DETERMINATION OF PHYSICOCHEMICAL AND BIOLOGICAL PARAMETERS OF DRINKING WATER OF H-11 SECTOR OF ISLAMABAD

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A thesis submitted to Bahria University, Islamabad in partial fulfillment of the requirement of the degree of BS in Environmental sciences

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Abstract

This thesis was carried out in December 2021 to January 2022 to know about the water quality of H-11 sector of Islamabad, Pakistan keeping in view the standards set by WHO. Twenty (20) samples were collected from different educational and government institutes, slums, mosque, graveyard and public place to determine the drinking water quality. Standard protocol was followed to collect the water samples. Physical, chemical and biological parameters were assessed of all samples. Physical parameters including electrical conductivity, total dissolved solids, turbidity, salts and temperature at all locations Headstart school both front and rear side, Beaconhouse International College, FAST, Al-Huda International, National Institute of Fire Technology, Punjab College, Islamabad Science School and College, EMS high school, The Millennium University College, PSO H-11/1, Anti-Narcotics force academy, National Police academy, Slums H-11/2, graveyard, PAEC general hospital, Ibne-Sina Institute of Technology, slums H-11/4, mosque H-11/4 and Bahria University H-11/4 were within the permissible limit except of pH of samples collected from locations at Punjab College, Islamabad Science School and College, EMS high school, The Millennium University College, PSO H-11/1, Anti-Narcotics force academy, National Police academy, Slums H-11/2, graveyard, PAEC general hospital, Ibne-Sina Institute of Technology, slums H-11/4, mosque H-11/4 and Bahria University H-11/4 were not in the permissible limit. While the pH of all other samples collected from Headstart school both front and rear side, Beaconhouse International College, FAST, Al-Huda International, National Institute of Fire Technology were in the permissible limit. Considering chemical parameters carbonates, hardness, calcium, magnesium and alkalinity of all samples at locations Headstart school both front and rear side, Beaconhouse International College, FAST, Al-Huda International, National Institute of Fire Technology, Punjab College, Islamabad Science School and College, EMS high school, The Millennium University College, PSO H-11/1, Anti-Narcotics force academy, National Police academy, Slums H-11/2, graveyard, PAEC general hospital, Ibne-Sina Institute of Technology, slums H-11/4, mosque H-11/4 and Bahria University H-11/4 were within the permissible limit except of chloride collected from Headstart school (front side), Beaconhouse International College, EMS high school and Anti-Narcotics force academy and sodium from, EMS high school and Anti-Narcotics force academy respectively. No E.coli and coliform bacteria was detected in any sample. Only 1 sample taken from National Institute of Fire technology shows the growth of salmonella and shigella. All other samples were free of salmonella and shigella. Total bacteria in water samples from slums in H-11/4, H-11/2, Anti-Narcotics force academy, PSO petrol pump in H-11/1, Islamabad science school and college, National institute of fire technology, FAST and Beaconhouse international college were greater than permissible limit. All other samples have total bacteria within limit. Water samples from Al-Huda international and Headstart school sample from rear side are completely safe. All parameters including physical, chemical and biological of these areas are within the limit.

Abbreviations

WHO World Health Organization

IMF International Monetary Fund

PCRWR Pakistan Council of Research in Water Resources

CDA Capital Development Authority

APEC Asia-Pacific Economic Cooperation

IUCN International Union for Conservation of Nature

PCBs Polychlorinated biphenyls

PAHs Poly-aromatic hydrocarbons

TDS Total dissolved solids

TSS Total suspended solids

EC Electrical conductivity

BOD Biological oxygen demand

COD Chemical oxygen demand

DO Dissolved oxygen

As Arsenic

Cr Chromium

Cd Cadmium

Mo Molybdenum

Mn Manganese

Mg Magnesium

Zn Zinc

Ni Nickel

Fe Iron

Hg Mercury

Pb Lead

K Potassium

CDI Chronic daily intake

HQ Hazard quotient

ANOVA Analysis of Variance

CA Correspondence analysis

PCA Principal Component Analysis

APHA American Public Health Association

HIE Hattar Industrial State

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Chapter 1

Introduction

Water is the key to survival of all living things. From plants to animals to microbes, water is an essential part of their existence. Water is an extremely important element for life. Without water no life can exist. Availability of safe water is basic right of mankind. In humans, 60% of the body is made of water. On the organ level, brain is 95% water, Bones are 31% water and muscles are 79% with skin being 64% water. On the physiological level, water plays role in enzymatic activity, prevention of diseases and homeostasis. It helps flushing out toxins from the body, so it prevents organs and tissues diseases such as cancers. On the global level, major proportion of earth surface is covered by water. 1.4 trillion cubic meters of water is present on earth Water covers 71% of earth surface. But the whole amount of water that is present on earth surface is not suitable for drinking purposes. (Bilal and Rahman, 2013). Water covers 71% of earth surface. Out of that 97% is salty water. It is present in oceans and seas. It is not suitable for drinking, agricultural and industrial activities apart from cooling. Fresh water that is suitable for drinking purposes and other life activities is present in small amount on earth surface. It is only 3%. That whole fresh water is not available to continue life. From that 3%, 68.7% fresh water is present in icecaps and glaciers, 30.1% in groundwater, 0.3% as surface water and 0.9%in other sources. The liquid form of water that is present as surface water is further divided into different sources. 87% is found in lakes, 11% in swamps and 2% in rivers (Shahzad et al., 2020; Farid et al., 2012).

