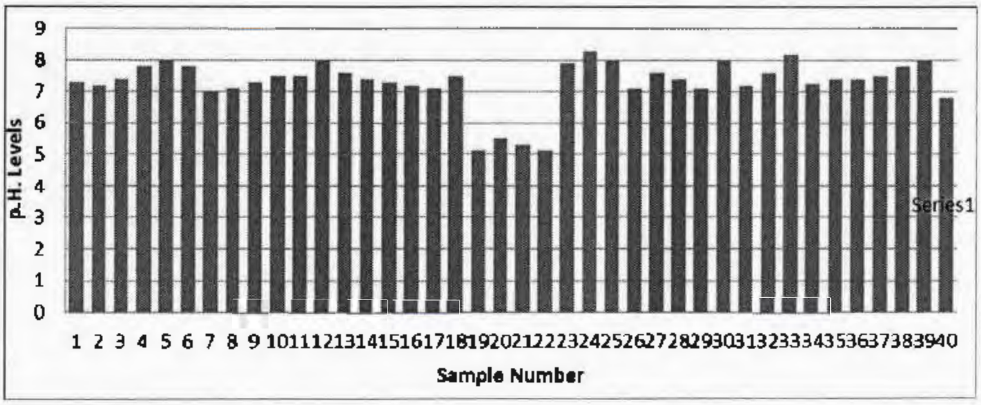

Figure 4 pH Values in water samples of Charikar City

4.2. TDS

The total dissolved solids mean number was 845.1, the mode was 572, and the median was 646.5. It is clear from most of the samples that there are many dissolved solids in the Charikar city water sources. EPA and WHO do not list an acceptable collective number for solids. But if separation of the particulate matter is done, then, there are distinct acceptable limits for any metals found in the drinking water. Tbe lowest T.D.S. level was 134 and the highest level was 3130.

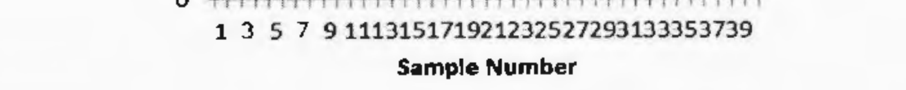

Figure 5 TDS Values in water samples of Charikar City

4.3. Electrical Conductivity (EC)

The electrical conductance mean number was 845. 1, the mode was 572, and the median was 646. 5. Because the TDS was high, it is logical to predict elevated levels in the electrical conductance of the water sampled as well. The particulate matter found in the water serves as a good conductor of electricity, escalating the electrical conductivity of the water. The lowest EC level found in the samples was 216 and the highest number was 1940.

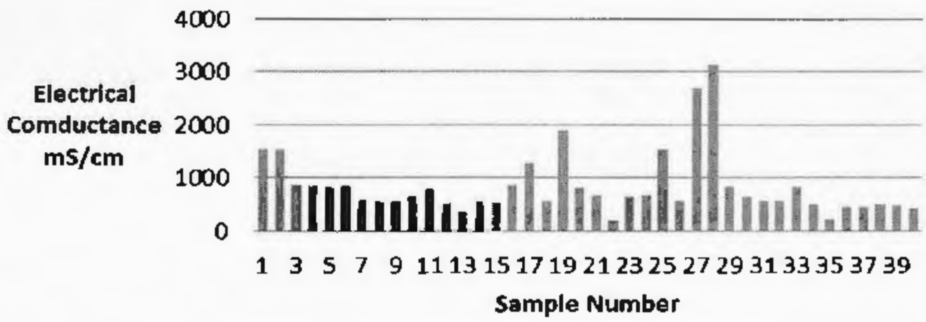

Figure 6 EC Values in water samples of Charikar City

4.4. Hardness

In the samples taken from Charikar city's water revealed hardness levels from 90 to 1810. A WHO recommendation for total hardness is 500. Seven of the 40 samples have levels higher than this. They are: 700, 870, 880, 920, 1091, 1500, and 1810. The mean was 455.9, the mode was260, and the median was 310.5.

