DRINKING WATER QUALITY ASSESSMENT OF SELECTED VILLAGES NEAR ISLAMABAD

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2024

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A thesis submitted to Bahria University, Islamabad in partial fulfilment of the requirement for the degree of BS in Environmental Sciences

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ABSTRACT

The study was conducted to determine the quality of water in Phulgran village of Islamabad. Total of 30 samples were analyzed for biological, Physio-chemical parameter. The water samples were collected by following proper standard protocols. Physical parameters including pH (6.3-7.3), temperature (10.9-12.6), electrical conductivity (with minimum value of 286 and maximum value of 1289), TDS (with minimum value of 210 and maximum value of 917) and total salts (varying (136-619) were within the permissible limit of WHO. Similarly, the chemical parameters including chloride (14.2-85.2), sodium (9.1-187), sodium chloride (23.3-140.2), alkalinity (30-268), total hardness (240-900), in carbonates, sodium bicarbonate (0.0006-0.003), sodium carbonate (0.0005-0.001), bicarbonate (0.0005-0.001), carbon trioxide (0.0001-0.001), nitrates (0.001-0.09) were within WHO permissible limit, but arsenic presence in our sample is zero. For microbial analysis, there was bacterial growth in MacConkey Agar, *Salmonella Shigella* agar and Nutrient Agar, in our samples.

These results suggest that some of the drinking water sources (bore and supply lines) need proper monitoring and better maintenance for better drinking water quality.

ACKNOWLEDGMENT

First and foremost, all the praises to Almighty Allah for giving us the strength and courage to complete this vast topic and blessing us with supportive instructors, family, friends, and great academic capabilities. We would like to express our gratitude to our supervisor, Dr. Said Akbar (Head of Department of Earth and Environmental Sciences) at Bahria University Islamabad for their constant encouragement and support to make this thesis as the way it should be and believing in our capabilities and for guiding and helping us.

We would like to appreciate and express our gratitude to Mr. Imtiaz (Lab technicians at BUIC) for his cooperation and helping us in doing our practical work and providing us with the proper guidance and advice to work in a proper working environment.

Lastly, the prayers of our parents and their encouragement, kept us going and with their much-needed moral and support in stressful times throughout our research time period.

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ABBREVIATIONS

WHO	World Health Organization
PCRWR	Pakistan Council of Research in Water Resource
CDA	Capital Development Authority
ICT	Islamabad Capital Territory
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
EC	Electrical Conductivity
E-coli	Escherichia Coli
HEPA	High Efficiency Particulate Air
EDTA	Ethylenediaminetetraacetic acid
EBT	Eriochrome Black T
NEQs	National Environmental Quality Standard
MAC	MacConkey
NA	Nutrient Agar
SS	Salmonella Shigella
TNTC	Too Numerous To Count

CHAPTER 1

INTRODUCTION

All living organisms depend on water for survival because it has so many unique qualities. 60% of a person's body is made up of water. Water not only performs maintenance of the human body by removing wastes, dissolving toxins, and aiding in detoxification but it also prevents diseases and issues such as cancers, headaches and UTIs (Adolph, 2019). All living things rely on water for survival, either directly or indirectly. The survival of life is not possible without water.

On this planet the total quantity of water is 1.4 trillion cubic meters (Qureshi & Iqbal, 2003). Although water is spread unevenly, the earth's water can be divided into two categories of fresh and marine water. Glaciers, groundwater, and some surface water make up the 3% of the world's total water supply that is fresh. Water from all sources is not fit for human consumption as it contains dissolved minerals, sediments, and biological contamination which has adverse effect on human beings. Less than 3% fresh water is available on earth according to the distribution. Out of this, 75% of water is frozen and in the form of glaciers and icecaps. The total water accessible to meet our present-day requirement is less than 1% that is present in rivers and underground resources.

In all parts of the environment water is a vital substance. Anthropogenic activities have led to widespread surface and ground water contamination, which is now a major global concern. Since 1990s, due to unprecedented growth in population, industrialization, and urbanization the threat of drinking water pollution has increased. The state of diseases and health controlling factors in living organisms depend on the biological, chemical, and physical characteristics of water (Shah et al., 2012, Kazi et al., 2009). Water unsafe for drinking purpose consists of different agents like bacteria, pathogen, organic substances, and various minerals that has adverse effect on human health. People suffer from various diseases due to the ingestion of contaminated water which include diarrhea, cholera, dysentery, hepatitis A and typhoid. Water pollution is mainly caused by waste, microorganisms and toxic chemicals coming from industries, domestic and agricultural activities that deteriorate the quality of water. Some of the other major reasons for water pollution is over population, lack of sewage, municipal and sanitation facilities. In developing countries, about five million children deaths occurred due to the contaminated drinking water supply (Daud et al., 2017).

By 2025, there will be an increase of 2.6 billion people, and this rapid growth is having an impact on both the quantity and quality of water. The population growth all around the globe is exponential and is putting a great pressure on all the resources, including water. At present, the population is increasing at the rate of about 80 million per annum (Kahlown, M. A., & Majeed, 2003). The current situation of water quality management all over the world is far from satisfactory due to the pressure of developing economy and increasing population. The rate of the global water crisis has increased due to climate change, pollution, and global warming. The uneven distribution and the limited availability of water in different parts of the world has an adverse effect on the quality of life of people. In some regions of the world heavy metal, organic and inorganic chemicals are found in in surplus amount. World Economic Forum has identified water crisis as the most important threat in the long run and will have catastrophic consequence on society (Durrani, 2020).

1.1 Significance of Drinking Water

Every individual requires safe drinking water as it protects them from getting infections. Water is an essential element to sustain life on earth. Unfortunately, not all water available is fit for human consumption. The quality of water can be determined by the evaluation of physical, chemical, biological, radiological, and bacteriological parameters (Perveen et al., 2007). The evaluation of these parameters is essential to determine the specific use of water as they are in relation to each other. Water that meets the permissible limit and is free from impurities is safe for human consumption. Due to the presence and concentration of certain organic or inorganic substance, minerals, sediments, and biological contaminants makes the water fit or unfit for human consumption. Clean potable water is required by living organisms to get rid of harmful toxins from their body. Along with that, clean water is also required for sanitation purpose. If cooking, washing, and bathing is done in a contaminated water it too will lead to number of diseases.

Pakistan is an agricultural country that has relied on rainwater, canal irrigation and underground water for fulfilling its requirements. In Pakistan over 40% of urban deaths are attributed to the disease caused by the drinking of the contaminated water (Perveen et al., 2007).

1.2 Pakistan’s water crisis

The pressure on the water resources in Pakistan is ever increasing and increasing population directly impacts on it. The increase in food demand has put pressure on agriculture and industrial sector of Pakistan. This has a multiplied effect on the already diminishing freshwater resources of Pakistan. The population of Pakistan is expected to rise from 140 million in 2000 to 250 million by the year 2050 (Kahlown, M. A., & Majeed, 2003). Due to the poor quality of water, people are also facing various health risks. Water borne diseases spread due to water contaminated with feces. Around 40% of all the deaths in the country and 30% of reported diseases are spread due to fecal contamination of water (Aziz, 2005).

Surface water and underground aquifers are source of drinking water supplies. The majority of Pakistan's regions rely more on ground water than on surface water sources. Around 70% of drinking water supplies come from aquifers (Aziz, 2005). The urban water supply does not meet the WHO drinking water quality guidelines. The primary causes are leaky pipes and the provision of water through pipes that are closely connected to sewage systems. The population of the whole country is exposed to hazardous drinking water to a degree of almost 90%. One of the major problems in Pakistan is the contamination of the water supply with bacteria, arsenic, nitrate, and fluoride. These contaminations later result in acute or long-term health problems.

1.3 Water shortage in Islamabad

Since Islamabad is the study area, so the source water used for drinking purpose, the distribution and the sources of contamination should be known. Basically, there are two main sources of fresh water supply in Islamabad which includes, Simly dam and Khanpur dam. The diverted water from spring located at Saidpur, Shahdara, and Noorpur villages also serve a source of fresh water supply. In different parts of the city, for extracting ground water about180 tube wells have been used. The two water treatment plants are installed at

Sangjani and Simly dam, having a design capacity of 352,000 m^3 per day (Shah et al., 2022). Due to increased economic activity during the past 20 years, Islamabad, the capital of Pakistan, has seen a significant pace of urbanization and population growth. These factors have raised the demand for natural resources, which has a negative impact on the environment. Safe drinking water is a fundamental requirement for everyone's health.

The drinking water quality in Pakistan, especially the Islamabad Capital Territory (ICT), is poor, according to a number of studies carried out in the past by government and non-government organizations as well as independent researchers. The drinking water quality is deteriorated due to the release of contaminants directly into water bodies, industrial effluents, agricultural waste, and exploitation of groundwater resources (Shabbir and Ahmad, 2015). The Capital Development Authority (CDA) has placed 80 filtration plants on various locations throughout the Islamabad Capital Territory (ICT) in order to supply the city's citizens with clean drinking water.

1.4 Sources of drinking water pollution

The pollution of drinking water is mainly caused by natural and anthropogenic activities. Many developing countries including Pakistan is facing shortage and pollution of water. The impurities present in water are either biological, chemical, and physical in nature. Various impurities inform of nutrients and microorganisms are transported from one place to another (Daud et al., 2017). In Pakistan many and most water resources have fallen prey to biological contaminations of coliform bacteria, pesticides, and hazardous metals (Azizullah et al., 2011). In Pakistan we commonly see improper activities of water treatment. Untreated water and wastes are dumped into the environment which spread over large areas and seep into the ground. This is the main culprit of water borne issues. Severe human health problem is caused by biological impurities which can be fatal sometimes. Most industrial and municipal waste discharge is under no supervision of authorities and agencies. The conditions are further aggravated by use inappropriate water disinfection and inefficient monitoring pf treatment plants (Hashmi et al., 2009). When toxic chemicals from various domestic waste, and industries either come in contact with water bodies or run off or leach to the ground water or surface water makes water unfit for drinking purpose. In rainy season, the growth and dispersion of bacteria is at peak due to drainage in river, lakes, and streams.

One of the major environmental issues around the world is the acid mine drainage-related water contamination. Mining by its nature consumes, diverts, and can seriously pollute water resources (Ochieng et al., 2010). The adverse effects of mine water on various aquatic habitats result in a drop in the pH of the water because of an increase in suspended particles, which causes the mobilization of metals such as iron, cadmium, cobalt, aluminum, zinc, and manganese.

Some heavy metals are necessary to keep the human body's metabolism functioning properly. Copper and zinc concentrations that are higher than recommended, have a negative impact on human health. Heavy metals can be found in industrial operations including metal smelting, electroplating, and industrial effluents (A. A. Khan & Saleem, 2018). Toxic metals like lead and mercury that are released into the atmosphere by industrial processes, effluents, and automobiles accumulate in the soil, where they eventually infiltrate various water sources because of to surface runoff. The untreated waste, municipal waste, and wastewater when mix with water sources it can adversely effects humans.

Water contamination is also caused by the fertilizers, pesticides, and other chemicals used in agricultural practices. They are removed from the fields by precipitation and mixed with runoff, which contaminates the water sources. At low levels, both nitrogen and phosphorus pose a risk to surface water. They overabundance of nitrogen and phosphorus leads to the phenomenon of eutrophication. Human and aquatic organisms that rely on water for consumption and habitat is affected by nutrients in surface and ground water (Easton & Petrovic, 2004).

1.5 Effect of contaminated water on human health

Contaminated water has a severe effect on human health and can be fatal sometimes since various diseases spread as a result of surface or ground water contamination. The pathogenic organisms, which are responsible for water pollution may cause intestinal infections like cholera, dysentery, fevers, skin diseases, and food poisoning (Memon et al., 2011). Due to the poor water quality in Asia, diarrhea is one of the leading causes of death among infants and cause illness to every fifth person.

There is a negative impact on human health when the physical, chemical, and biological parameters are above the limit that is permissible. Surplus amount of heavy metals in water bodies are carcinogenic for humans. In water bodies, where the concentration of Sodium is higher people usually suffer from hypertension and kidney issues. In Pakistan, it is estimated that due to water borne diseases about 230,000 infants (less than five years old) die each year (Mohsin et al., 2013). Reproductive and endocrinal damage is caused by the excess amount of chlorides in the water. The right monitoring and filtration methods can stop the spread of these diseases. However, due to the fact that new pollutants are frequently not even investigated, current filtration technologies for water purification are ineffective for removing them (Mohsin et al., 2013).

1.5.1 Water washed diseases

When there is not enough water available for personal hygiene, water-washed diseases occur. The diseases can spread due to the shortage of water and can be contagious sometimes. Diseases include skin infections like scabies, fleas, and more, while ocular infections like trachoma and others are considered diseases (Macy, 2009).

1.5.2 Water borne diseases

Water borne diseases are caused by the consumption of water contaminated with pathogens due to either inorganic substances or fecal contamination. Various diseases are caused such as nausea, vomiting, diarrhea, gastrointestinal problems, dysentery, and typhoid. It is one of the biggest public health issue due to poor water quality and lack of sanitation (Macy, 2009).

1.5.3 Water related diseases

Insect vectors that reproduce in water are the main cause of diseases associated with water. After completing their life cycle in insect vectors, they cause disease when they reach the human body. Numerous illnesses include filariasis, yellow fever, dengue, and malaria (Macy, 2009).

1.5.4 Water based diseases

Water based diseases are caused by the pathogenic microbes which are found in

Intermediate organisms living in water. Diseases includes schistosomiasis, dracunculiasis, and other helminths. Ingestion or skin serve as the medium of entrance for these pathogens (Macy, 2009).

1.6 Physio-chemical and biological parameters

1.6.1 pH

Normal pH range of drinking water quality varies between6.5-8.5. High level of pH can make the water taste bitter. pH range of water is also affected due to the presence of various minerals, carbon dioxide and waste water. Variation in the pH level of water can also affect the balance of the body and can lead to various kind of viruses, bacteria, fungi, and parasites (Addy et al., 2004)

1.6.2 Electrical conductivity (EC)

Electrical conductivity represents the presence of impurities i.e., chemicals, minerals, and dissolved substances in the water. Higher the electrical conductivity, higher will be the concentration of substances dissolved in water. Measure of capability of the water to transmit electric current and to assess the purity of water is known as electrical conductivity (Ajit et al., 2012).