Availability of safe drinking water is now a major concern. Water sources have become polluted due to various natural factors but mostly by anthropogenic activities. Entry of large number of pollutants in fresh water sources have put great stress on fresh water sources. When drinking water quality deviates from physical, chemical and biological standards, it can cause adverse health effects. People suffer from various diseases due to drinking, contact with and pathogens growing in contaminated water. Common diseases caused by contaminated water are polio, diarrhea, cholera, dysentery, hepatitis A and typhoid. The major reason of water pollution is over-population, lack of sanitation and proper sewage and municipal facilities. Over-population, urbanization and industrialization at a great pace is not only putting great stress on freshwater resource but is also deteriorating freshwater quality (WHO). Combination of heavy metals, chemicals and different contaminants in freshwater resource due to various anthropogenic activities have deteriorated water quality and cause various health problem. Stress on drinking water resource have been increased since 1990s due to over-population, urbanization and industrialization at a great pace without any preventive and protective measures (Khan et al., 2013).

Availability of safe water in whole world is now becoming a major concern. It is due to unsustainable use of fresh water, population bomb and urbanization at a great pace, resource that is already present in minute quantity. Especially in developing countries due to excessive and unplanned industrialization and urbanization is causing this problem. This problem is magnified

due to financial, political constraints, lack of management and professionals. Countries of Africa, Asia and Middle East will face water shortage in coming 2 decades (Azizullah et al., 2011).

Unfortunately, Pakistan is among the water stressed countries. Availability of water in Pakistan is 1200 m^3 per capita. This available water is further deteriorating. 4 million acres feet waste is being produced in Pakistan which is contaminating the freshwater resource. Majority of population in Pakistan relies on groundwater resource. Water is being contaminated due to improper disposal of waste, improperly treated waste and faulty distribution system (Mohsin et al., 2013). According to International Monetary Fund (IMF) Pakistan is ranked third among the countries facing severe water shortage. Pakistan Council of Research in Water Sources (PCRWR) predicted there will be no clean water available in Pakistan by 2025. It is said water will be a luxury in future because water quality and quantity deterioration. Clean and safe drinking water will be in shortage in upcoming years due to pollution, long drought, less precipitation, more evaporation, lack of proper management and not enough reservoirs for storing water. Wastage of water, entry of polluted and untreated wastewater, industrial and agricultural run-off is deteriorating quality as well as quantity of fresh water. This not only reduces the quantity of potable water but also cause various health effects and diseases like diarrhea, polio, teeth problems, dysentery, typhoid, cancer and hepatitis. Annually many people and infants die to due contaminated water. WHO estimated nearly 2 million deaths due to waterborne diseases and majority of children. After every 8 second a child dies in developing country due to water-borne disease. 40% people in urban area die due to consumption of contaminated water in Pakistan. Now only 20% of population in Pakistan has access to safe drinking water. Unfortunately remaining 80% of population drinks water that is contaminated with fecal contamination, fertilizer, pesticides, and industrial effluents(Nabi et al., 2019; Perveen et al., 2007). It is estimated about one-third deaths and 80% diseases are caused by use of contaminated water in developing countries like Pakistan (Perveen et al., 2007).

1.1 Importance of potable water

Every water is not potable water. Water that is free from colour, objectionable taste, odour, turbidity, organic and inorganic substances and disease-causing pathogens is considered as potable water. Water that matches with the standards of drinking water made by WHO is regarded as potable water. Water whose physical, chemical, biological, and radiological characteristics does not have adverse effects on health is considered as potable water (Perveen et al., 2007).

Water is a very important commodity. Water is extremely important for human beings. It is an essential component of life. Without it no human being can survive. Without it human can die of dehydration in only 3 days. Human requires 2 liters of water every day (Perveen et al., 2007). But on other hand humans can survive without food for a week. Water plays an important role in metabolism, blood circulation and other life activities. The major component in human body is water. Water makes two-third of human body weight. Water is also responsible for the prevention of diseases (APEC, 2006). So safe drinkable water is essential for every person. Other

than water used for drinking purposes water is essential for other purposes as well, which are extremely important for human life such as agriculture, energy and irrigation purposes. Without water crops and plants cannot grow resulting in food shortage. Water is necessary as for maintaining aquatic and terrestrial ecosystems along with their biodiversity (Pimentel et al., 1997)

1.2 Use of water

Mostly water is considered necessary for drinking purposes and maintaining homeostasis inside the body. But other than its function in human body and body of other organisms it has other functions as well. It is used in several agricultural activities. It is used in irrigation, making land suitable for growing and sowing crops and for cattle and poultry. Water plays a very important role in industrial activities as well. It is used for various reactions, as a raw material as well as for cooling purposes. In medical field water is used for different medical procedures like dental procedures and dialysis (Mayer et al., 1999).

Water acts as a medium for various organisms. It provides habitat to large number of organisms. Other than that, it plays a vital role in maintaining terrestrial and aquatic ecosystem. It is necessary for soil dwelling organisms as well. Both single and multicellular organisms residing in soil are highly dependent upon water for their food, respiration and other activities (Liu et al., 2009).

Water plays its role in climate regulation as well. Water vapour acts as greenhouse gas maintaining the required temperature of earth. It is the gas in largest proportion found in atmosphere. That's why it plays the most important role in regulation and maintenance of climate and temperature. Moreover, it transfers heat from region having high temperature to regions having low temperature. In this way heat is distributed evenly (Loch et al., 2013).

These are the brief uses of water. We normally considered water necessary for drinking purposes, but it plays a very important role not only in lives of every organism but also in ecosystem and climate.

1.3 Condition of drinking water of Islamabad

As our study area is Islamabad, we need to know the sources of water used for drinking purposes, distribution system and source of contamination. The main source of fresh water in Islamabad is Simly dam and Khanpur dam. Other sources are tube wells, underground water and service reservoirs. Water is distributed through a system and mechanism developed and maintained by CDA including pipelines, filter plants and tanker systems (CDA).

Different tests performed by PCRWR and study was conducted for assessing the water quality gave the results that 75% of water available in Islamabad is not suitable for drinking purposes. Poor water quality is due to release of contaminants directly into water bodies, exploitation of groundwater resource and release of agricultural effluents (Shabbir and Ahmad, 2015). For ensuring good quality water CDA had developed filtration plants to treat as well as to add

necessary supplements to ensure standard drinking quality water. They add required amount of fluorine and chlorine in water to make it suitable for drinking purposes. This has helped to reduce various water-borne diseases, but if these filtration plants are not managed properly, then may be source of decreasing water quality (IUCN,2015).