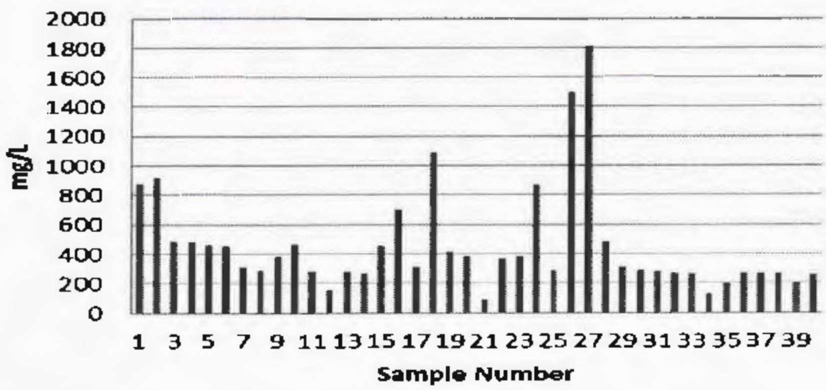

Figure 7 Hardness Levels in water samples of Charikar City

4.5. Fluoride (F^-)

The F^- ranged from 0.13mg/L to 0.89mg/L. WHO recommended level is 1.5 mg/L as safe for drinking water. Levels of F^- in the samples were found to be relatively low.

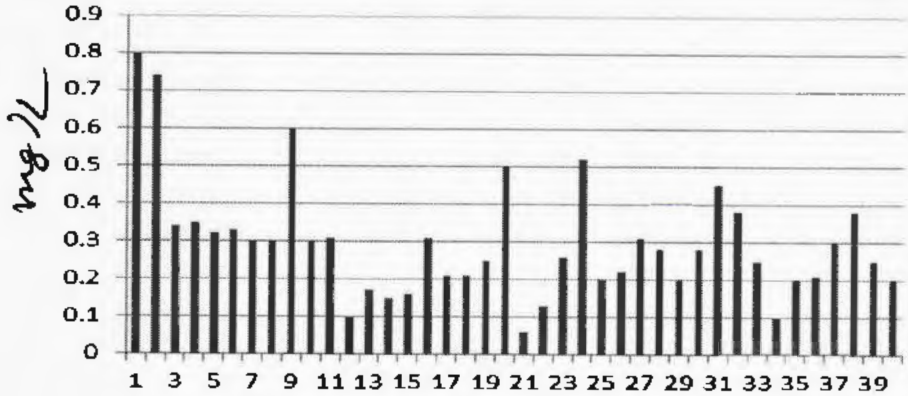

Figure 8 F⁻ in water samples of Charikar City

4.6. Chloride

The samples were tested for chloride and ranged from 10mg/L to 600mg/L. WHO standard for safe levels of Chloride in drinking water is 200mg/L and EPA safe levels were listed as 250mg/L. Three samples were listed above these ranges. The average value was 71.12mg/L.

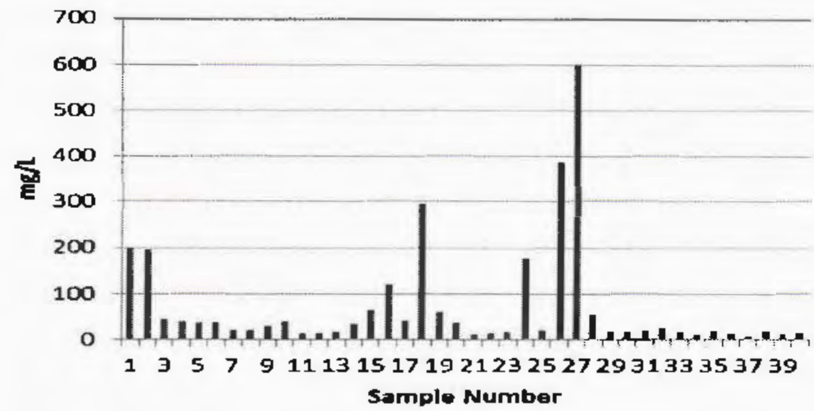

Figure 9 Chloride level in water samples of Charikar City

4.7. Sulfates (SO_4)

The SO_4 in water samples ranged from 10mg/L to 285mg/L. SO_4 are used virtually everywhere. Commonly found in a variety of salts. WHO safe level for SO_4 is 250 mg/L. Two samples exceeded the safe SO_4 level. The mean value for SO_4 was 72.23mg/L.