1.6.3 Temperature

Temperature has some impact on the chemistry of water and it also starts the biological growth and activity. At higher temperature the rate of chemical reactions also increases generally, When the temperature in the ground water increases, the water dissolves more minerals from the rocks which will increase the electrical conductivity as well (Khan et al., 2017).

1.6.4 Total Dissolved Solids (TDS)

Total dissolved solid level helps to indicate that whether the drinking water quality is fit for filtration or highly contaminated. It shows to the presence of salts, minerals, organic and inorganic materials like magnesium, sodium, calcium, bicarbonates, sulfates, chlorides, and some organic materials which are dissolved in water. If the presence of these elements exceeds the permissible limit, the taste of water will turn salty.

1.6.5 Heavy metals

Some of the heavy metals include As, Cr, Cd, Mn, Mg, Z, Ni, Fe, Hg, and Pb (Khan et al., 2019). Presence of heavy metals in water generally in small quantities to maintain the human health which are essential. Contrarily, it will leave adverse effect to human health if the concentration of these heavy metals exceeds more the permissible limit.It can affect the normal functioning of lung, kidney, brain, and liver. It also changes the composition of the blood and cause different types of cancers. Heavy metals enter the water bodies through natural as well as anthropogenic activities. They are naturally present in earth's crust, sediments and rocks. When water passes through these sediments and rocks heavy metals become part of the water. Whereas, water is also contaminated by the industrial discharge, refineries, municipal waste, and mining.

1.6.6 Cations

Cations are essential for the normal growth and function of human body in small quantity including Na, K, Ca, and Mg. Whereas, if they are taken in excessive amount it will lead to different health problems (Daud et al., 2017).

1.6.7 Anions

If the amount of anion exceeds the permissible limit, it will cause different health problems. In drinking water, the most abundant anions include sulfate, nitrate, nitrite, chloride, carbonate and bicarbonates.

1.6.8 Microbial contamination

According to World Health Organization (WHO), more than 25% of the environmental issues and health problems are mainly due to diarrheal diseases which is caused by contaminated water (Gwimbi et al., 2019). Microbial contamination is one of the major public health problem due to poor sanitation and hygiene practices. Sewage contamination in water indicates the presence of *fecal coliform* bacteria. Along with that, other bacteria like *campylobacter*, *salmonella*, *shigella*, and *giardia* also effect human health.

1.7 Literature review

Water is considered as an important element of life. There are some elements which are required to make water suitable for drinking purpose. Contrarily, it will have adverse effect to human health and environment if limit of these element exceeds the permissible limit. The contamination of the water is due to the presence of fecal matter, domestic waste, agricultural and pasture runoff. Elements which have a specific density of 5 g/cm^3 are defines as heavy metals. heavy metals also contaminate the water. Drinking water quality is also contaminated by the presence of pathogenic bacteria which includes *thermo-tolerant coliforms, total coliforms, Escherichia coli, fecal streptococci, clostridium perfringens, parasites,* and *viruses* (Shaukat et al., 2019). The exposure of cadmium, lead, mercury, and arsenic have threats to human health. The small concentration of these elements is essential for the body of human but, if the concentration exceeds, they may cause acute or chronic toxicity (Fernández-Luqueño et al., 2013). In addition to these, there are 19 elements which are considered as heavy metals and cause adverse effect to human health.

Out of the total water on earth, fresh water is only 3%. For human use only a small percentage of 0.01% of fresh water is available (Azizullah et al., 2011). Drinking water is taken from various resources depending on the availability of the resource. Rivers, lakes, and streams, whereas underground aquifers used for drinking water purpose are known as surface water bodies. Although not all water available is used for drinking purpose due to the chances of pollution. Pollution depends on different factors which are responsible for adverse effect to human and environment. Lithogenic and anthropogenic sources such as urban development, agricultural activities, and industrialization are deteriorating the quality of surface water. Depending on the environment, movement and source of the ground water, the nature and concentration of ground water becomes saltish. Primarily, from the weathering of rock material, high concentration of soluble salts is found in ground water. Salt water intrusion, leakage of underground storage and septic tanks, landfills, severe agricultural practices may seep through aquifers and contaminate groundwater (Azizullahet al., 2011).

In developing countries of South Asia, Africa, and Middle East, the quantity of the available water is sharply decreasing whereas, due to urbanization, land degradation, deforestation and industrialization the quality of water is deteriorating as environmental concerns are arising all around the world. Asia being the largest continent of Earth is facing poor quality of water, organic and inorganic nutrient material in drinking water due to discharge of domestic and industrial waste water into these resources (Mohsinet al., 2013). Asia, due to the poor quality of water and bad sanitation more than 0.5 million deaths of infants occur per year along with various health threats (Mohsin et al., 2013). About 26% of deaths around the world are due to the poor quality of water and contagious diseases which are caused by pathogenic bacteria. Various Diseases spread due to the poor quality of water which sometimes are contagious and become fatal for living organisms. In developing countries, the most common and serious health problem is water-borne disease which are related to contaminated water. The water is contaminated by microbiological or chemical contaminants either directly or indirectly. The water sources become contaminated due to the environmental pollution caused by the domestic and industrial activities. In the ground water supply, various pathogens including bacterial, viral, and protozoan agents are the main source of the diarrheal diseases each year (Chandio et al., 2019). The health of human is greatly affected by the presence of bacteria in the drinking water as presence of E. coli causes a potential hazard to human health and has a high significance in water supplies, according to WHO. It also indicates the failure in the chlorination system as well as the recontamination of the water after disinfection.

In the developed world, the issue of drinking water quality has an increasing concern whereas, a little discussion in developing countries. With the availability of about 1,200 m^3 per capita which is declining, Pakistan is ranked a water stress country. The unrest is created among the federating units due to the gap between the demand and supply of water. Pakistan ranked 80 out of 122 nations regarding the drinking water quality. In the recent years, the fresh water supplies of the country are reduced due to the extended droughts. Therefore, in order to use the finite quantity of water, water conservation techniques and new sources should be developed (Kahlown, M. A., & Majeed, 2003). Depending on the location in Pakistan, the availability of the water resources includes precipitation, surface and ground water. The contaminants can be biological, chemical, or pesticides all over the country. Mostly, the public health problems are caused by microbial or the chemical pollutants (Azizullah et al., 2011).

Forty percent of the population is living in slums and has limited sanitary and water infrastructure and poor quality of in a city of more than 10 million people, Karachi (Hasnie, F.R. and Qureshi, N.A., 2004). The study was conducted in the coastal community in Rehri village, Karachi to determine if the water is suitable for drinking water purpose.

Different samples were collected from storage containers, tanks at households, springs and main supply line present in the vicinity, and tested for chemical and microbiological parameters. The results showed that the bacterial count was high as the exceeded the maximum acceptable concentrations. Due to the fecal contamination in the drinking water the presence of the *coliform, Escherichia coli, Enterobacter sp.* and *Serratia sp*. were detected. On the contrary, other parameters including heavy metals such as NO_3, NO_2, NH_3PO_4, free Cl, Ca, Mg, hardness, Fe, Cu, and Cr where below the quality guidelines of WHO.

This study was about Pakistan's groundwater and surface water quality for drinking and irrigation conducted at Rawalpindi, Samples from groundwater (n = 30), surface water (n =27 from the river Soan), and wastewater (n = 21) were obtained for this purpose. The physiochemical characteristics and quantities of potentially hazardous elements (PTEs) were examined in each sample. Wastewater had the highest levels of physiochemical parameters and PTE contamination, followed by surface water according to the findings (River Soan). The national environmental quality criteria (NEQs) established by Pakistan's environmental protection agency were exceeded by the PTE contamination levels in groundwater, River Soan, and wastewater (Pak EPA) (Khan et al., 2019). The sources

Of groundwater (hand pumps, bore wells, and tube wells) were assessed for the risk of PTE ingestion through drinking water. The hand pump water had the highest levels of PTE contamination, which increased Zn's average daily intake (ADI) value to 0.079 mg/kg-d and Cd's hazard quotient (HQ) value to 11.7. For all sources of drinking water, the HQ values of Cd were greater than 1. Higher HQ values of Cd could cause a variety of immediate and long-term health issues in the research area's exposed population (Khan et al., 2019).

A study was conducted in Islamabad, Pakistan to investigate the presence of arsenic (As) and heavy metal (HM) in drinking water sources. Heavy metals are present in water due to natural as well as anthropogenic activities. The consumption of contaminated water leads to cancer or chronic health issues in human population. From various drinking water sources including tube wells, tap, bottled water, filtration plant, and bore wells, total 60 samples were collected. These samples were analyzed for basic parameters like pH, total dissolved solids, electrical conductivity, HM: Cd, Zn, Pb, Ni, and Fe; anions: As, chloride, and fluoride. The results showed that the concentrations of As, Pb, Ni, Fe, and Cd exceeded the permissible limits by World Health Organization (WHO) by 3.34%, 23.3%, 1.67%, 20.0%, and 6.67%(Abeer et al., 2020).

Arsenate and arsenite are two forms of arsenic. A poisonous metalloid arsenic which is found in earth's crust. Its presence in water is currently a terrible catastrophe. It is the 20th most prevalent element in the crust of the earth. Compared to organic arsenic, inorganic arsenic is more harmful. It is an inorganic material with trace amounts of methyl and dimethyl arsenic compounds that is found in water. Natural processes like weathering, volcanic eruption, biological activity, and human-made processes including the usage of pesticides, herbicides, and wood preservatives mobilize arsenic in the environment (Kavcar et al., 2009). A list of carcinogens now includes arsenic. Due to favorable geological, chemical, and physical conditions as well as the interaction of rocks with water,arsenic is added to water. Arsenic is added to food, and from there, it travels through the food chain to many creatures. Arsenic is extremely harmful at higher concentrations. The world's largest mass poisoning has just occurred. Arsenic pollution of drinking water poses a threat to about 60 million people in Pakistan, 60 to 100 million people in India, and 60 to 200 million people in Bangladesh. Various unfavorable health impacts of arsenic pollution include gangrene, hyperpigmentation of the soles and palms, cardiovascular issues, lowered immunity, problems with the liver and bladder, black foot disease, and others socioeconomic issues as well as keratosis, diabetes, cancer, hypertension, and pulmonary issues (Muhammad et al., 2010).

Numerous samples were discovered to not be in compliance with WHO guidelines when different Samples were taken from Islamabad's Margalla Hills to gauge the purity of the water. While several parameters' thresholds exceeded the acceptable limits, some elements were within the limit which includes microbial content, EC, DO, cadmium, and lead. All of these elements seriously harm one's health. A 100 ml sample of water must be free of feces, yet samples taken from this area and along the River Swat from surface and subsurface water were polluted with both human and animal waste. Similarly, Lower Shahdara's water was contaminated with staphylococcus spp. It is advised that a 100 ml sample of drinking water be *staphylococcus*-free. It is the root of many deadly diseases, including pneumonia, chest discomfort, and skin infections. *Pseudomonas spp.* contamination was also extremely high in samples taken from the Margalla hills. It serves as a gauge for water quality. They are widespread in water systems due to their ease of colonization and capacity to build dense biofilms that affect turbidity, odor, and taste. It causes a variety of illnesses in immune- compromised people as well as urinary tract infections, burns, wounds, and different pulmonary tract issues (Batool, 2018).

This study conducted to analyze the health risk assessment due to heavy metal and arsenic in water used for drinking. The study examined the contamination of drinking water sources in Islamabad, Pakistan, with heavy metals (HM) and arsenic (As). Samples (n=60) were obtained for this purpose from diverse sources of drinking water (bore wells, tube wells, tap, filtration plant, and bottled water). The samples' physicochemical properties were examined, including fundamental factors like pH, electrical conductivity, total dissolved solids, anions such as fluoride, chloride, and as well as HM elements such as Pb, Cd, Ni, Zn, and Fe (Abeer et al., 2020). The results showed that the amounts of Pb, Cd, Ni, Fe, and as exceeded the World Health Organization's (WHO) drinking water recommendations by 23.3%, 6.67%, 1.67 %, 20.0%, and 3.34%, respectively. The average daily dose (ADD), hazard quotient (HQ), and carcinogenic risk were calculated to assess the chronic danger posed by exposure to the detected as and HM concentrations (CR). The findings showed that the HQ values for HM were 1, but the values for drinking water for children (in 3.34% samples) were >1 (Abeer et al., 2020).

To evaluate the water's purity, samples from Islamabad's Margalla Hills were taken. It was found that numerous samples were not compliant with WHO standards. Some components, such as microbiological content, EC, DO, cadmium, and lead, were under the limit even though the thresholds for some metrics were over the permissible range. All of these elements seriously harm one's health. Samples of surface and subsurface water taken from this region and along the River Swat were contaminated with both human and animal waste, despite the requirement that a 100 ml sample of water be free of feces. The water at Lower Shahdara was also contaminated with s*taphylococcus* species. A 100 ml sample of drinking water should be devoid of *staphylococci*. It is the cause of numerous fatal diseases, such as pneumonia, chest pain, and skin infections. *Pseudomonas spp* contamination was also extremely high in samples taken from the Margalla hills. It is used as a water quality indicator. They are common in water systems because of how easily they can colonize and because of their ability to create dense biofilms that have an impact on turbidity, odor, and taste. It causes a variety of illnesses in immune- compromised people as well as urinary tract infections, burns, wounds, and different pulmonary tract issues (Batool, 2018).

In this study, heavy metals (HM) and arsenic (As) contamination of drinking water sources in Islamabad, Pakistan, were investigated. The research was done to evaluate the health risks associated with drinking water that contains heavy metals and arsenic. For this objective, samples (n=60) from various drinking water sources (bore wells, tube wells, taps, filtration plants, and bottled water) were collected. The samples' physicochemical properties were examined, including fundamental factors like pH, electrical conductivity, total dissolved solids, anions such as fluoride, chloride, and as well as HM elements such as Pb, Cd, Ni, Zn, and Fe (Abeer et al., 2020). The results showed that the amounts of Pb, Cd, Ni, Fe, and Arsenic exceeded the World Health Organization's (WHO) drinking water recommendations by 23.3%, 6.67%, 1.67 %, 20.0%, and 3.34%, respectively. To evaluate the long-term risk presented by exposure to the found As and HM concentrations (CR), the average daily dose (ADD), hazard quotient (HQ), and carcinogenic risk were computed. The findings showed that the HQ values for HM were 1, but the as values for drinking water for children (in 3.34% samples) were >1 (Abeer et al., 2020).