1.4 Sources of drinking water pollution

Drinking water is obtained from underground water resource or any other water reservoir that is suitable for drinking purposes. Pollution of drinking water can be natural or anthropogenic, but in today's world condition drinking water pollution is mostly caused by anthropogenic activities. Over-population and deterioration of water resources is the main cause of water pollution. Both point and non-point sources are cause of water pollution. Pollutants are present in water in both suspended and dissolved form.

The natural sources of water pollution are weathering and erosion of rocks. When water passes through rocks, mountains and regions having high concentration of inorganic sediments or heavy metals their concentration increases in water, making it unsuitable for drinking purposes.

But the anthropogenic factors are causing deterioration at a major scale. Urbanization and industrialization had taken place at a great pace, but at the same time it had deteriorated the environment. Fresh drinking water has been polluted at a large scale by developmental activities (Farid et al., 2012). One of the sources which cause water pollution is release of industrial effluents directly or with little treatment in water bodies. Effluents are in from of liquid, semi-liquid and solid form. They include heavy metals, pesticides, polychlorinated biphenyls(PCBs), dioxins, poly-aromatic hydrocarbons (PAHs), petrochemicals, phenolic compounds, oil, greases, acids, colouring agents, biodegradable and non-biodegradable compounds and microorganisms. This activity makes this water unsuitable for drinking purposes and dangerous for the organisms living there. Some of the contaminants present in industrial discharge are carcinogenic like copper, sulphur and zinc salts released from dyeing industry. These effluents change the water quality by altering its properties. Value of TDS, TSS, EC, hardness, nitrates, carbonates, BOD, COD and bicarbonates increase causing deviation from the standards of drinking water quality (Owa, 2013).

Sewage is also deteriorating water quality on a big scale. Due to over-population, improper sewage disposal and mismanagement, large quantity of sewage, municipal waste and waste water is added in water bodies. When untreated and little treated sewage is added in water bodies it increases the concentration of disease causing pathogens. The same scenario happens with animal waste from farms and other settlements flows through surface run-off or is dumped into nearby water body which is used as a source of drinking water as well. Along with it due to increase in organic compounds present in water dissolved oxygen (DO) decreases because of increase in biological oxygen demand(BOD). It kills fish and other organisms in water due to decline in oxygen. This factor is also responsible for eutrophication. It affects the appearance, aesthetics, is source of odour and make water unsuitable for drinking purposes (State, 2011; Owa, 2013).

Pesticides, fertilizers, herbicides and other chemicals used in agricultural sector is also a main cause of water pollution. When they are applied on fields, they are washed from there due to rain and surface run-off. These chemicals increase the concentration of inorganic substances in water bodies making it unsuitable for drinking purposes as well as it causes damage to aquatic environment. Concentration of phosphorous and nitrate is increased which can lead to eutrophication as well. Eutrophication make the aquatic environment unsuitable for habitat as well (Owa, 2013).

Mining is also responsible for water pollution. Mining highly pollutes the water. This practice deteriorates both surface water catchment area and underground water resource. The major problem is caused by acid mine drainage. It changes the pH level of water, increases salinity, change the ions concentration in water and increase the concentration of heavy metals. The sulphur content present in coal produces sulphuric acid which leaches the heavy metal present nearby and adds sulphuric acid and heavy metals in water. Mostly nickel, zinc and manganese concentration are increased by acid mine drainage in water (Wright et al., 2018).

Heavy metals are present in water naturally. They are required by human body, but the excessive concentration in body through water and food lead to several problems. In today's condition heavy metals concentration have been increased due to human activities. Naturally they are present in water by weathering and erosion of rocks. When water passes through a passage that have sediments and rocks made up of heavy metals, heavy metals concentration increases in water. Atmospheric deposition also plays its role in heavy metals deposition in water reservoirs. But the human activities have magnified the concentrations. Mining, smelters, leakage of contaminated water from heavily polluted area, industrial discharges and effluents released in water reservoirs contaminate the water with heavy metals (Kavcar et al., 2009).

1.5 Types of contamination in water

1.5.1 pH

pH does not have a direct effect on health. But it has some indirect effects. When the pH water varies it provides habitat and suitable condition to pathogens to grow and changes parameters of water like metal ion solubility. High level of pH gives water a bitter taste. It is also an indicator of water pollution level.

1.5.2 Electrical conductivity (EC)

It represents the concentration of dissolved inorganic substances and ionized species present in water. Higher value of EC shows higher concentration of substances dissolved in water. Higher level of EC shows water is contaminated. Example is high level of nitrate shows high value of EC, which is dangerous. High level of nitrate is extremely dangerous especially to young ones. It causes blue baby syndrome among toddlers.

1.5.3 Total Dissolved solids (TDS)

TDS stands for total dissolved solids. It represents the level of organic or inorganic materials,

minerals and ions dissolved in water like sodium, potassium, calcium, magnesium, manganese, iron, cobalt etc. Certain level of ions is required in water. But the high concentration beyond the permissible limit is dangerous. It causes various problems. Water with high level of TDS have bitter taste. High concentration of some substances like copper can lead to adverse health problems (Muhammad et al., 2011).

1.5.4 Temperature

Temperature is involved in making thermocline in reservoir. High temperature is not suitable for sustaining a good environment for aquatic organisms. Moreover, high temperature causes decline in the level of dissolved oxygen. High temperature causes decline in standard level of oxygen in water which is 5mg/l. High temperature influences turbidity as well. High temperature causes sedimentation near thermocline.

1.5.5 Dissolved Oxygen (DO)

Dissolved oxygen is an important parameter for assessing the water quality. Dissolved oxygen is required by aquatic organisms to live in water. It is produced as a by-product of photosynthesis. Low temperature water holds more oxygen in it than high temperature water. When level of dissolved oxygen drop down extremely aquatic organisms cannot survive. Salinity is involved in determining dissolved oxygen level in water. More saline water holds less amount of dissolved oxygen. Excessive growth of algae and bacteria is also involved in declining the level of oxygen in water body. Level of dissolved oxygen in water is an indicator of water quality.