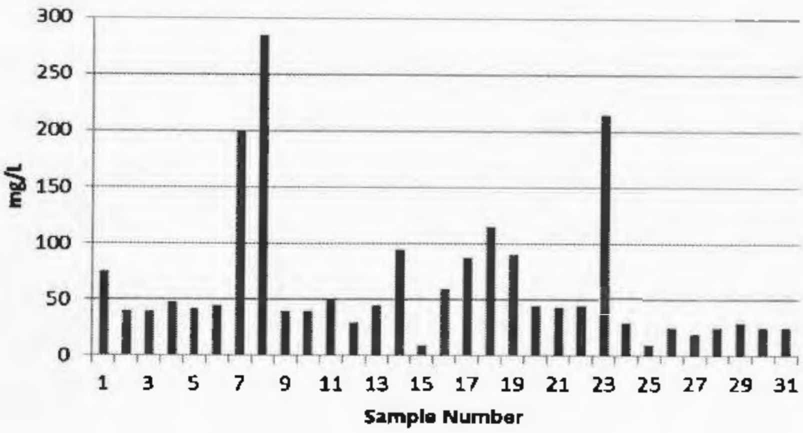

Figure 10 SO_4 in water samples of Charikar City

4.8. Nitrates (NO_3)

NO_3 levels in the samples from Charikar city drinking water were ranged from 1.4mg/L to 11.8mg/L. Recommended NO_3 level for safe drinking water is set at 10mg/L. Despite the land being used for agriculture and waste disposal purposes, only one sample exceeded the safe limit for drinking water.

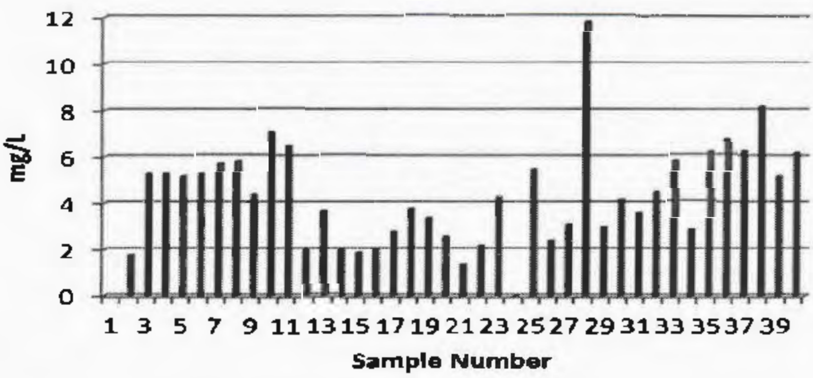

Figure 11 NO_3 in water samples of Charikar City

4.9. Iron (Fe)

The samples ranged for Fe from 0.02mg/L to 0.38mg/L. WHO standards for safe drinking water set a safety limit of 0.3 mg/L. Only one sample was found containing higher amount of Fe than the WHO safe limits. High levels of Fe can be fatal and are known to cause birth defects in children. The average value of Fe was 0.05mg/L.

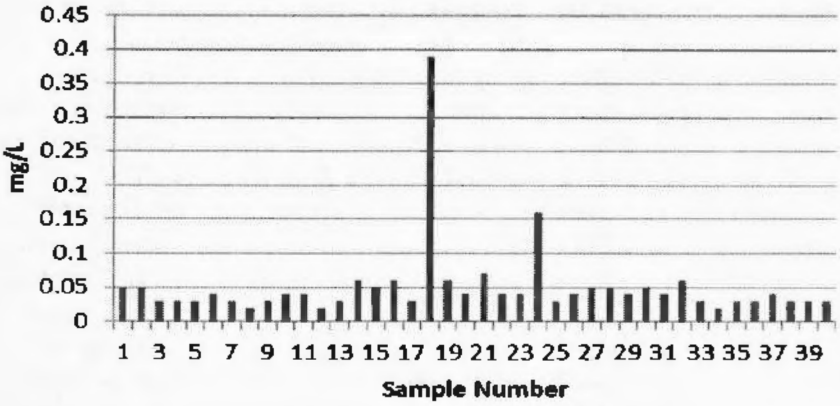

Figure 12 Fe in water samples of Charikar City

4.10. Escherichia Coli (E. coli)

Out of the 40 samples tested at Charikar city, 17 samples tested positive for E. coli bacteria. E. coli bacterium is considered to be the most dangerous for human health. Most E. coli contamination found at shared water sites can be contributed to human sources. E. coli can also contaminate food sources and it can be transmitted easily. There is no acceptable level for E. coli it should be zero.