To determine the quality of the drinking water, a bacteriological assessment study was carried out in the Pakistan's district of Rawalakot, Azad Kashmir. Between September 2017 and March 2018, descriptive study was done in the Rawalakot District. Out of 90 samples, 45 samples—exactly from the same 45 sites—were collected in September and October 2017 as pre-rainfall samples (15 from each bore-well, open-well, and spring water—and 45 samples—exactly from the same 45 sites—were collected in February and March 2018 as post-rainfall samples). Each sample was subjected to *total bacterial* and *coliform* counts, *Escherichia coli, Shigella, salmonella,* and *Shigella* counts (Shoukat et al., 2019). Pre-rainfall season samples from bore wells (n=11/15; 73.33%) and post-rainfall season samples from open wells (n=12/15; 80%) had higher rates of overall bacterial growth on Nutrient Agar. In samples of spring water, *total coliforms* growth on MacConkey agar was more common in the post-rainfall season (n=9/15; 60%). The bulk (n=5/15; 33.33%) of *Escherichia coli* growth on eosin methyl blue agar was seen in post-rainfall season in spring water samples. When compared to pre-rainfall water samples, almost all of the post-rainfall season samples showed less *Shigella and Salmonella* species (Shoukat et al., 2019).

Another research was done to determine the water's purity for drinking in a Pakistan's significant city i.e., Faisalabad. As a result of the presence of industry, Faisalabad is a popular city. It's referred to as the Manchester of Pakistan. It has a large population. Due to population growth, water use has increased. Industries are largely to blame for the issue. Direct wastewater and solid waste discharge from industries into groundwater and surface waters (Farid et al., 2012). Only a small number of enterprises clean wastewater before releasing it into bodies of water. Industries in Pakistan release over 9 billion gallons of effluent each year. In order to evaluate the quality of groundwater used for drinking, samples were taken at sewage treatment facilities along a 10-meter path that travels through urban areas. Although pH doesn't directly affect health, it does so indirectly. All of the sample's pH values fell between 6.5 and 8.5, which is within the permitted range for drinking water. TDS, however, is substantially higher in every sample. TDS stands for total dissolved solids, which is the sum of all the dissolved ions in water, including magnesium, calcium, sodium, potassium, chlorides, sulphates, bicarbonates, and trace amounts of organic material. Values between 1190 and 2415 mg/l.

These samples' hardness values complied with WHO recommendations but not APHA ones. The main causes of hardness in water include bicarbonates, calcium, magnesium, sulphates, chlorides, and magnesium. Alkalinity was likewise above the stated threshold. It can result in gas, kidney stones, skin and mucous membrane problems, and eye infections. The sulphate concentration ranged from 241 to 570 mg/L. However, the WHO recommends 250 mg/L. More chloride was also present in the samples. The acceptable limit is 250 mg/L, although the results range from 171 to 380 mg/L. Too much of a Chloride concentration can have an impact on one's stomach, taste buds, gastrointestinal tract, hydration, and hydration. The salt content was also exceeding 250 mg/L. Excess sodium contributes to hypertension, vascular problems, heart disease, and kidney disease. Liquids cannot contain more potassium than 12 mg/L. However, the samples' concentrations varied from 32 to 60 mg/L. Dehydration is a result of excessive potassium content in water. The threshold level for cadmium levels was also exceeded. Value lies between 0.01 and 0.02 ppm. However, the WHO has set a limit of 0.005 pm (Farid et al., 2012).

Research was done in Dera Ghazi Khan to determine the characteristics of drinking water. The conductivity value is much higher than the allowed limit. It might be brought on by the local geography. Concentrations of bicarbonates, salt, calcium, chloride, and magnesium are significantly over the WHO-recommended range. Their concentration is raised by sewage, industrial waste, and runoff from precipitation. Due to inadequate drainage systems, mine drainage, inefficient sewage and sludge disposal, and mine drainage, sulphate concentrations were also higher in samples. In addition to metal poisoning, microorganisms also contaminated the water. It is caused by an open, leaky, and unclean drainage system and incorrect sewage disposal. The levels of arsenic, fluoride, potassium, and alkalinity were within the permitted ranges. However, the results of the entire research showed that the water in Dera Ghazi Khan is unsafe for human consumption(Malana & Khosa, 2011).

1.8 Objectives

The study's objective is to:

- To assess the physicochemical parameters in drinking water from selected village (Phulgran) of Islamabad.
- To assess the biological parameters in drinking water from study area.

CHAPTER 2

METHODOLOGY

1.1 Study Area

Water has a big impact on human health because it is one of the essential requirements of life. Water-borne diseases are also eventually passed on by unsanitary and unhygienic conditions. In order to check the drinking water quality from different sectors that were selected, Islamabad sampling was done. The drinking water samples were collected in sterile bottles for biological, chemical, and physical parameters.

Table 3.1 Sampling source and location

S.NO	LATITUDE	LONGITUDE	SOURCE
S1	33.7419307	73.1986037	Supply line
S2	33.7397305	73.1964101	Boring
S3	33.7447868	73.1970817	Boring
S4	33.744026	73.2005692	Boring
S5	33.7484227	73.2191499	Boring
S6	33.7478897	73.2223327	Boring
S7	33.7480416	73.2270027	Boring
S8	33.7493866	73.2305742	Boring
S9	33.7490494	73.2299035	Boring
S10	33.750401	73.2388142	Boring
S11	33.7507401	73.2388142	Boring
S12	33.7479571	73.2204119	Boring
S13	33.7551072	73.2242662	Boring
S14	33.7544497	73.2237442	Boring
S15	33.7536739	73.2222858	Boring
S16	33.7549084	73.223979	Boring
S17	33.7531381	73.2227339	Boring
S18	33.7441222	73.1975983	Boring
S19	33.7386906	73.1920623	Supply line
S20	33.73655432	73.1997099	Supply line
S21	33.7365373	73.2002293	Boring
S22	33.7373439	73.207844	Supply line
S23	33.7353766	73.215144	Supply line
S24	33.7439811	73.1966795	Boring
S25	33.7416361	73.1990055	Boring
S26	33.7425634	73.2007043	Boring
S27	33.7397347	73.1944957	Boring
S28	33.7460024	73.2041925	Supply line
S29	33.7404715	73.2005953	Supply line
S30	33.7390249	73.1951166	Supply line

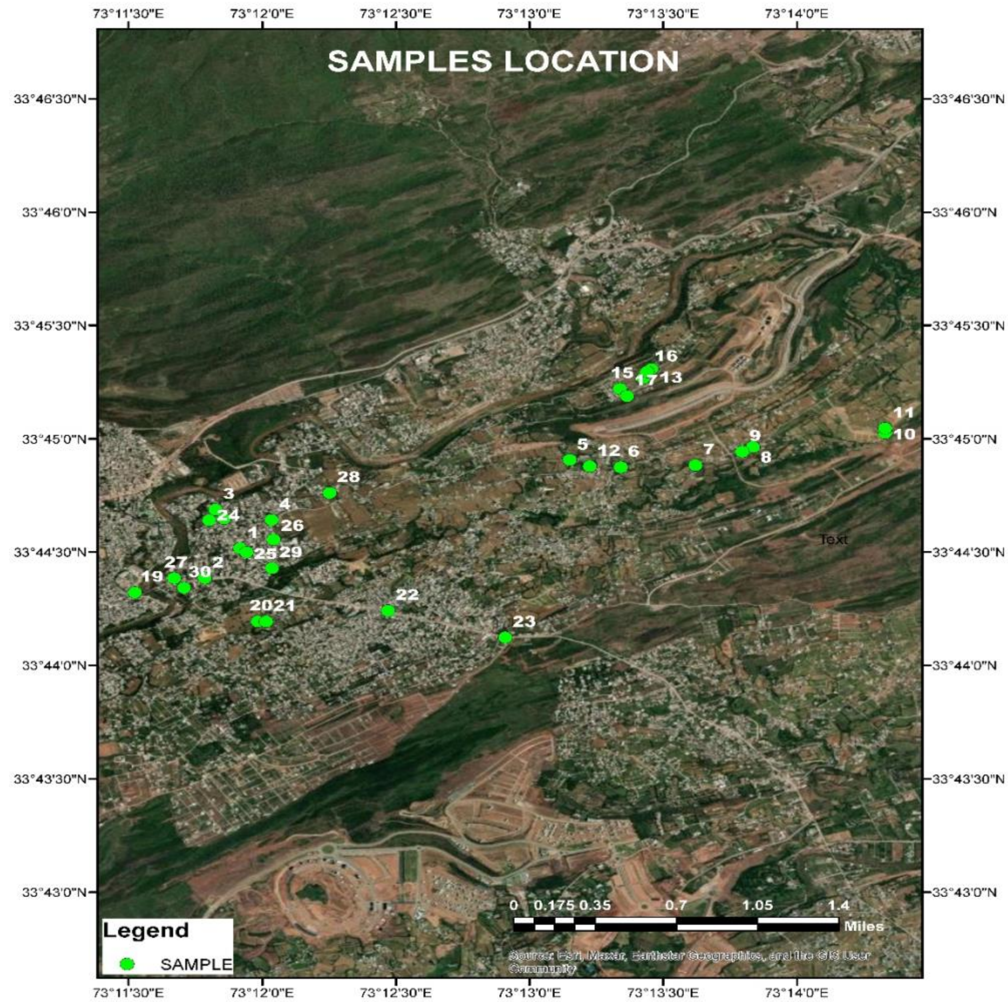

Fig 2.0 Study area map

1.2 Water sample collection

Drinking water samples were collected from different locations. The samples werecollected from Phulgran village, Majority samples were taken from bore well and some samples were collected from supply lines . For the testing of physical, chemical parameters and heavy metals, each drinking water sample was collected in a single bottle. The bottle was rinsed with the sample water and later it was filled with same water for testing. Contrarily, for the testing of biological parameters sterilized bottles were used. Hands were sanitized prior the collection of water sample in a bottle.

1.3 Sample size

A total of 30 samples were collected from Phulgran village of Islamabad that have been selected, for the testing of physical, chemical, and biological parameters. Samples were collected according to standard protocols in plastic bottles. Each sample of drinking water was collected from bore well and supply line for biological testing from main source of water. The microbial analysis was carried out within 24 hours of collectionof the water samples.

1.4 Data collection and analysis

Both primary and secondary data was collected. The primary data was collected on the spot by collecting the samples and the required information. Whereas the secondary data includes the permissible limits, or the standards of various parameters set by World Health Organization (WHO) for drinking water.

1.5 Physical parameters analyzed

The physical parameters were analyzed in Environmental lab of Bahria University H-11/4 Campus. Using pH/TDS/Conductivity/Salinity/Temperature Meter-(IMCTS-08) physical parameters were analyzed which shows pH, electrical conductivity, TDS, salts and temperature.

1.5.1 pH

The pH of the samples was measured using pH meter. The probe of the meter was rinsed with distilled water to avoid mixture of any other samples and to record the accurate readings. The beaker used is also rinsed with distilled water and the water sample was poured in it and probe of the pH meter was dipped in the sample for few minutes until the accurate reading was noticed after it was stabilized (Akter et al., 2016; Napacho & Manyele, 2010).

1.5.2 Total dissolved solids (TDS)

Total dissolved solids in the water sample were measured with the same meter used for pH in a similar manner. After the pH was noticed, Press the mode button present on the meter to record the readings of TDS after it was stabilized (Akter et al., 2016).

1.5.3 Electrical conductivity (EC)

The electrical conductivity of the water sample was measured in a similar way as pH and TDS were measured. The reading of electrical conductivity was noticed (Ji. A., and uddin, S. 2019)

1.5.4 Temperature

The temperature of the water sample was measured with the same meter in a similar way by which pH, TDS, EC salts were measured. The reading of temperature was displayed on the screen when the probe was dipped in the water sample (Omar, 2009).

1.5.5 Salts

The salts in the water sample were measured by using the same meter in a similar manner. The reading of the salts was noticed after it was stabilized. Once, all the readings were noticed the probe was rinsed with distilled water (Akter et al., 2016).

1.6 Methods of chemical parameters

The chemical parameters for the drinking water samples are as follows;

1. Chloride (Cl)
2. Sodium (Na)
3. Sodium chloride (NaCl)
4. Total hardness

5. Alkalinity
6. Carbonates ($NaHCO_3$, Na_2CO_3, HCO_3,CO_3)
7. Nitrates
8. Arsenic

1.6.1 Estimation of chlorides (Cl)

The chlorides in the drinking water sample were tested by titration. The burette, titration flask, and measuring cylinder were washed and rinsed with distilled water to remove any contamination.

1.6.1.1 Reagents

1. Standard solution $AgNO_3$ (0.01 N)
2. Indicator K_2CrO_4
3. 10 ml water sample

1.6.1.2 Procedure for analysis of sample

Standard solution of 0.01 N $AgNO_3$ was added in the burette. Then 10 ml water sample was measured in the measuring cylinder and shifted to titration flask. The indicator used is K_2CrO_4 which indicates the endpoint. Add three drops of indicator to the water sample in a flask. The titrant from the burette is added drop wise until color of the water sample changes, and insoluble white precipitates will appear if Cl reacts with $AgNO_3$ (District et al., 2012; Napacho & Manyele, 2010). The initial and final level of standard solution i.e., before and after dripping is noted and the difference is taken to know how much standard solution is used. This procedure is repeated thrice to eliminate the chances of error and the average of the difference is taken to know the average volume.

Calculations

The calculation to know the concentration of chloride is done by the following formula.

$$\text{Cl}\left(\frac{\text{mg}}{\text{l}}\right) = \frac{\text{Normality} \times \text{Volume} \times \text{Molecular weight} \times 1000}{\text{Sample volume}}$$

1.6.2 Determination of NaCl

The NaCl in the water sample is determined by putting the value of normality, volume, molecular weight of NaCl and the sample volume and perform calculation according to the following formula;

$$\text{NaCl}\left(\frac{\text{mg}}{\text{l}}\right) = \frac{\text{Normality} \times \text{Volume} \times \text{Molecular weight} \times 1000}{\text{Sample volume}}$$

1.6.3 Determination of Na

The determination of Na in the water sample is done by subtracting the value of NaCl from Cl.

$$Na = NaCl\ concentration - Cl\ concentraion$$

1.6.4 Estimation of total hardness

The total hardness in the drinking water was estimated by using a certified method by PCRWR. The burette, volumetric flask, and cylinder were washed and rinsed with deionized water to avoid any contamination.