1.5.6 Total Suspended Solids (TSS)

TSS stands for total suspended solids. It involves the particles that are larger than 2 microns in water. Particles whose size is smaller than 2 microns is involved in the category of total dissolved solids. It is the amount of particulate matter present in the water sample. It refers to the turbidity. TSS involves the inorganic salts, silt, gravel, sand or clay. Decomposing parts of plants and animals are also involved in this category. It affects the aesthetics. Over the time heavier particles settle down like gravel and silt. This is also an indicator of water quality. As more TSS makes the clear water turbid. So clear water is considered more healthy than turbid water. Excessive suspended solids present in water are concern to human health as well (Elçi, 2008).

1.5.7 Microbial contamination

For checking the microbial content in water fecal coliform bacteria is analyzed. Every 100 ml sample of water should be free from fecal coliform. Presence of fecal coliform bacteria indicates sewage contamination in water. In this E.coli is observed. Water used for drinking purposes should be free from E.coli, otherwise it can cause adverse health effects. Other bacteria like salmonella, shigella, camphylobacter and giardia also pose threat on human health when are taken inside body through ingestion (Azizullah et al., 2011).

1.5.8 Heavy metals

Heavy metals are present in water in small quantities. These are trace metals and are required by human for normal growth and functioning. But the excessive amount is extremely dangerous. When the concentration of heavy metals exceeds the normal limit set by WHO or any other organization of environment and health, it is dangerous. Heavy metals are present naturally as well as by human activities. They are the part of earth crust, rocks and sediment. When water passes through it heavy metals become part of water by the process of erosion and weathering. Human activities like mining, industrial discharge, refineries, metallurgy and municipal effluents contaminates water with heavy metals. Corrosion of plumping system and pipes in homes is also cause of deterioration of water by heavy metals. Heavy metals can also be accumulated in stagnant water if water remains stagnant for a long time especially at night times. They are extremely toxic and cause various physical and psychological problems. It causes various problems like renal damage and failure, lungs, heart, change in blood composition, several types of cancers and blood pressure problems. Excessive concentration of heavy metals causes both acute and chronic toxicity. Some of them are As, Cr, Cd, Mo, Mn, Mg, Zn, Ni, Fe, Hg, and Pb.

1.5.9 Cations

Cations such as Na, K, Ca and Mg are required in specific amount by human body for proper and normal growth and function. But the excessive amount is dangerous. Like large amount of calcium or exposure to calcium for long period time can cause change in blood composition, urinary tract calculi, hypercalciuria, calcification in soft tissues like kidneys and in arterial walls and suppression of bone remodeling.

1.5.10 Anions

Anions that are important for health are nitrates and nitrites. But their concentration is required in a specific amount. High level of concentration in water is due to pesticides, fertilizers and effluents released from industries. Nitrates in large quantity are extremely dangerous. They cause a condition known as methemoglobinemia commonly known as blue baby syndrome. High levels of nitrates can also be the cause of increased risk for respiratory tract infections and goiter development in children. Same is the case of fluoride that is required in small amount. Deficiency and excessive concentration both are dangerous to bones and teeth. Other anions that cause problems are carbonates, bicarbonates and chlorides.

1.5.11 Pesticides, fertilizers and other agrochemicals

Pesticides are applied on the crops for their protection from pests. Fertilizers are involved for increasing the fertility and other chemicals are involved for greater production of crops. But unfortunately, they are involved in environmental pollution. They are dispersed in soil and water and cause pollution during their production, transportation, surface run-off and improper storage and disposal. This problem is more aggravated in monsoon. These chemicals increase the BOD,COD, TDS,TSS and turbidity (Azizullah et al., 2011).

1.6 Literature review

Drinking water is taken from different resources depending on type of availability of resource. Drinking water can be derived from lakes, rivers, streams, reservoirs, any other surface water body or underground water (aquifer). Concentration of substances present in groundwater depends on movement of water, environment and source of water. There are different factors responsible for water pollution. These are increase in concentration of heavy metals, pesticides, industrial effluents, sewage, municipal waste, nitrate and fluoride contamination from agricultural run-off, run-off from informal settlements, damaged pipes and connections, lack of administration, microbial contamination and mixing of untreated water in fresh water source. Groundwater pollution is caused by leakage in septic tanks, salt applied for snow control, salt water intrusion, landfills and severe agricultural activities (Malana and Khosa, 2011).

Surface water is most exposed to pollution and contaminants. Pollution occurs due to both natural and anthropogenic factors. Natural factors are weathering of rocks, soils and sediments and then their transportation. Whereas anthropogenic factors release pollutants and then they are added to water which ultimately deviates the water from its standards (Jabeen et al., 2014).

Some trace elements are present in water, which are essential for making water suitable for drinking purposes. But if concentration of trace elements exceeds the normal limit water does not remain suitable for drinking purposes. These trace elements are heavy metals as their densities are greater than $5g/cm^3$. These are indestructible because they cannot be decomposed naturally. Excessive trace elements are naturally present in water because of weathering of rocks and soils which is transported by air or water. The major cause is anthropogenic cause. Pollution of water due to heavy metals is now capturing interest worldwide. Major source of increase in concentration of heavy metals in water is due to mining, industrial activities, metallurgy, urban run-off, municipal waste and agricultural processes. Mining cause excessive groundwater pollution. Excessive industrialization and urban activities have contaminated freshwater resource from heavy metals. Metals become dissolved in water or become integral part of sediments. From there metals are either stored in sediments or transported to underground water. 50 elements have been identified as heavy metals. Among them 17 are highly toxic and in easy reach. When this underground water is used as drinking water, or it comes from springs and wells it is contaminated with heavy metals which poses a great threat on human health. When the water polluted with heavy metals is used for agricultural practices it is a serious threat to human health as well. Heavy metals in water are problematic due to their persistent nature, non-biodegradable, bio-available, toxicity and bioaccumulative nature. Neurotoxin, teratogen, carcinogenic, toxic and mutagenic effects are caused by heavy metals. The concerned heavy metals are chromium, cadmium, iron, arsenic, copper, nickel, manganese, zinc, sodium, potassium, calcium and magnesium. All these metals are required in small amounts for proper functioning of human body, but when their concentration increase above the prescribed limit, they become dangerous. Excessive concentration of heavy metals cause heart problems, anemia, anorexia, abdominal pain, hypertension, liver and kidney problems. Like chromium is required in