Table 6 Positive Results of E.coli from Charikar City 2016

Sample Code	Village	E.coli	Source Type	Static Water Level	Depth
C1	p-1	Positive	Pipe	3m	54m
C2	p-2	Positive	Pipe	2m	2m
C3	p-2	Positive	H- Pump	2m	2m
C4	p-2	Positive	Well	1m	2.3m
C5	p-3	Positive	H- Pump	1.5m	0.5m
C6	p-3	Positive	H- Pump	3m	0.15m
C7	p-3	Positive	WSN	0,5m	2m
C8	p-4	Positive	Well	3m	150m
C9	p-4	Positive	H- Pump	1m	0.5m
C10	p-5	Positive	Spring	4m	54m
C11	p-5	Positive	D-well	100m	7m
C12	p-5	Positive	Pipe	5m	70m
C13	p-5	Positive	Pump	100m	1.5m
C14	p-5	Positive	D-well	3m	85m
C15	p-5	Positive	D-well	100m	9m
C16	p-7	Positive	Well	1m	100m
C17	p-8	Positive	Well	7m	5m
C18	p-8	Positive	Well	2m	50m

4.11. Field Survey

Field survey was carried out in November 2016 and questionnaires were filled from about 200 households. The average household size was six individuals in which 5% were from 0-10 years of age group, 78% were 10-50 years old and 17% were above 50 years of age. The results indicated that water in Charikar city is changing. 70% of the people surveyed agreed with this statement. They agreed that there have been noticeable changes since the year 2000.

The survey also found that 100% of the people surveyed had diarrhea at least one time per year and 91% of the people surveyed told us that the frequency of their diarrhea was 1-3 times per year. 6% of the people surveyed had diarrhea 1-5 times per year and 3% said they had diarrhea more than 5 times per year.

6% of the surveyed people showed water had a color and 8% said water had odor. These findings showed that there is some contamination in the water they are drinking.

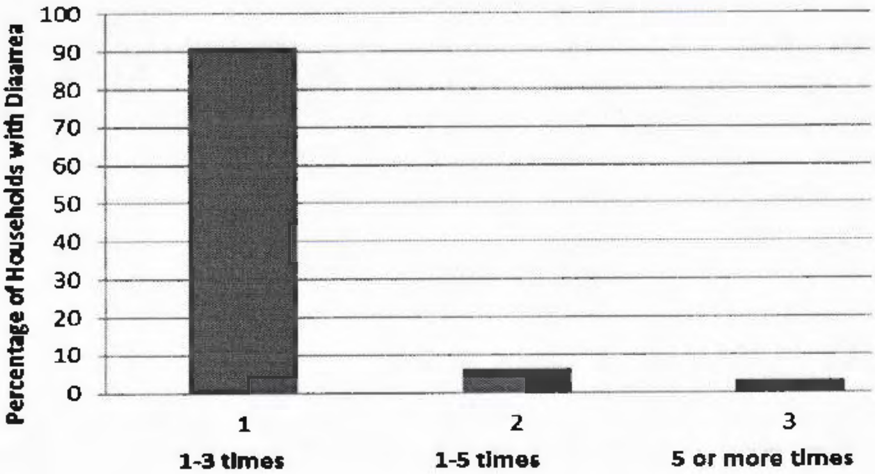

Figure 13 showing the rate of diarrhea per year

**Where '1' is the frequency of diarrhea 1-3 times per year in the people, '2' is the frequency of diarrhea 1-5 times per year while '3' is more than 5 times per year.*

The Parwan main hospital records showed that at least one time per year each person or each family member coming to the hospital due to diarrhea in which 42% were children between 1-16 years old, 31% were between 16 to 30 years old and 27% were above 30 years of age.

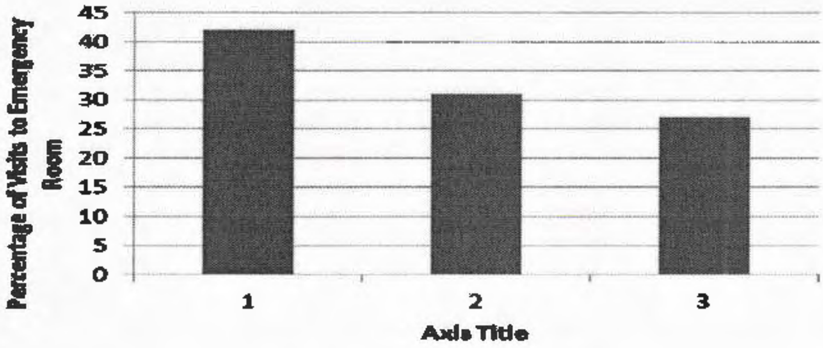

Figure 14 Age-wise percentage of people having diarrhea

- **Where '1' is showing children between 1-16 years of age,*
- *'2' between 17-30 years,*
- *'3' is above 30 years of age having diarrhea*