1.6.4.1 Reagents

1. Standard solution EDTA (0.01 N)
2. Buffer inhibitor mixture
3. Indicator EBT
4. 20 ml Distilled water
5. 10 ml water sample

1.6.4.2 Preparation of buffer inhibitor mixture

1.6.4.3 Reagents

1. Conc. HCl
2. 2-Aminoehtanol
3. Magnesium salt of EDTA

1.6.4.4 Procedure

For the preparation of buffer inhibitor mixture, the volumetric flask of 1000 ml and measuring cylinder of 500 ml was washed and rinsed with distilled water. The concentrated HCl of 55 ml was measured in measuring cylinder and then shifted to volumetric flask. After that, 400 ml deionized water is added to the cylinder. 300 ml 2-aminoethanol was measured and shifted to volumetric flask. The 5g Magnesium salt of EDTA was measured in an analytical balance and later shifted to the same flask.

1.6.4.5 Procedure for analysis of sample

The burette was filled with standard solution of 0.01 N EDTA. The drinking water sample of 10ml was measured and added to titration flask. Measure and add 20ml deionized water in the same flask. Add 1ml of buffer inhibitor with the help of a syringe. The indicator used was Eriochrome Black T (EBT). Add few drops of indicator and shake gently until it is completely mixed and wine-red color is produced. The standard solution from the burette was added drop wise with constant stirring until the sky-blue color appears (Napacho & Manyele, 2010).

Calculation

Multiply the EDTA burette reading with 100. Result will show the total hardness in the sample.

1.6.5 Estimation of Alkalinity

Alkalinity ability of the water to neutralize acids and bases and maintaining a fairly stable pH, Alkalinity is also known as the buffering capacity of the water. (Addy et al., 2004). The burette, titration flask, and measuring cylinder were washed and rinsed with distilled water to remove any contamination. The alkalinity in the drinking water sample were tested by titration. Titration with a standard acid solution (H_2SO_4) using selective indicators either methyl orange or phenolphthalein is used to measure alkalinity (Omer N. H., 2016).

1.6.5.1 Reagents

1. Standard solution H_2SO_4 (0.02 M)
2. Indicator for basic sample is Phenolphthalein

3. Indicator for acidic sample Methyl orange (2 to 3 drops)

1.6.5.2 Procedure for analysis of sample

The burette was rinsed with distilled water first then filled with a standard solution of 0.02 M sulphuric acid. Measure 50 ml of water sample and shifted to titration flask. Phenolphthalein indicator is used for the basic water sample whereas, methyl orange indicator is used for the acidic water sample. The titrant from the burette was added drop wise in a sample with constant stirring. The initial and final level of standard solution i.e., before and after dripping is noted and the difference is taken to know how much standard solution is used. To know the average volume, the average of the difference is taken. The basic media will change into pink color while, the acidic media will give red to orange color (District et al., 2012).

Calculation

$$\text{Alkalinity} = \frac{\text{Normality of acid} \times \text{Volume of acid} \times 50{,}000}{\text{Sample volume}}$$

1.6.6 Estimation of carbonates

Carbonates in water comes from the percolation of water through deposits of limestone, chalk and gypsum which are made up of calcium and magnesium carbonates , bicarbonates and sulphades. There are 4 types of carbonates are Sodium Bicarbonate, sodium carbonate, bicarbonates and carbon tetra oxide. Carbonates and bicarbonates ion in the sample were determined by titrating it against standard 0.1M HCL using methyl orange as an indicator. Addition of methyl orange will give pink red color in the presence of carbonates.

1.6.6.1 Reagents

1. Standard HCL solution
2. Methyl orange indicator
3. 50ml of sample

1.6.6.2 Procedure for analysis of sample

Firstly, the flask was rinsed with distilled water and 50ml of sample was added. Add a few drops of methyl orange indicator to the sample solution. Methyl orange is orange in the presence of carbonates ions. Set the burette with the 0.1M HCL solution. Slowly add the HCL solution to the carbonates solution by stirring continuously. Continue adding HCL until the color changes to orange to pink or red. This color indicates the carbonates ion have been neutralized. Note the volume of HCL solution used for titration this is the end point of reaction.

Calculation

$M1V1 = M2V2$

Amount per dm3= Molarity x Molecular weight of carbonate

1.6.7 Estimation of Nitrates:

Nitrate is major nutrient needed by living organisms for their physiological processes if their concentration is more by limit they are considered as pollutant. They come from nitrogenous fertilizers, sewage, dumps, municipal leakage contaminate land etc. they may be successfully removed by ion exchanged, distillation and reverse osmosis. Measurement of UV absorption at 220nm enables determination of nitrates on spectrophotometer follow Beer's Lambert law.

1.6.7.1 Reagents

1. 100mg/l potassium nitrate stock
2. Distilled water
3. 1N HCl
4. Distilled water

1.6.7.2 Procedure for preparation of Nitrate stock and working standard

Weight 0.721g of well dried KNO_3. Quantitatively transferred to 1000ml volumetric flask. Make the volume up to the mark with distilled water. Transfer to appropriate label bottle container. Preserve stock solution by adding 2ml of chloroform in 1L. Take 10ml of 100mg/l stock solution in to 100ml to prepare a 10mg/l secondary standard. Make the volume up to the mark with distilled water. Verify standards with the previous made standards by comparing the two curves. Prepare standards of 1,2---7 ppm using formula C1V1=C2V2 by making dilution from 100mg/l Nitrate stock solution.

1.6.7.3 Procedure for analysis of sample

Take 10ml deionized water in the beaker and add 0.2ml 0f 1N HCL in it. Apply special correction or blank correction. Now take 10ml standard or sample in cuvet and add HCL to it. Take absorbance reading at 220nm to measure nitrate concentration in the sample.

Calculation

Conc. of sample = Abs. of sample x Conc. of standard÷ Abs. of standard.

1.6.8 Estimation of Arsenic

Arsenic happens normally in soil and rock. Arsenic from soil and rock can break down into groundwater and enter drinking water wells. For a great many people, food and water are the greatest wellsprings of openness to arsenic. Some arsenic in the environment comes from human movement. Arsenic was a fixing in certain pesticides and was utilized as a wood additive for wood establishments, decks, and kids' open air play structures.

1.6.8.1 Procedure for analysis of sample

To the reaction bottle slowly add water sample to upper mark line on the bottle (50ml). Add 1 level pink spoon of the first reagent to the reaction bottle. Cap securely with the red cap and shake vaguely with bottle upright for 15 sec. Uncap the reaction bottle an add 1 level red spoon of the 2^{nd} reagent. Recap security with the red cap and shake vigorously with bottle. Up right for 15 sec. Uncap the reaction bottle and add 1level white spoon of

3rd reagent. Cap security with red cap and shake vigorously with bottle. Upright for 5sec.Iimmediately uncap and recap. Securely using the white cap White cap must be dry. Remove one arsenic test strip from its bottle. Insert the test strip into the turret. Wait for 10 minutes. After 10 minutes wait pull up the turret and carefully remove the test strip. Use the next arsenic test kit color chart to match the test strip pad color within the next 30 seconds. Record results.

2.7 Biological parameters

The water samples collected from different sectors of Islamabad were tested for biological analysis. The biological analysis was done for *total coliform*, *salmonella*, *shigella*, and *total bacterial* load. Sterilization of hands as well as equipment's used is one of the most important step in the assessment of biological parameters. Sterilized bottles were used to avoid any kind of contamination. The tap of the water coolers and hands were properly sterilized with methylated spirit prior the collection of water in a bottle.

The medium of Nutrient agar, SS agar, and MacConkey agar was prepared according to the number of samples. Approximately 20ml of media is required for each petri dish. Therefore, the number of media was calculated by the following formula:

1 petri dish = approx. 20ml Total samples = 30

Quantity required = 20 x 30 = 600ml

This process was based on two phases; In phase 1, 30 samples were prepared. In phase 2, 30 samples were prepared in a similar manner. The total number of samples prepared in two phases were 60.

2.7.1 Estimation of *total bacteria* by using nutrient agar (NA)

28 gram of nutrient agar was added in 1 liter of water to prepare the solution.

1 $liter$ = 1000 $milliliter$

$$\frac{28\text{g}}{1000} = 0.028\text{g}$$

$$0.028 \times 680 = 16.8\text{g}$$

The nutrient agar of 16.8g was measured in the analytical balance and mixed with 600ml distilled water in a glass bottle and covered by a cotton plug.

2.7.2 Estimation of *total coliform* by using MacConkey agar (MAC)

51 grams of *MacConkey* agar was added in 1 liter of water to prepare the

solution.1 $liter$ = 1000 $milliliter$

$$\frac{51\text{g}}{1000} = 0.051\text{g}$$

$$0.051 \times 600 = 30.6\text{g}$$

The *MacConkey* agar of 30.6g was measured in the analytical balance and mixed with 600 ml distilled water in a glass bottle and covered by a cotton plug.

2.7.3 Estimation of *salmonella, shigella* by using *salmonella, shigella* agar (SS)

60 grams of *salmonella, shigella* agar was added in 1 liter of water to prepare the

solution.1 $liter$ = 1000 $milliliter$

$$60 \div 1000 = 0.06\text{g}$$

$$0.06 \times 6000 = 36\text{g}$$

The *salmonella, shigella* agar of 36g was measured in the analytical balance and mixed with 600ml distilled water in a glass bottle and covered by a cotton plug.

After the preparation of all the media, they were kept in an autoclave for wet sterilization at 121°C for 15 minutes. The petri dishes were kept in laminar flow hood which is covered with 3 sides and consists of HEPA filter to eliminate bacteria. Before the filling of petri dishes, sterilization of hands with methylated spirit was very important step. The filing of petri dishes was done inside laminar flow to avoid any contact with bacteria. After, the media solidifies in the petri dishes they were covered with a lid. Micropipette was used to put the sample in the petri dishes.

The amount of water sample taken was 100 microliters. Sample was sprinkled over a petri dish with the help of a glass spreader. The spreader was sterilized with methylated spirit and then heated over spirit lamp and spreading was done at an angle of 45°. The petri dishes were sealed with tape after the spreading so there is no chances of any other particle involve in this process and sample numbers were written on each petri dish, medium name was written on the lid for the purpose of identification. The petri dishes were kept in an incubator in inverted form for 18 to 24 hours at temperature of 36.6°C. Petri dishes were kept inverted so that the excess moisture stays on lid and bacteria do not get excess moisture or else they may slip (Brenner et al., 1993).

After 24 hours, put out the petri dishes from the incubator and note the results of microbial parameters.

CHAPTER 3

RESULT AND DISCUSSION

3.1 Assessment of water quality

The samples were examined, and both their microbiological and physicochemical characteristics were evaluated. The results of the analysis gave us values that indicate if the water is suitable for drinking.

3.2 Physical Parameters

Tests were carried out and tabulated in a lab for several physical water properties.

Table 3.2 Table of physical parameters of Phurgran Village

S.NO	pH	EC(μs/cm)	TDS(mg/l)	Salts(mg/l)	Temperature(˚C)
S1	7.36	286	340	197	11.1
S2	7.1	496	357	234	11
S3	6.74	485	344	223	11.1
S4	6.65	610	433	283	11.2
S5	6.53	748	530	350	11.2
S6	6.62	776	551	364	11.1
S7	6.62	718	510	335	11
S8	6.58	605	430	281	10.9
S9	6.66	602	428	280	11.2
S10	6.53	630	446	293	11.4
S11	6.59	726	449	296	11.5
S12	6.49	686	516	298	11.4
S13	6.47	768	487	320	11.3
S14	6.52	703	546	361	11.4
S15	6.55	703	500	331	11.5
S16	6.41	1289	915	619	11.7
S17	6.66	1288	917	619	11.7
S18	6.38	753	535	254	11.8
S19	6.43	556	394	259	12.2
S20	6.7	313	223	144	11.7
S21	6.45	671	476	313	11.8
S22	6.76	298	212	137	12
S23	6.77	295	209	135	12.2
S24	6.38	658	467	308	12.3
S25	6.79	861	612	408	12.3
S26	6.76	872	620	413	12.2
S27	6.41	578	410	270	12.4
S28	6.76	296	210	136	12.6
S29	6.76	299	212	137	12.4
S30	6.79	302	215	139	12.6
Limit	**6.5-8.5**	**1000**	**500**	**200**	**25˚C**

3.2.1. pH

pH is an essential factor when determining the acid-base balance of water. It is also known as the concentration of hydrogen ions in aqueous solution or the negative logarithm of hydrogen ions. pH values range from 0 to 14, with 7 being neutral. If the pH value is lower than 7, the solution is acidic. pH greater than 7 indicates that the solution is basic. The samples for the present study had pH levels that were within acceptable limits i.e., 6.5-8.5 as described by WHO.

While pH does not directly affect human health, it does offer a favorable environment for bacteria and several chemical process.