minute quantity but excessive concentration leads to cancer, kidney and liver problems. Cobalt is required as a metal component for vitamin B12, but large concentration causes artery, thyroid and red blood cells problem. Chromium and manganese excessive concentration can cause Alzheimer disease and intellectual functions problems when in large quantity. Lead is highly toxic. Due to their toxic nature, it can cause chronic problems, headache, memory loss, anemia, abdominal pain, nerve damages, cancer, lungs and kidney problems. These problems occur due to high concentration of lead in water. Zinc is necessary for normal functioning of body. It is required for proper functioning of respiratory muscles, wound healing, hair growth and for immunity but high concentration due to water pollution cause several acute and chronic problems and cancer. A study was conducted in Kohistan found in Northern areas of Pakistan to know about the quality of water. Source of water in this region is springs, rivers and Indus River. People use this water for domestic, agricultural and drinking purposes. Agricultural practices are limited because of mountainous region. Samples were collected from three different areas based on geological and tectonic settings. 45 sites were selected for sample collection. Samples were collected from groundwater as well as from surface water. Water samples were collected in plastic bottles which were treated before with the required reagents. pH was analyzed on spot by CONSORT C931 instrument. Graphite furnace atomic absorption spectrometer was used to analyze the concentration of heavy metals present in water samples. Chronic daily intake (CDI) and hazard quotient (HQ) were calculated by using mathematical equation. Statistical analysis was performed by using SPSS software version 17. Statistical analyses were one-way ANOVA procedure, intermetal co-relation, CA and PCA. The results showed pH value, chromium, cobalt, manganese, and copper concentration was within the standard limits of WHO. Some samples have high concentrations due to ultramafic rocks concentration but still it was within the range. Cadmium, zinc, lead and nickel concentration was not in the limit. People body weight, height, smoking, food and workout habits were compared with HQ and CDI to know the health status. It was found people were safe from toxic effects. But still areas having high level of metals concentration is not fit for drinking. People should treat water before consumption and Government of Pakistan should provide alternative sources (Muhammad et al., 2011).

Another study was performed in Hassan Abdal to know about the levels of trace elements in drinking water sources. Although concentration of trace elements have been increased in water bodies due to various anthropogenic activities but still their concentration is within permissible limits set by various of organizations (Bilal and Rahman, 2013; Muhammad et al., 2011; Mohod and Dhote, 2013; January et al., 2013).

The problem of trace elements and major elements present in water bodies is mostly in regions with heavy industrial development. Such study was conducted in Lahore and Kasur region to analyze the trace and major elements along with other physical and chemical properties. Investigation leads to the result that sodium concentration is higher in the regions of Lahore and Kasur near to industrial sectors. Sodium is extensively used in tanneries; from there it is released in the nearby water resource. The metal content comprising of calcium, magnesium, sodium and

potassium is higher in Misri Shah because of low elevation. Effluents released from industries flow down easily to low lying areas and pollute the drinking water resource. The water present here is also influenced by nearby municipalities. Metal content is higher in regions of Kasur because of tanneries and concentration is increased because of porous and saline nature soil. It is of high permeability as well. Industrial effluent is disposed of at some points of River Ravi but still luckily, the concentration of metals is within permissible limits and less than underground water. Zinc concentration was found nil in the region and no case of zinc toxicity is reported here. The trace elements concentration was analyzed by atomic spectroscopy method. Water was taken out from underground at the depth of 200 feet. Water was taken from depth because of effective filtration at this depth. The instrument was calibrated with standard instruments and solutions. Drinking samples were collected to found out the concentration of trace elements and other physicochemical properties. It was found out that various physical and chemical properties limits were within permissible limits but still their values were higher. The properties were hardness, EC, pH, density and hardness. Toxic elements concentration was within the maximum permissible limits. But the concentration of sodium was much higher and beyond the standards.

Sampling was done in Mohmand agency in north of Peshawar. EC, pH, TDS and temperature were determined on the spot by using CONSORT C931 instrument. Chemical analysis was done on acidified water samples for light and heavy metals present in water. The values of pH, EC, sodium, potassium, TDS, copper, lead, manganese, zinc and cadmium were within the ranges, but the concentrations of calcium, cobalt, magnesium, chromium and nickel exceeded the limit. The values of heavy and light metals were compared with the gender, age, dietary habits, health status, smoking and source of water to know the effect of toxicity. Diseases reported in this area are vomiting, stomach problems, headache, hepatitis, gastrointestinal problems, nerve damage, hypertension, liver and kidney problems. Authorities have banned the contaminated sources and provided alternative sources (Shah et al., 2012).