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

It is clear from the study that approximately 50% of water in Charikar city of Parwan province is safe for drinking and the other 50% contains E. coli bacteria. The primary cause of E. coli in the drinking water can be attributed to lack of proper sewage and sanitation, in addition lack of water purification system. This problem is becoming even worse with increase in population, agricultural and industrial activities..

AUWSSC and the departments of Public Health, Environment, Agriculture and Energy and Water have responsibility and accountability to work harder to achieve the goal for clean potable water for all people in the district. Periodic testing of water must be done; data must be accumulated and sent to the Ministry of Public Health in Kabul. An action plan must be developed and followed until all people in this province have safe drinkable water. Water is vital and necessary for life. It is so important, the God emphasize this point by covering the Earth with 2/3rds water and composing the weight of the human body with 2/3rds water. There is enough water in the world for everyone to have water. The bigger question is how to clean the water and make it safe for drinking.

Every country is not developed; therefore, not all countries have drinkable water. In order for all people to enjoy clean and safe drinking water we must work together and help accomplish this task.

5.2. RECOMMENDATIONS

- A program for drought prevention and water loss should be developed.
- A water resource network should be developed along with a water recycling plan to prevent waste and loss.
- An inspection of all water sources must be done to include: water aquifers, dams, reservoirs, open wells, tube wells, tanks, pipes, hand pumps and pumps. Repairs and cleaning should also be done to prevent contamination.
- The Department of Agriculture must carefully monitor the use of chemicals in forming and develop a drainage system for agricultural chemical runoff.
- The Department of Public Health must test regularly for E. coli and publish their findings and notify tbe public when water safety is a concern. Educating the public on water safety and conservation must be a priority.
- The Municipality must properly dispose of waste and sewage to help control contamination of the water supply.
- Laboratory centers must be equipped for sampling and analyses of water at agricultural areas, industrial areas, WSN and all other water resources.
- Community must become involved in the prevention of contamination and conservation of water resources.
- Organization of proper training programs should be implemented by the professionals and information should be shared with the public.

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APPENDIX 1: HOUSEHOLD SURVEY QUESTIONNAIRE

1. General Household Information	
Date ...Nov 5-10/2016 **Time ....**	**Name of data collector** **Abdul Basit Azami**
Name of respondent	**Area/District** **Charikar City, Parwan Province**
Number of household members Total ☐ Between 0 to 10 years ☐ Between 10 to 50 years ☐ Above 50 years ☐	**Family system** ☐ Joint ☐ Single
Sex☐ male ☐ female	**Source of income**
2. Information on drinking water quality	
1. Is Parwan Province water quality changing? ☐Disagree☐ Agree ☐ Strongly Agree	
2. How is the drinking water quality of your district? good ☐ very good ☐ drinkable ☐ undrinkable ☐ Do not know ☐	
3. How was water quality of your area before 2000? ➢☐good ☐ very good ☐ drinkable ☐ undrinkable ☐o not know	
Brief opinion?	
4. Which District of Parwan Province has been most affected by water quality? Mention the name of District;	
5. What do you think changed the water quality? ➢☐Human activities ☐ Natural Proces☐ Carbon emissi☐ Deforestation	
6. What are the main activities of humans that affected the drinking water quality? ➢ Deforestation ☐ over population☐ mining ☐ wars ➢☐Carbon emission ☐griculture ☐ All 'a' to 'f ☐ Any other....................	