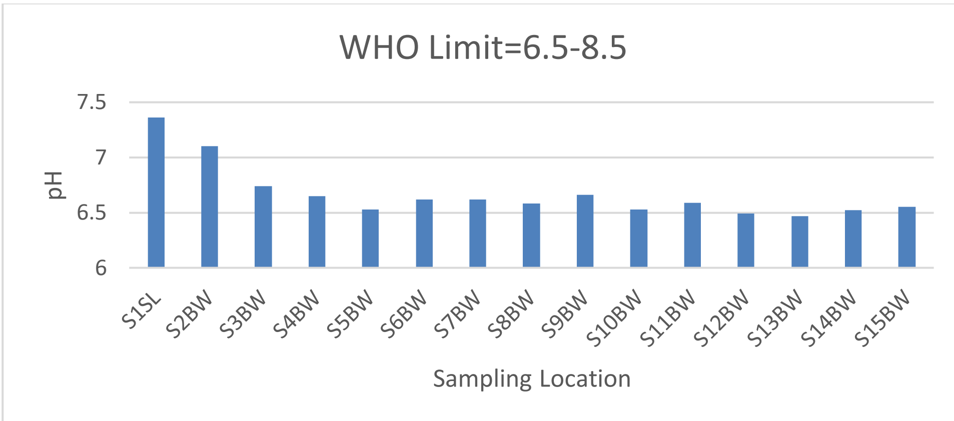

Fig 2.1 pH concentration in drinking water quality of different sources

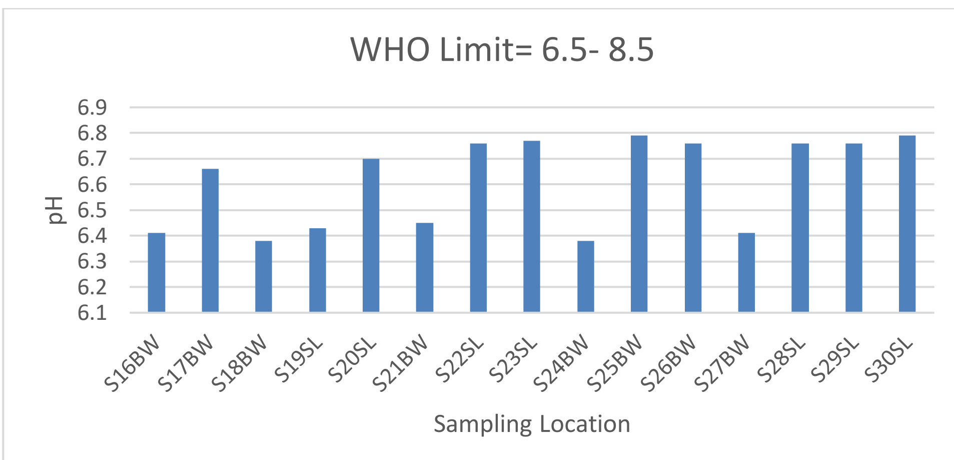

Fig 2.2 pH concentration in drinking water quality of different sources

3.2.2 Electrical Conductivity

Electrical conductivity is the measurement of a substance's capacity to carry electric current. Ions and total dissolved solids (TDS) are directly involved in how electricity is transmitted.

The WHO states that the allowable limit for EC in drinking water is 1000µS/cm. Due to the presence of salts and inorganic ions in drinking water, a higher EC level indicates that the water is contaminated. For all samples examined in this study, the current EC findings were within the WHO-permitted level except sample (16,17).

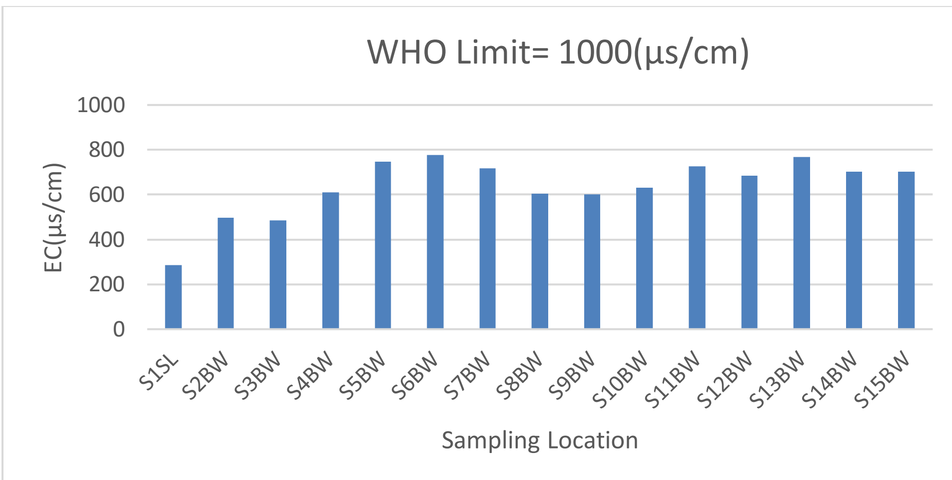

Fig 2.3 EC concentration in drinking water quality of different sources

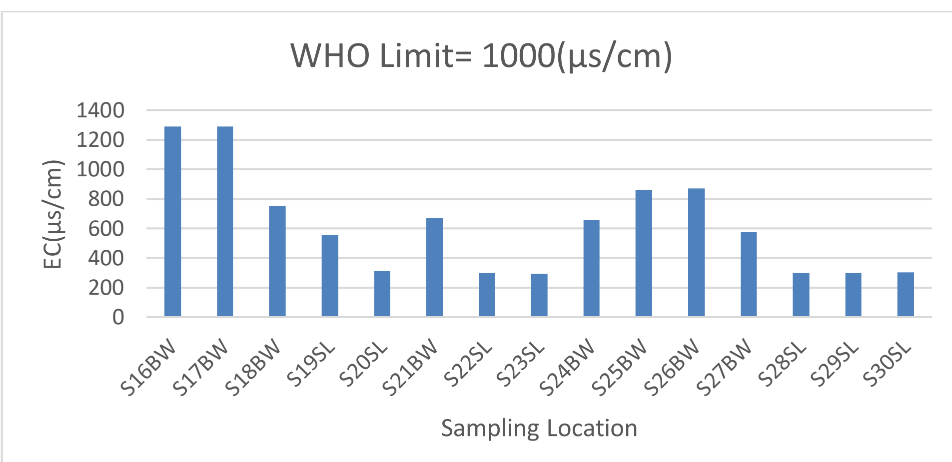

Fig 2.4 EC concentration in drinking water quality of different sources

3.2.2 Total Salts

Salts are found in water, including sodium chloride. Total dissolved solids and salt concentration are directly proportional to one another. When the concentration of salt rises, TDS also rises in parallel. Higher levels of salt can have harmful health effects, suchas nausea, twitching muscles, and vomiting. Prolonged exposure can also lead to heart ailments. In contrast, low amounts of salt in water are also bad for your health because they make you tired and give you headaches.

The WHO sets the allowable limits for salts in drinking water at 200 mg/l. Our inquiry revealed that the salt concentration in every sample of water was higher than allowed, except sample(1,20,22,23,28,2,30) whose value are within the permissible limits i.e., below 200 mg/l. The possible reason of high salt concentration in drinking water can occur due to natural mineral deposits in the ground, leading to dissolution of salt into the water.

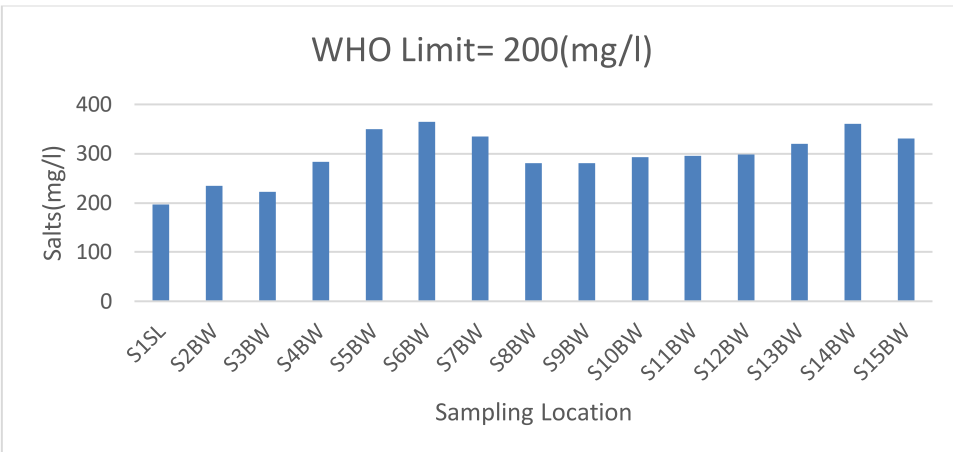

Fig 2.5 Total salts concentration in drinking water quality of different sources

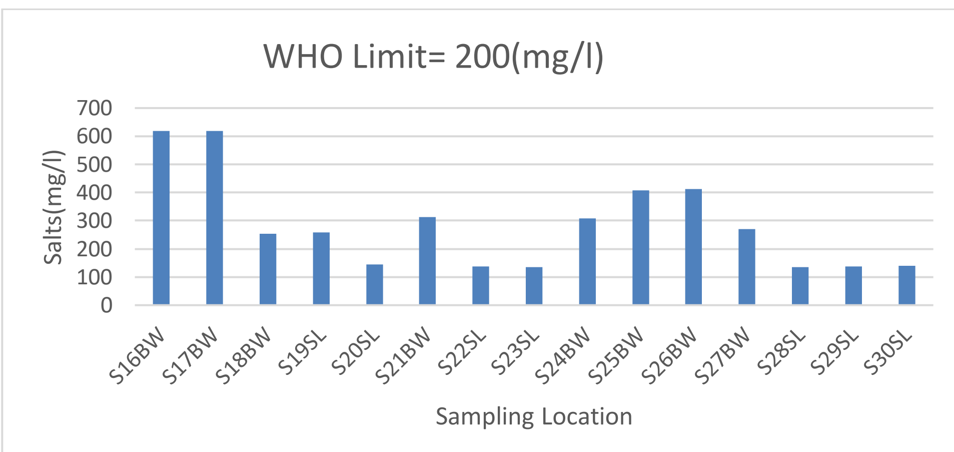

Fig 2.6 Total salts concentration in drinking water quality of different sources

3.2.3 Total Dissolved Solids (TDS)

Total dissolved solids, or TDS, is essentially the sum of all cations and anions, or positive and negative ions. The total quantity of solids dissolved in water is another way to define it. Higher TDS levels in water can be concerning because they can cause health problems like bone and tooth ailments and reproductive system affects. The salty taste of water with a higher TDS indicates that sodium chloride is present; this usually raises people's blood pressure. TDS has an allowed level of 500 mg/l specified by WHO, and the study revealed that sample(5,6,7,12,14,16,17,18,25,26) exceeded this limit while rest of them were safe for consumption. The possible reason for high TDS in improperly treated or untreated sewage.

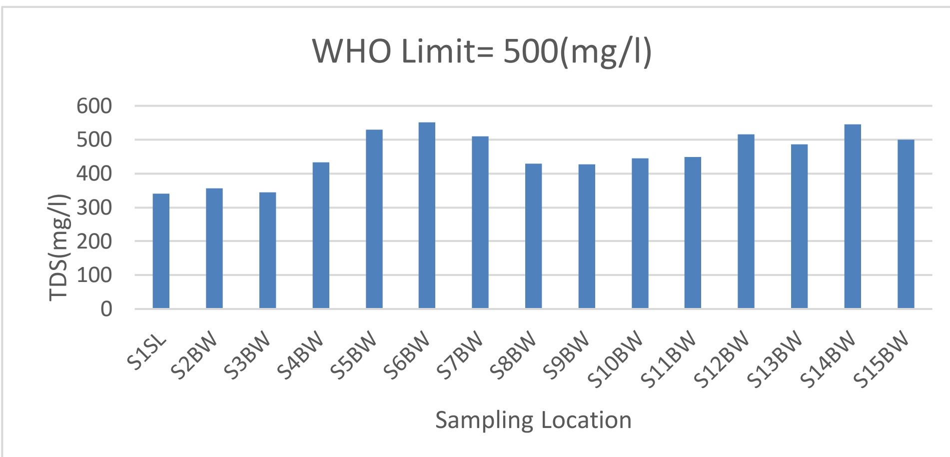

Fig 2.7 TDS concentration in drinking water quality of different sources

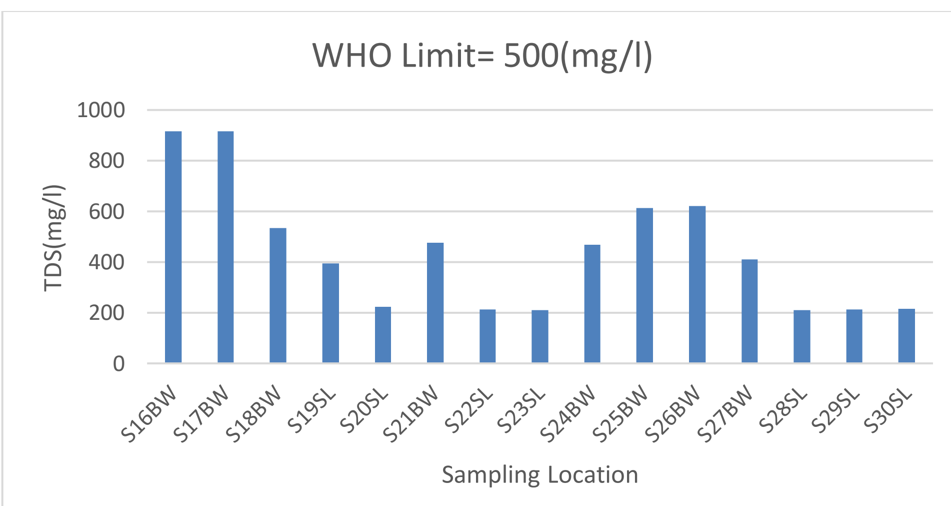

Fig 2.8 TDS concentration in drinking water quality of different sources

3.2.4 Temperature value in sample

Temperature creates ideal conditions for some chemical processes and serves as a habitat for numerous microorganisms. These microorganisms have the potential to produce waterborne illnesses that are harmful to people's health. The permissible limit defined by WHO is 25°C which shows that all the samples were within the permissible limit.