Arsenic is a toxic metalloid. It is found in earth crust. It is the 20^{th} most abundant element found in earth crust. Its presence in water is now a serious calamity. Inorganic arsenic is more dangerous than organic arsenic. It is found in water as an inorganic substance with small quantity of methyl and dimethyl arsenic compounds. Arsenic is found as arsenate and arsenite. Arsenic is mobilized in environment by natural process like weathering, volcanic eruption and biological activities and man-made activities like use of wood preservatives, pesticides, herbicides and petroleum refining. Arsenic is added in water due to favourable geological, chemical and physical conditions and interaction of rocks with water. Arsenic is added in food and from there it is transported to different organisms through food chain. Arsenic is added in list of carcinogens A. Increase in concentration of arsenic is highly dangerous. About 60 million people in Pakistan, 60 to 100 million people in India and Bangladesh are at risk of arsenic contamination through drinking water. This is the largest mass poisoning of world. Arsenic contamination causes various adverse health effects like gangrene, hyperpigmentation in soles and palms, cardiovascular problems, decrease in immunity, liver and bladder problems, black foot disease,

keratosis, diabetes, cancer, hypertension and pulmonary problems along with socio-economic problems. Arsenic contamination in shallow water reservoirs and in underground water has been observed in different countries like Mexico, India, Pakistan, Argentina, USA, Canada, China, Hungary, Romania, Vietnam and Bangladesh. Manchar lake in Sindh is the main source of fresh water for domestic and agricultural purposes. It has been polluted with arsenic heavily. Different samples were collected from different spots of lake to analyzed various physico-chemical properties especially arsenic. It was found out by cluster analysis that EC and arsenic values are much higher and are beyond permissible limits set by WHO for drinking water (Nabi et al., 2019; Baig et al., 2009; Malana and Khosa, 2011).

Samples collected from Margalla hills located in Islamabad to assess the water quality. It was found out that many samples were not according to the WHO standards. Some factors were within the standards while limits of some parameters exceed the permissible limits. These parameters were microbial content, EC, DO, cadmium and lead. These all factors have serious detrimental effects on health. 100 ml sample should be free from fecal contamination, but samples collected from here and along River Swat from surface and ground water was contaminated with human and animal fecal matter. In the same way water from Lower Shahdara was contaminated with staphylococcus spp. It is recommended that 100 ml sample of drinking water should be free from staphylococcus. It is the cause of skin infections, pneumonia, chest pain and various lethal diseases. Samples collected from Margalla hills were also highly polluted with Pseudomonas spp. It is an indicator of water quality. They are common in water systems because of their ability to colonize easily and formation of thick biofilms that has effect on turbidity, odor and taste. It is responsible for various diseases in immune-compromised population and of urinary tract infection, burns, wounds and various pulmonary tract problems (Batool, 2018).

An experiment was performed in Karachi, the largest city of Pakistan. One of the major problems of Karachi is shortage of clean drinking water. A study was performed in various colleges of Karachi to know the quality of drinking water. As large number of students daily drink this water for 5 to 6 hours, so contaminated water can cause illness among students. When different factors were analyzed, it was found EC, metal concentration, colour and turbidity was within range, except for one college. Zamzama college water have high concentration of ions. It may be due to sea water intrusion. The water here was saline in nature as well. But the water in all colleges was hard. As the range was between 124-449 mg/l as $CaCO_3$. While the standard for hardness is >200mg/l as $CaCO_3$. Sodium, sulphate and potassium concentration was within the limits of WHO in all samples. Chloride concentration was also in limit in all standards except of one college in Clifton due to sea water intrusion. Value of TDS was also within the limit except for one sample. High value of TDS decreases the dissolved gases like oxygen in water and increases the density. Shockingly 48% samples were contaminated with nitrate compounds. Nitrate is highly toxic and cause blue baby syndrome in infants. It can cause death of the affected babies as well. Fluoride is required for the teeth and bones development. But excess fluorine cause fluorosis in human body. Some of the samples contain high concentration of fluorine

which is dangerous. This whole study was performed with different instruments made for analyzing specific type of element. Like potable digital pH meter and conductivity meter was used for measuring pH and conductivity on the spot. Calcium and magnesium by complexometric titration, chloride by argentometry, alkalinity by acidmetric titration, fluoride by fluoride Ion Selective electrode, nitrate by nitrate Ion Selective electrode by using Digital Ion Analyzer. On the basis of results of experiments authorities should take actions and work to provide clean and safe drinking water (Perveen et al., 2007).

Faisalabad is an important city of Pakistan. It is an important city because of the presence of industries. It is known as Manchester of Pakistan. It is heavily populated. Study was conducted here to know the quality of drinking water. Use of water has been increased due to increase in population. The main problem is due to industries. Industries discharge their wastewater and solid waste directly into surface water and ground water. Only few industries treat wastewater before their discharge into water bodies. Approximately 9000 million gallons of wastewater is discharged by industries of Pakistan. Wastewater is composed of toxic compounds, toxic metals, ions, chemicals and degradable substances. Groundwater has more dissolved substances than suspended matter. Samples were collected near sewage plants in the circumference of 10 meters that passes through the urban settlements to assess the quality of groundwater that is used for drinking purposes. pH does not have any direct effect on health but indirectly it effects the health. The pH of all the samples were within 6.5 to 8.5, which is within the prescribed limit of drinking water. But the value of TDS is much higher in all samples. TDS is concentration of dissolved ions present in water including magnesium, calcium, sodium, potassium, chlorides, sulphates, bicarbonates and small amounts of organic matter. Value ranges from 1190 to 2415 mg/l. This range is far above the prescribed limit i.e., 1000 mg/l. This makes water unfit for human consumption. The value of hardness in these samples were within limit given by WHO but not by APHA limits. Hardness in water is caused by bicarbonates, calcium, magnesium, sulphates, chlorides and magnesium. In the same way alkalinity was above the prescribed limit. It causes gas, kidney stones, skin and mucus problem and eye infections. Sulphate concentration was within 241 to 570 mg/l. But the WHO recommended level is 250 mg/l. Although it is the least toxic anion but still due to high concentration it can cause several problems. Chloride level was also higher in the samples. The results show 171 to 380 mg/l but the standard limit is 250 mg/l. Excessive concentration of chloride cause taste problems, gastrointestinal problems, dehydration and stomach problems. In the same way sodium level was above 250 mg/l. Excessive sodium causes hypertension, artery problems, heart and kidney disease. The allowed level of potassium is 12 mg/l. But in samples the concentration was within 32 to 60 mg/l. Large amount of potassium in water causes dehydration. Cadmium concentration was also above the critical level. Value ranges 0.01 to 0.02 ppm. But the allowed limit is 0.005 pm by WHO. Large quantity of cadmium in water cause kidney damage. Chromium concentration was also above the prescribed limit. It may cause allergic dermatitis. Iron concentration is also above the prescribed limit. The standard is 0.30 ppm. But the concentration was within 0.24 ppm to 0.45 ppm. It causes problem to aesthetic more than to health. It provides medium to pathogenic organisms as well. Manganese is essential for a good health but excessive concentration cause abnormalities.