7. Comparing the last 10 to 20 years, is the temperature changing in Parwan province? Yes ☐No ☐ Don't know
8. Comparing the last 10 to 20 years, has the intensity of cold weather during winter increased? ☐ Yes ☐No ☐ Don't know
9. The intensity of rainfall during rainy season has decreased in the last 10 to 20 years? ☐ Yes ☐No ☐ Don't know
10. Compared to last 10 to 20 years, the water availability in the area is? ☐ Increases ☐ Decreases ☐ Remain same
11. Is there any reason for water pollution? ☐ Yes ☐No
12. Has the drinking water quality had an economic effect on people? ☐ Yes ☐ No
3. Information about drinking water quality
13. Is the water quality stable? ☐ Yes ☐ No
14. Does the water have an odor? Yes No
15. Does the Water have color? Yes No
16. Has any member of the family had diarrhea in the last year? Yes No
17. How many times per year has some one in this house had diarrhea? None 1 – 3 3 -5 5 or more
18. Do you use the river or streams water for drinking? Yes No

APPENDIX 2: RESULTS OF THE SURVEY

Q1.	21% disagree	58% agree	12% strongly agree	9% no answer	
Q2.	21% good	9% very good	11% drinkable	58% undrinkable	1% don't know
Q3.	Same Answer as Q2				
Q4.	100% left blank				
Q5.	85% humans activities	8% natural process	7% left blank		
Q6.	75% wars	7% over population	15% agriculture	3% left blank	
Q7.	81% yes	3% no	16% don't know		
Q8.	2% yes	78% no	20% don't know		
Q9.	45% more	32% less	13% don't know		
Q10.	8% increased	83% decreased	10% same		
Q11.	58% yes	32% no	10% left blank		
Q12.	92% yes	1% no	7% left blank		
Q13.	3% yes	87% no	10 % left blank		
Q14.	6% yes	5% no	89% left blank		
Q15.	8% yes	13% no	79% left blank		
Q16.	93% yes	2% no	5 % left blank		
Q17.	91% (1-3)	6% (3-5)	3% (5-more)		
Q18.	65% yes	29% no	7% left blank		

APPENDIX 3 PHOTOGRAPHS DURING SAMPLING

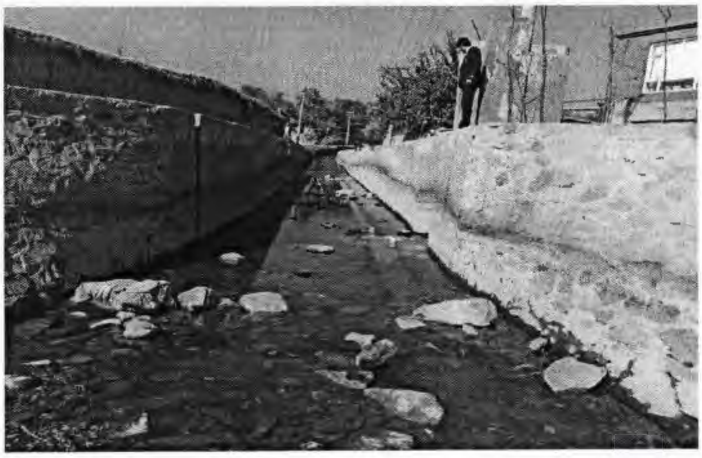

Figure 15 Small Stream Source, Charikar City, Parwan 2016

Figure 16 Main Stream Water Source, Charikar City, Parwan 2016

Figure 17 Spring Water Source, Charikar City, Parwan 2016

Figure 18 Tank Water Source, Charikar City, Parwan 2016

Figure 19 Charikar City 2016

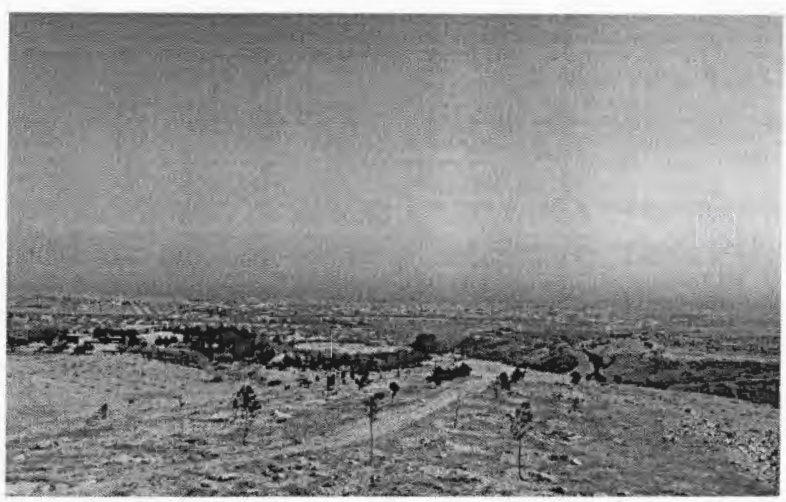

Figure 20 Charikar City 2016