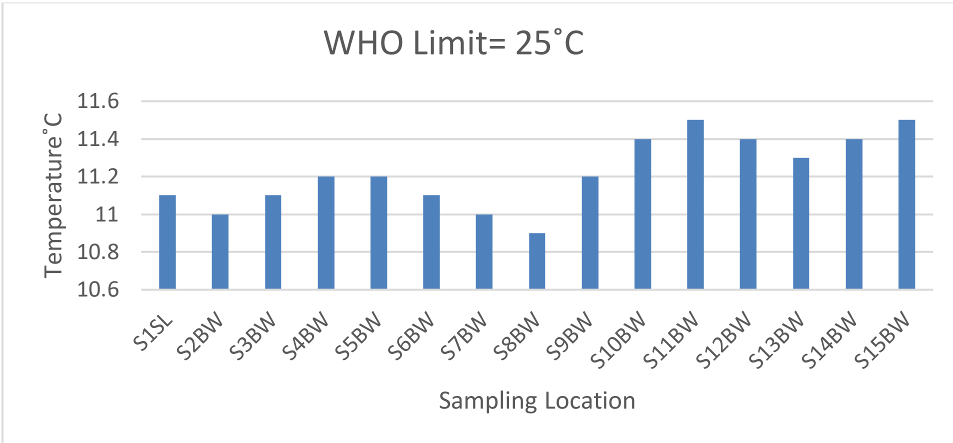

Fig 2.9 Temperature results

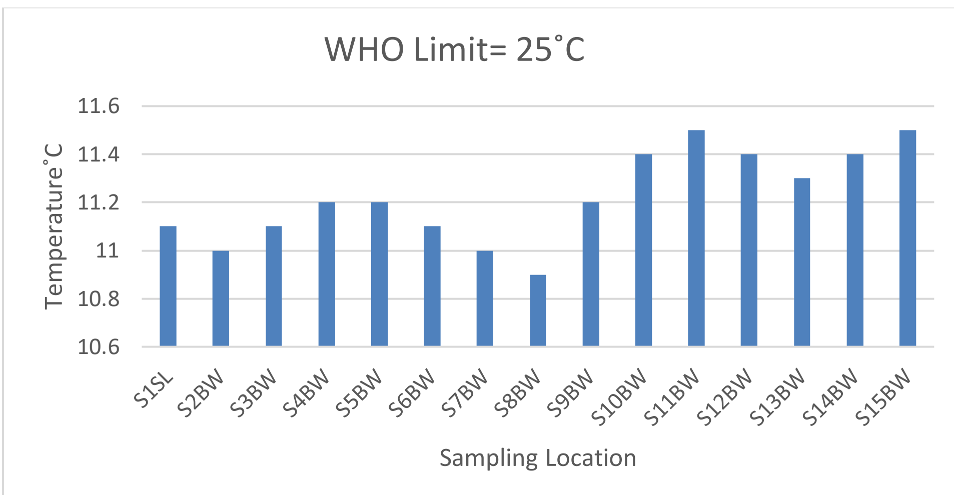

Fig 2.10 Temperature results

3.3 Chemical Parameters

Table 3.3 Chemical parameters of Phurgran Village

S.No	Cl(m/l)	Na(mg/l)	NACl (mg/l)	Hardness (m/l/)	Alkalinity (mg/l)	Nitrates (mg/l)	NAHCO3 (m/l)	NA2CO3 (mg/l)	HCO3(mg/l)	CO3(m g/l)	Arsenic (mg /l)
S1	14.2	9.1	23.3	380	166	0.021	0.00092	0.0011	0.0067	0.0007	0
S2	53.2	34.4	87.6	390	30	0.002	0.001512	0.0008	0.0005	0.0005	0
S3	21.3	13.7	35.0	410	130	0.001	0.001008	0.001	0.0007	0.0012	0
S4	60.3	38.9	99.3	460	98	0.017	0.001092	0.0014	0.0008	0.0008	0
S5	67.4	43.5	111	610	164	0.01	0.00344	0.0043	0.0025	0.0025	0
S6	31.9	20.6	52.5	340	100	0.028	0.00084	0.0011	0.0006	0.0006	0
S7	42.6	27.5	70.1	550	108	0.034	0.001176	0.0015	0.0009	0.0008	0
S8	35.5	22.9	58.4	500	114	0.016	0.001092	0.0011	0.0008	0.0008	0
S9	34.9	187.1	222	550	268	0.018	0.00126	0.0016	0.0009	0.0009	0
S10	42.6	27.5	70.1	450	122	0.004	0.00756	0.0095	0.0005	0.0005	0
S11	28.4	18.3	46.7	480	104	0.014	0.000924	0.0017	0.0007	0.0007	0
S12	39.0	25.2	64.2	620	138	0.011	0.002352	0.003	0.0017	0.0017	0
S13	42.6	27.5	70.1	650	120	0.01	0.001176	0.0015	0.0009	0.0008	0
S14	63.9	41.2	105.1	550	102	0.016	0.001344	0.0017	0.001	0.001	0
S15	49.7	32.1	81.8	610	168	0.016	0.001008	0.0013	0.0007	0.0012	0
S16	56.8	36.7	93.5	900	120	0.056	0.00126	0.0016	0.0009	0.0009	0
S17	42.6	27.5	70.1	720	112	0.097	0.00126	0.0016	0.0009	0.0009	0
S18	63.9	41.2	105.1	840	118	0.012	0.001344	0.0017	0.000976	0.001	0
S19	39.0	25.2	64.2	520	134	0.009	0.001008	0.0013	0.0007	0.0012	0
S20	63.9	41.2	105.1	380	136	0.024	0.000672	0.0008	0.0005	0.0005	0
S21	56.8	36.7	93.5	580	110	0.008	0.000756	0.001	0.0005	0.0005	0
S22	31.9	20.6	52.5	400	120	0.025	0.00084	0.0011	0.0006	0.0006	0
S23	49.7	32.1	81.8	240	80	0.03	0.000672	0.0008	0.0005	0.0005	0
S24	56.8	36.7	93.5	460	70	0.011	0.001008	0.0013	0.0007	0.0012	0
S25	85.2	55.0	140.2	300	92	0.015	0.001176	0.0015	0.0009	0.0008	0
S26	67.4	43.5	111	380	15	0.022	0.00084	0.0011	0.0006	0.0006	0
S27	53.2	34.4	87.6	520	118	0.013	0.000756	0.001	0.0005	0.0005	0
S28	24.8	16.0	40.9	450	94	0.033	0.000672	0.0008	0.0005	0.0005	0
S29	53.2	34.4	87.6	350	136	0.028	0.000672	0.0008	0.0005	0.0005	0
S30	63.9	35.4	99.3	330	84	0.044	0.001092	0.0014	0.0008	0.0008	0
Limit	**250**	**200**	**Nil**	**500**	**200**	**50**	**Nil**	**Nil**	**Nil**	**Nil**	

3.3.1 Chloride concentration in sample

Since the human body needs a certain quantity of chloride, the presence of chloride in drinking water has no detrimental effects on public health. While too much chloride can have an unpleasant, salty taste and have negative effects on the digestive system, including nausea and diarrhea.

The results showed that chloride concentration of all water samples is within the permissible limit The chloride concentration is shown in figure 2.11. Old or corroded water pipes can contribute to increased chlorine levels as the chlorine interact with materials in the pipes.

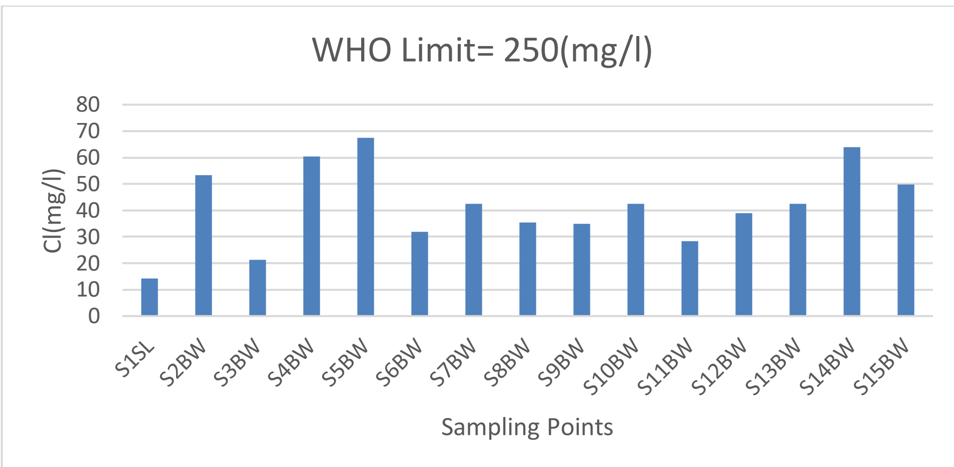

Fig 2.11 Cl concentration in drinking water quality of different sources

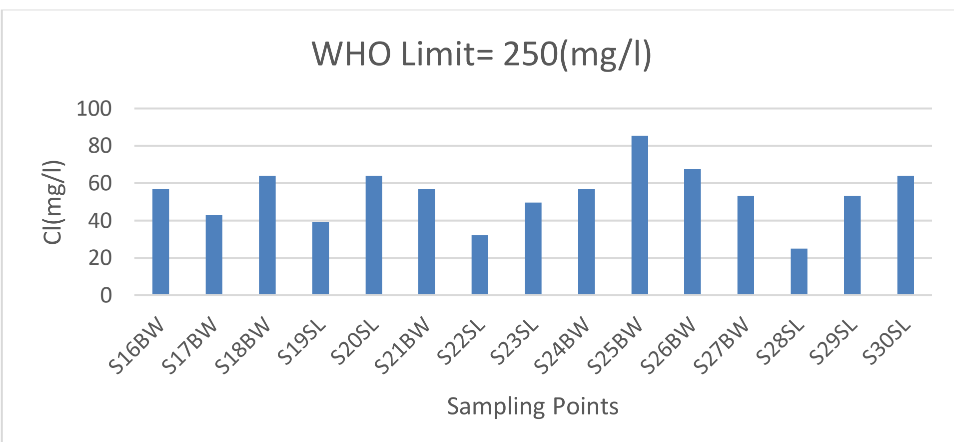

Fig 2.12 Cl concentration in drinking water quality of different sources

3.3.2 Sodium concentration in sample

The human body needs salt to function normally, but if the concentration of sodium surpasses a certain limit, it can be hazardous to human health. The human body needs sodium to function normally. However, if the sodium content is too high, it can lead to health problems like high blood pressure, strokes, and cardiovascular illnesses.

The results showed that sodium concentration of all water samples is within the permissible limit. The amount of sodium in the samples is depicted in figure 2.13. The composition of underlying rocks and soil can influence sodium content.

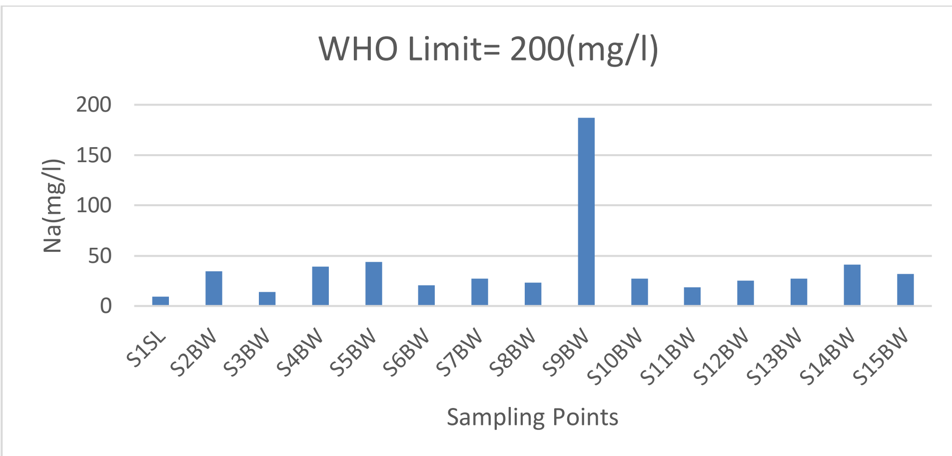

Fig 2.13 Na concentration in drinking water quality of different sources

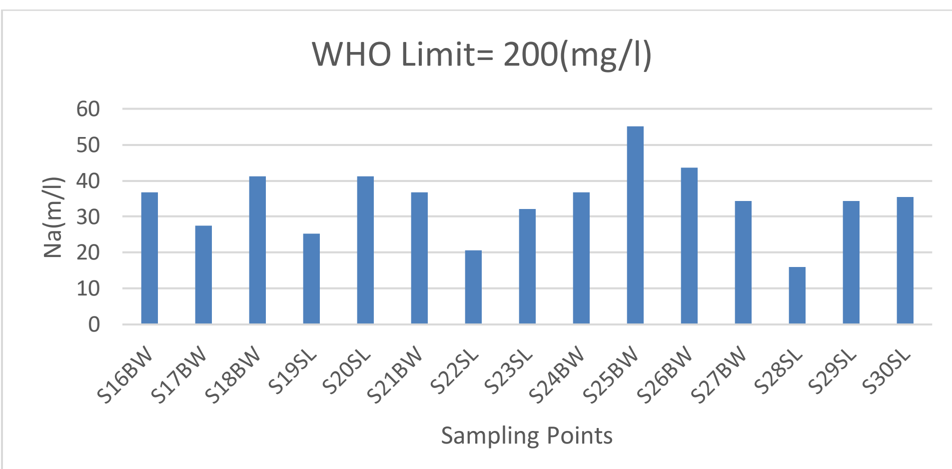

Fig 2.14 Na concentration in drinking water quality of different sources

3.2.3 NaCl Concentration in sample:

Drinking water will taste saltier at higher sodium concentrations. If a person has high blood pressure, cardiovascular illness, heart disease, kidney problems, or is required to follow a low sodium diet, then the sodium content of drinking water should be considered.

The permissible limit of NaCl is not defined by WHO. The values of NaCl are shown in figure 2.15.