The concentration of manganese was also above the critical limit. The concentration range was within 0.08 to 0.38 ppm. Which is much higher than the prescribed limit 0.05 ppm. Copper is rarely found in water. The presence of copper is due to mixing of untreated industrial water and delivery system. Copper concentration was within the limit. Other than copper, lead is the element found with the permissible limit in the samples of Faisalabad. In the same way samples were also free from heavy concentration of nickel. Zinc was also within the prescribed limit. Other than these few metals all other parameters crossed the line. So, it indicates water collected from points in Faisalabad is not fit for human consumption. To protect human health water should be supplied from safe sources and wells should be constructed near safe rivers. Alternative sources should be identified. Along with it water must be treated before discharge from industries (Farid et al., 2012).

Study was done in Dera Ghazi Khan to find the characteristics of drinking water. The value of conductivity is much higher than the prescribed limits. It may be due to geography of region. The concentration of bicarbonates, sodium, calcium, chloride and magnesium is much higher than the prescribed limit of WHO. Their concentration is higher due to rainwater run-off, sewage and industrial discharge. Sulpahte concentration was also higher in samples due to improper disposal of sewage and sludge, mine drainage and poor drainage system. Other than metal contamination water was also polluted with bacteria. It is due to improper sewage disposal, open leaky and unhygienic drainage system. Arsenic, fluoride, potassium and alkalinity values were within the limits. But the overall analysis gave the result that water present in Dera Ghazi Khan is unfit for human consumption (Malana and Khosa, 2011).

Swat is valley in north of Pakistan. Water used in Swat is derived from rivers, dug wells, springs, streams and tube wells. Study was conducted here to know about physicochemical properties of water to assess the health risk. Before collection of samples water was allowed to flow for 2 to 5 minutes from tube wells and hand pumps. Gas was removed form bottles by filling in water in it. This activity was performed twice and then bottles were filled. Before collection of samples bottles were washed with deionized water. Interviews were conducted to know about the body mass index along with their source of water, eating and smoking habits to do health risk assessment. Statistical analysis was performed using SPSS software. One-way ANOVA comparison, Inter-metal correlation and principal component analysis was performed. Inter-metal correlation is one of the best methods to know about concentration along with their pathways. Analysis shows the value of copper, manganese and zinc were within permissible limits, but the values of cadmium, chromium, nickel and lead was much higher. The values could be higher due to ultramafic, mafic rocks, mining and agricultural activities. Analysis was done of both groundwater and surface water samples. It was recommended to not use contaminated water and government should take precautionary measures along with alternative sources (Khan et al., 2013).

Ground and surface water in Haripur basin present in Pakistan has been deteriorated in the past two decades because of the establishment of Hattar Industrial Estate (HIE). It has engineering, paper and paint industries. People residing there use tap water and water from dug wells.

Industry release effluents and wastewater directly on the surface. This will ultimately deteriorate the water quality. Samples were collected from both surface water and ground water samples. For the collection of samples polythene bottles were treated with nitric acid and deionized water before collection of samples. EC, temperature, pH and TDS were measured on the spot by using CONSORT C931 instrument. Perkin Elmer graphite furnace atomic absorption spectrometer was used for chemical analysis. Arsenic and mercury were analyzed by Hydride Generation System (HGS-10) fitted with Perkin Elmer spectrometer. Values of pH, TDS, temperature and EC was within the range. Value of EC was higher but lower than the maximum limit. All heavy metals concentration was less except lead. Zinc, iron, manganese, nickel, chromium, mercury, cadmium, chromium, arsenic and copper concentration was within the limit. Lead was found in drinking water excessively because of the effluents released from the industries (Jabeen et al., 2014).

Recent studies have shown that water quality of Africa, Middle East and South Asia is deteriorating due to land degradation, deforestation, urbanization, population bloom and mismanagement of resources. Concentration of nutrients and organic matter had increased in water of many cities of Asia because of improper or no treatment of waste and sewage before throwing into water bodies. A study was conducted in Bahawalpur to know about the water quality and its effect on human health. Naturally water in Bahawalpur is saline and brackish except in areas near to canal and Sutluj river, which is a big river and main source of water supply to nearby residents. Due to recent population explosion and economic activities water quality is declining. 3 different sectors of Bahawalpur sector were selected to know the water quality. 1 is a typical slum area, 1 is a properly planned area where middle income and wealthy people reside, and the last area has people from every socioeconomic category. Different parameters were assessed. Water in majority areas was colourless except in few areas. Colour can be due to excessive pumping, lowering of water table, suspended organic matter and minerals. Taste is one of the parameters. According to taste water is divided in three groups including sweet, medium and brackish. Majority of water present in Bahawalpur is sweet in taste except in few areas. Medium taste is due to naturally present inorganic salts. Brackish water is due to sewage leakage, improper disposal and groundwater exploitation. People having brackish water were forced to drink that water because they can't afford mineral water. Smell in water is further divided in to 3 different categories which include no smell, fast smell and slight smell. Only few areas of Bahawalpur have slight smell due to sewage leakage. Smell was found in those areas having low income. Different physical and chemical parameters were assessed. Water was tested in labs of PCRWR in Bahawalpur city. Values of EC were within the standards and posed no threats on human health. It was found out water was good conductor of electricity. This shows the values of EC was higher than the WHO standards. pH value of all water samples were within the range. Bicarbonates concentration is related with pH of water. Bicarbonates are added in water by weathering of rocks and make water alkaline. However, all the samples of water have bicarbonates within the acceptable range. Chlorides concentration in surface water is less than groundwater. They are added by industrial effluents and sewage. Excessive chloride concentration damages the pipes as well. All the samples have very low concentration of