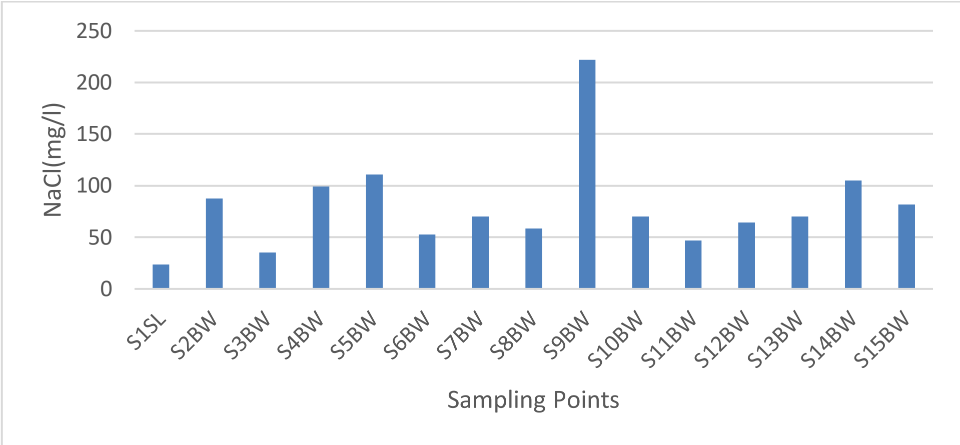

Fig 2.15 NaCl concentration in drinking water quality of different sources

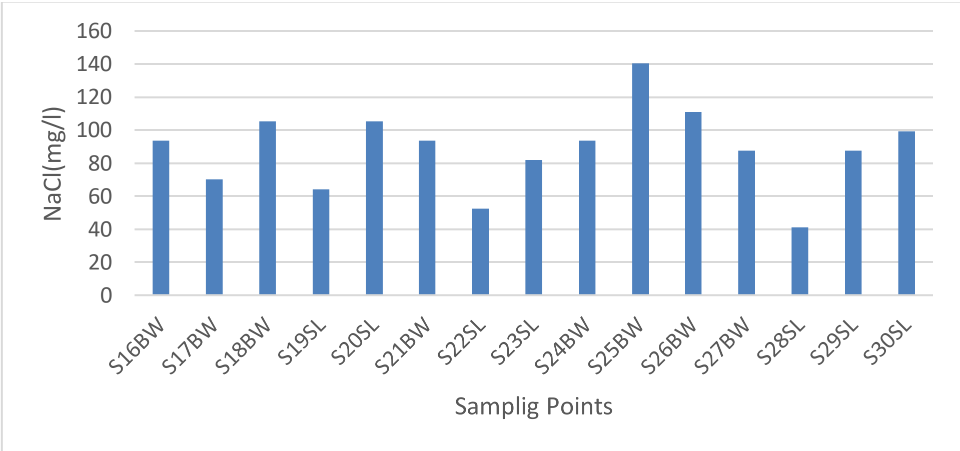

Fig 2.16 NaCl concentration in drinking water quality of different sources

3.2.4 Concentration of total hardness in sample

It has been noticed that excessive hardness might cause bloating, diarrhea, renal stones, and heart problems. Hardness may also have other negative consequences on human health, such as causing dry skin and hair.

The results showed that the hardness concentration of the sample(5,9,12,13,14,15,16,17,18,19,21,27) is beyond the permissible limit. Whereas, the hardness concentration in remaining samples is within the permissible limit. The result of total hardness concentration is shownin figure 2.17. High level of minerals like calcium and magnesium in water can contribute to hardness.

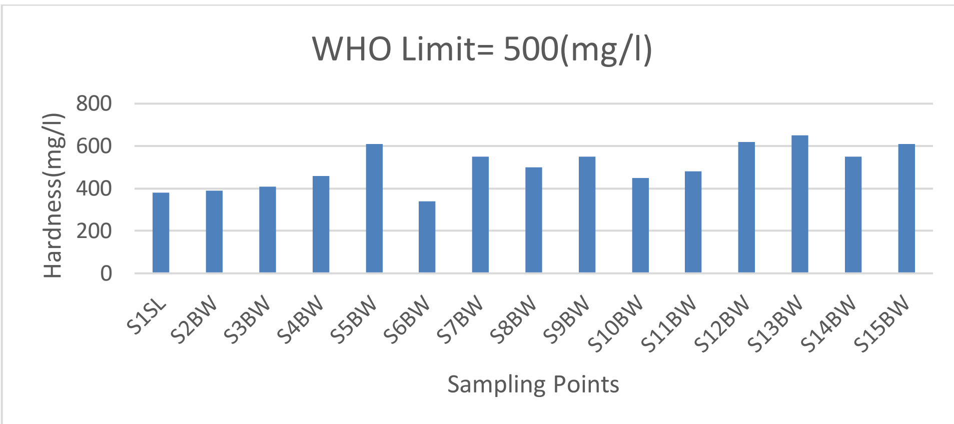

Fig 2.17 Total hardness concentration in drinking water quality of different sources

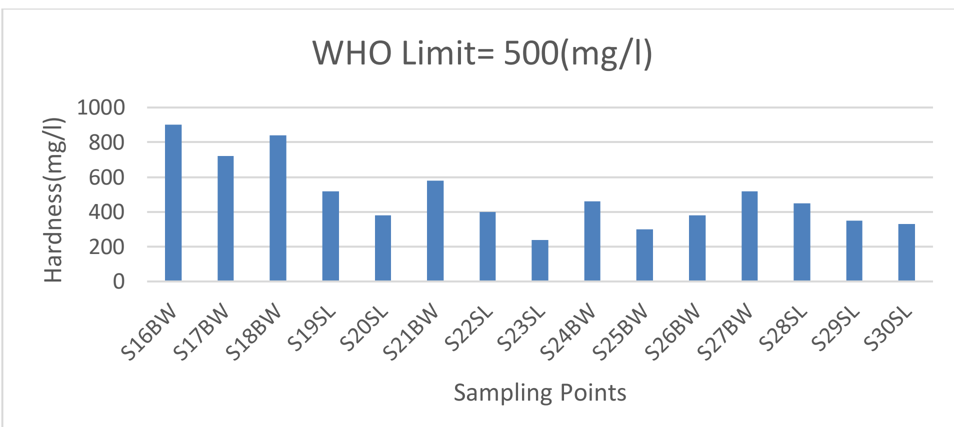

Fig 2.18 Total hardness concentration in drinking water quality of different sources

3.2.5 Concentration of alkalinity in sample

Alkalinity is a water's capacity to balance acid and base in order to preserve a comparatively stable pH. Unless you have kidney disease, drinking alkaline water has no serious health hazards.

The results showed that alkalinity concentration in all the samples is within the permissible limit except one sample(9) Figure 2.19 shows the level of alkalinity in samples.

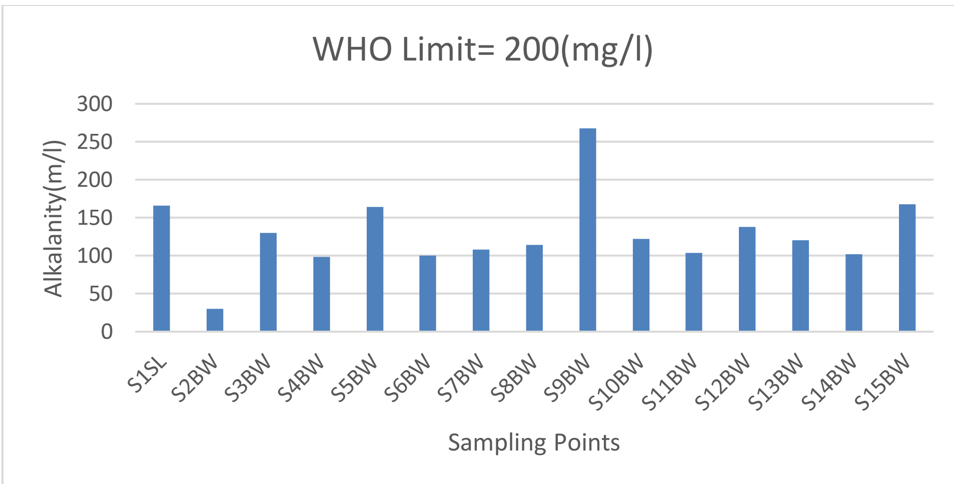

Fig 2.19 Alkalinity concentration in drinking water quality of different sources

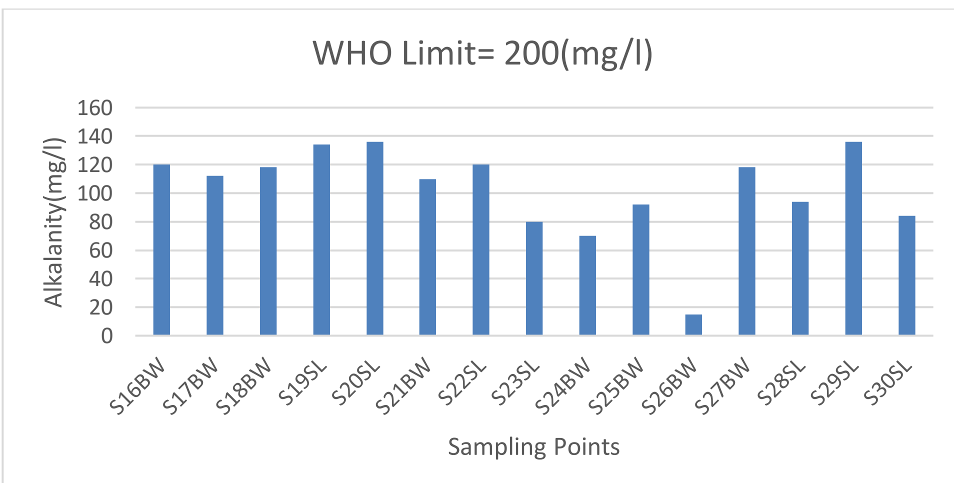

Fig 2.20 Alkalinity concentration in drinking water quality of different sources

3.2.6 Concentration of nitrates in sample

Nitrate is major nutrient needed by living organisms for their physiological processes if their concentration is more by limit they are considered as pollutant.

The results showed that nitrates concentration in all the samples is within the permissible limit. Figure 2.21 shows the level of nitrates in samples. Certain geological formations and microbial activity can naturally release nitrates into ground water, affecting drinking water quality.

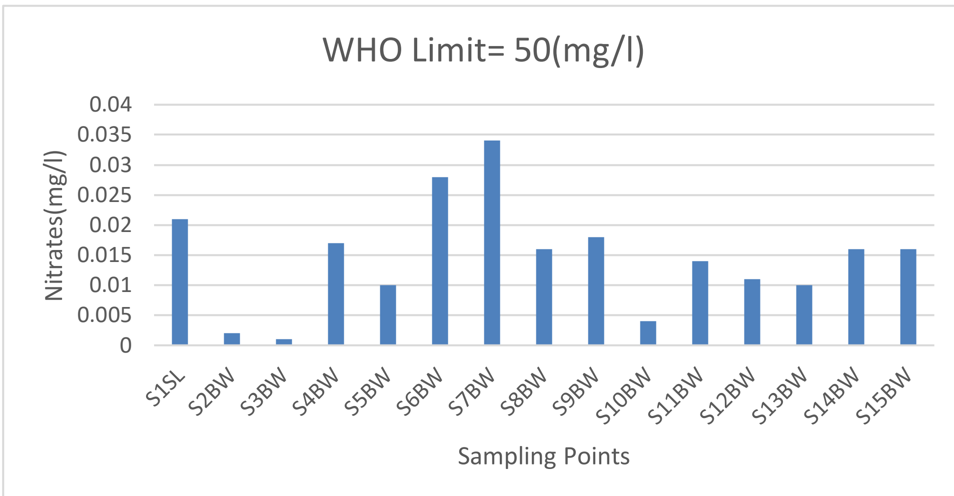

Fig 2.21 Nitrates concentration in drinking water quality of different sources

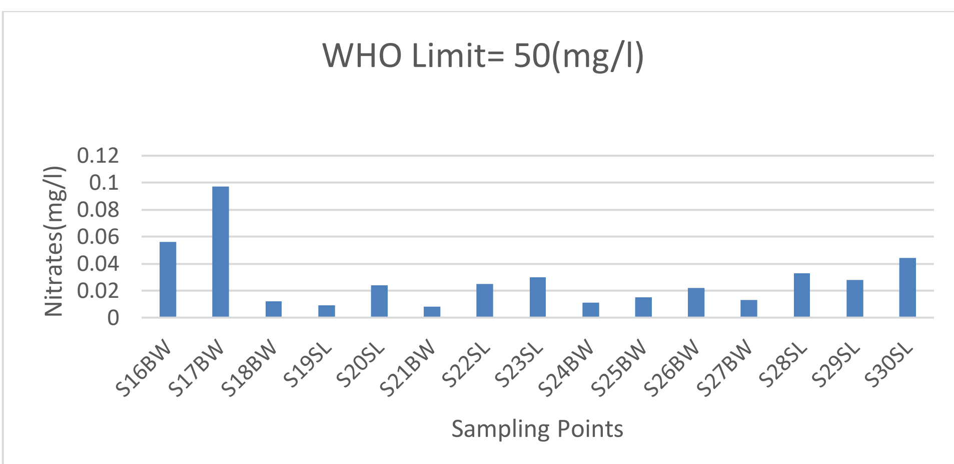

Fig 2.22 Nitrates concentration in drinking water quality of different sources

Carbonates in water comes from the percolation of water through deposits of limestone, chalk and gypsum which are made up of calcium and magnesium carbonates, bicarbonates and sulphades.

The limit of carbonates is not defined by WHO. The results are shown in fig 2.23

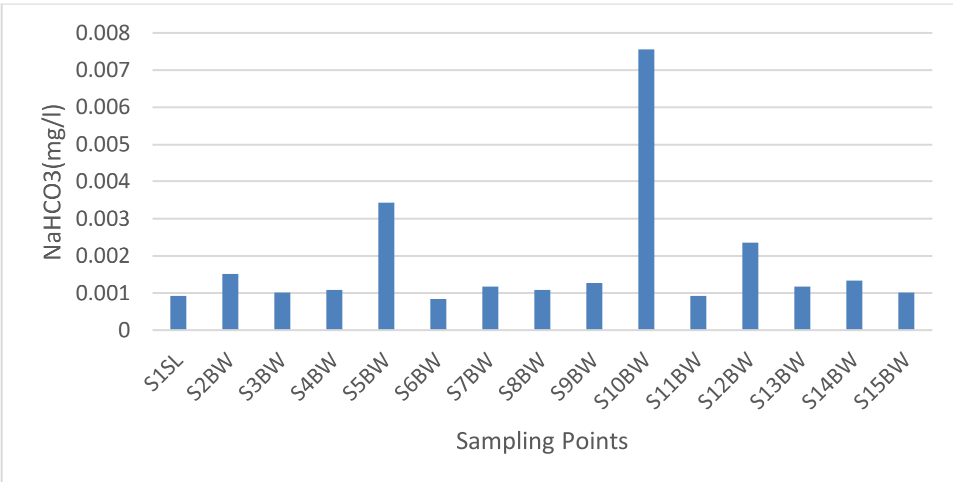

Fig 2.23 NaHCO3 concentration in drinking water quality of different sources

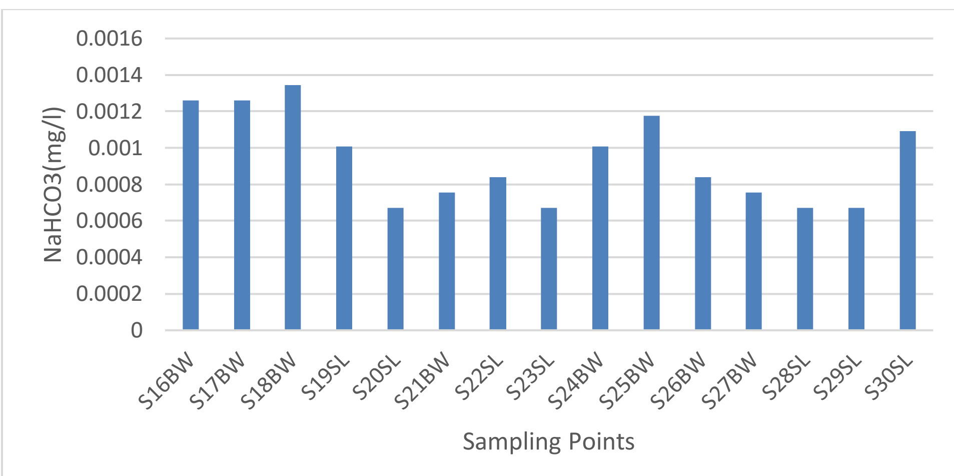

Fig 2.24 NaHCO3 concentration in drinking water quality of different sources

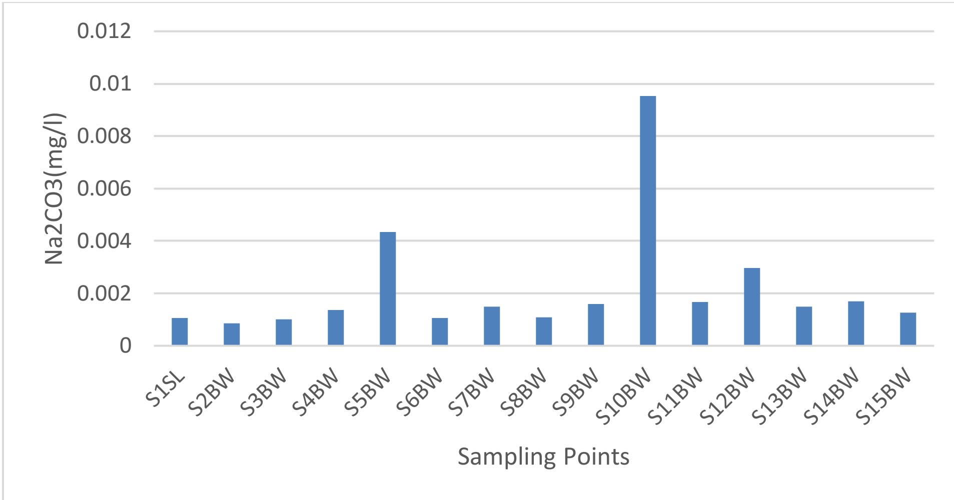

Fig 2.25 Na2CO3 concentration in drinking water quality of different sources

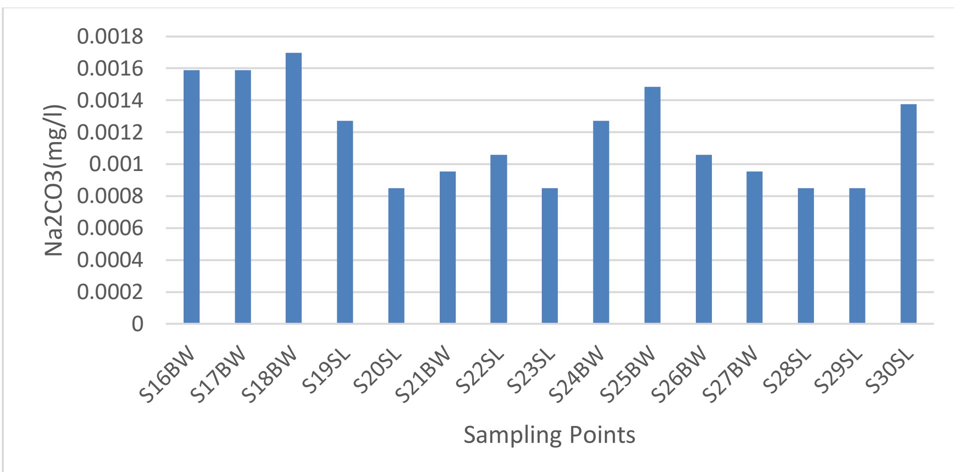

Fig 2.26 Na2CO3 concentration in drinking water quality of different sources

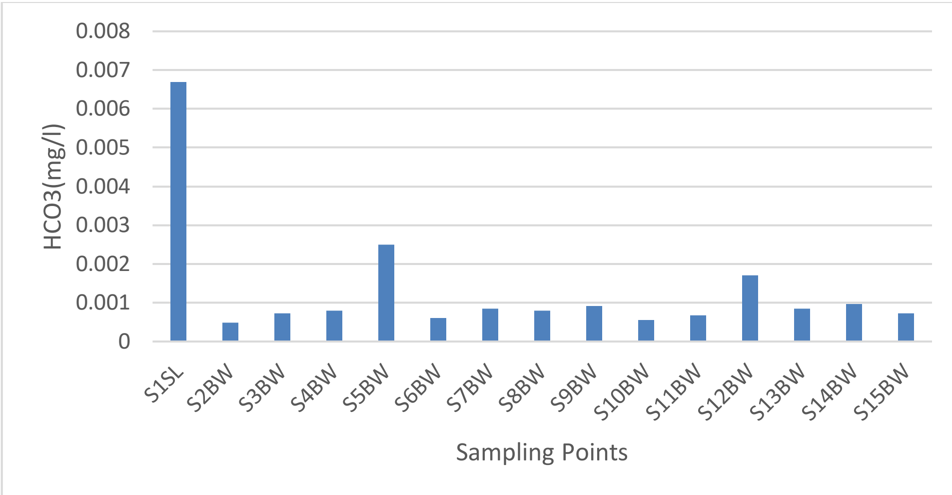

Fig 2.27 HCO3 concentration in drinking water quality of different sources

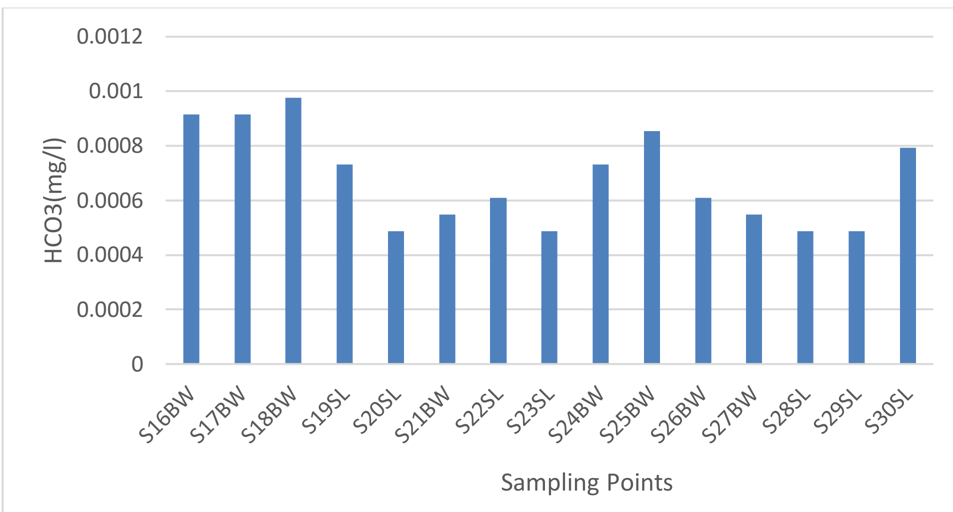

Fig 2.28 HCO3 concentration in drinking water quality of different sources

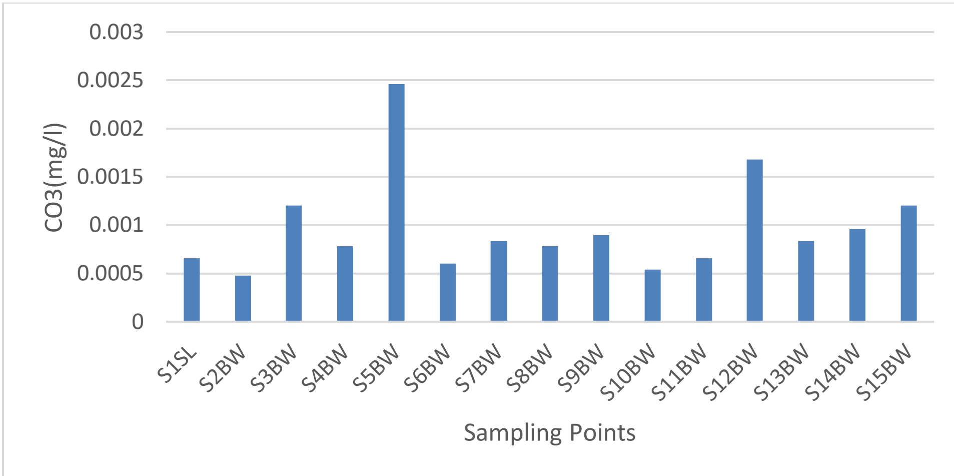

Fig 2.29 CO3 concentration in drinking water quality of different sources

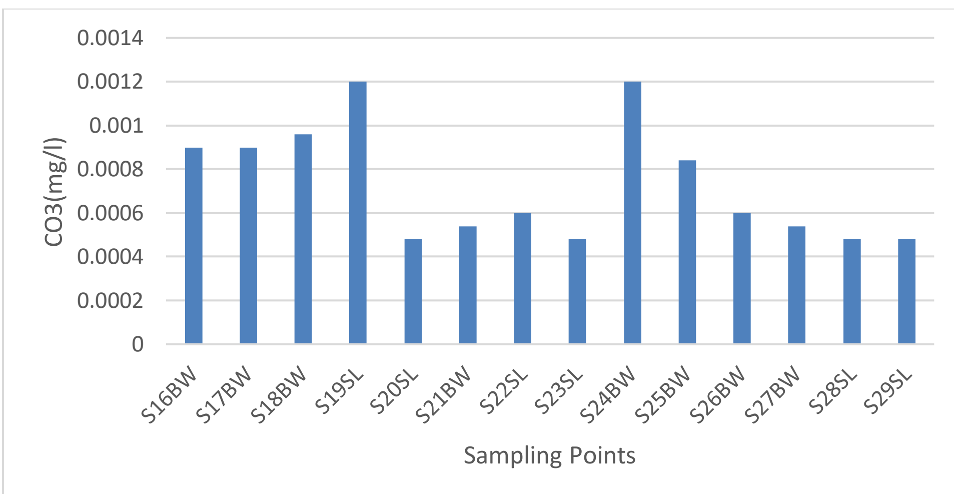

Fig 2.30 CO3 concentration in drinking water quality of different sources

3.3 Result of biological parameters

Tests were carried out and noted the results in a lab for *Total bacteria*, *Total coliform* and *Salmonella Shigella* which are displayed in the table 3.4

Table 3.4 Results of biological parameters of Phurgian Village

S.NO	Total Bacteria (cfu/ml)	Total Coliform (cfu/ml)	Salmonella Shigella (cfu/ml)
S1	0	1	100
S2	525	46	3
S3	54	55	0
S4	1	0	5
S5	165	0	7
S6	11	30	0
S7	105	0	0
S8	1	0	1
S9	10	5	5
S10	150	0	0
S11	230	6	0
S12	170	0	0
S13	1	0	0
S14	0	0	0
S15	1	0	0
S16	1	0	25
S17	0	0	0
S18	2	0	35
S19	0	0	0
S20	0	0	0
S21	0	0	0
S22	0	0	0
S23	10	4	0
S24	66	4	18
S25	80	35	55
S26	130	105	4
S27	20	8	0
S28	0	0	0
S29	0	0	0
S30	15	3	6
Limit	**100**	**<1**	**<1**

3.3.1 Result of Total Coliform

The results showed that, in sample (1,2,3,6,9,11,23,24,25,26,27,30) there is significant growth. The growth of coliforms in drinking water is showed by MacConkey agar. Elderly patients who develop community- acquired pneumonia may also develop ventilator-associated pneumonia, both of which are caused by *Enterobacteriaceae.* Poorly maintained sewage systems may allow c*oliform* bacteria to seep into groundwater, impacting the quality of drinking water.

3.3.2 Result of Total Bacteria

The results of NA showed that, in most of the water samples total bacteria growth were higher and, in few samples, exceeds the limit. Some variations are present in total bacteria in all sample which is shown. The total bacterial load in drinking water is determined by nutrient agar. The permissible limit of total bacteria is 100. If total bacteria exceed the limits, it has negative effect on human health.

In samples (2,5,7,10,11,12,26) bacteria were beyond the permissible limits. Improper disposal of waste, sewage overflows can introduce bacteria in drinking water.

3.3.3 Result of Salmonella Shigella

The results showed that, in sample (1,2,4,5,8,9,16,18,24,25,26,30) there is significant growth. The growth of coliforms in drinking water is showed by *Salmonella Shigella* agar.

Poorly maintained sewage systems may allow c*oliform* bacteria to seep into groundwater, impacting the quality of drinking water.

CONCLUSION

1. Drinking Water samples were collected from different bores and supply water in Phulgran village of Islamabad. Total 30 samples were collected and tested in the Environmental lab of Bahria University, for different parameters which include physicochemical and biological parameter. Then, compared the results with WHO guidelines.
2. The pH and temperature were within the WHO guidelines whereas, few samples of TDS, EC and salts was above the limit.
3. The chemical parameters showed chloride, sodium, sodium chloride, alkalinity and nitrates were within the limits and few samples of total hardness, were above WHO permissible limit.
4. The results of microbial analysis showed the presence of bacteria except for few samples.
5. The results of heavy metals analysis showed the absence of Arsenic metal in samples.

RECOMMENDATIONS

Some recommendations are drawn below on the basis of results of all parameters.

1. The small water filter should be installed in each home where there are bores.
2. Government should take initiative to install water filtration and supply plants to provide treated water.
3. Water source should be placed away from the garbage site area as it becomes the source of biological contamination.
4. Drinking water quality should be assessed regularly.
5. Management of bores, and water supply should provide hygienic conditions to all the nearby villages by providing quality of drinking water.

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