chlorides. It was within the range. Magnesium is required by human body and metabolism. All the water samples have low magnesium concentration than the limit. One sample has very low concentration which can pose threat to health as there could be deficiency of magnesium in body. In the same way calcium is important for proper functioning of body. All the samples except for one have high concentration which can have negative effect on health. Sodium concentration was within the limit except for one sample. It was extremely low which can cause deficiency in human body causing problems. Hardness values of all samples were within the range. Value of potassium and alkalinity were within the limit and does not have threat to human health. Nitrate excessive concentration is extremely dangerous. All the samples except one have concentration within the limit. It may pose serious health problems like blue baby syndrome. Sources are fertilizers, nitrogen cycle and industrial waste. Questionnaire was also involved in the sampling. It was found some proportion of population was suffering from various water-borne diseases because of poor quality of water. People suffered from jaundice, cholera, typhoid, diarrhea and kidney stones. People of low socioeconomic category were affected by low water quality. It is because they are not able to get bottled or mineral water and could not afford filtration plants. Government should take actions to provide safe and clean drinking water. Regular monitoring and precautionary measure should be taken to protect the water quality. Sewer drains should be kept away from freshwater resources to prevent water deterioration and contamination. District governments should take actions and install filtration plants to provide safe and hygienic water to residents.

A general study was conducted in different areas of Pakistan to know the quality of water. It was found samples of Islamabad were toxic and dangerous to human health. Water of Punjab was contaminated with arsenic due to industrialization and release of chemical effluents. Water of KPK and Sindh is contaminated with high turbidity levels. Same was found in Karachi. Water samples did not match with water standards (Mohsin et al., 2013).

In Pakistan availability of safe water is not only important for drinking purposes only but for agricultural activities as well. As Pakistan is an agricultural country safe water is an essential requirement. When irrigation is done with polluted water contaminants are added in crops, vegetables and fruits as well. When they entered in the food chain, they have the same detrimental effect as of polluted water. Such toxic effect was seen in Faisalabad. Polluted water was irrigated to crops. This contaminated both soil and water along with crops. Study was performed on Lahore service canal to know about the water quality. It passes through Lahore and Kasur. It irrigates a large piece of land. Water in this lake is used for agricultural, boating, swimming, recreational, fishing, drinking and washing purposes. But now visually remains of fruits and vegetables, excreta of human, plastic remains, domestic waste, industrial waste, sewage, accumulated organic and inorganic contaminants, wood and glass remains can be seen. They are thrown into canal directly because of lack of unchecked disposal and administration. Samples were collected from canals even at a great depth of 2 to 3 meters. Water samples were collected in plastic bottles which were washed with detergents, distilled water and tap water. Analysis was performed, and results show water of Lahore canal is not much polluted except the

values of turbidity and cadmium was high. Turbidity interferes with the aesthetics and can be problematic to sensitive skin people during swimming. Still, it is advised to take care of such precious gift and adopt precautionary measure. As it is great source of water for irrigation, domestic and gardening purposes in Lahore and Kasur (Aftab et al., 2011).

Bacteriological contamination is a major problem in Pakistan. Many samples collected from different area are contaminated with bacteria even at treatment plants. Samples collected from Rawalpindi, Kherpur in Sindh, Peshawar, Lahore and Karachi were contaminated with total coliform and fecal coliform. Samples were taken from distribution systems, taps and treatment plants. Rawal lake present in Islamabad that provides water to large number of consumers about 15 million is also contaminated with bacteria. Treatment plants in Islamabad do not treat and purify water properly for bacterial content. This situation can be worse in such areas where there is no proper check and balance.

Water quality problem is not only in Pakistan but in other countries as well due to developmental and industrial activities. Studies are performed in various countries as well to know the water quality. One study over water was done in Australia to know about physicochemical properties and other parameters of water. Samples from river in Australia were collected to know the water quality as mining practices and acid mine drainage had affected the water quality. Water samples were collected at different intervals. It was found out that level of pH is on decline mode due to addition of acid. Values of EC, sulphate, zinc, nickel, manganese and iron has been increased if compared before mining and after mining. Values of all these components have been extremely high when measured before mining, during mining and after mining. There is a great difference between pre-mining values and post mining values (Wright et al., 2018).

Water quality of Izmir was tested. It is the 3rd largest province of Turkey. It is located on Aegean Sea shore. Tahtali dam is the major source of water of Izmir. Balcova dam and groundwater wells are the secondary sources of water for Izmir. Samples were collected from water treatment plants, bottled water and tap water. 100 samples were collected from different districts of Izmir to know the concentration levels of different trace elements, exposure and risk level. Samples concentration was based on population concentration. Questionnaire was also given to participants. Questions were regarding source of water, gender, weight, body mass, education, income level and type of water source to assess the risk. Primary and secondary questionnaire was made for participants. Secondary questionnaire includes the number of glasses drunk in a day and source of water. Samples were collected in bottles that were treated with nitric acid. HDPE bottles were used. After 3 minutes of flushing tap water bottles were filled. Water was also collected from water treatment plants as well. Acid was added in water to acidify the water and kept for 3 hours at room temperature. Afterwards they were refrigerated and kept at 4 centigrade. Inductively coupled plasma-optical emission spectroscopy (ICP-OES) was used for the analysis trace elements including beryllium, chromium, cadmium, cobalt, copper, lead, nickel, manganese, zinc and vanadium. Arsenic was determined by Atomic Absorption Spectroscopy AAS. All trace metals were not found in all samples so statistical analysis was

done. Daily exposure and risk assessment was done as well to know the risk level among individuals. All the samples have trace elements within the range except arsenic and nickel (Kavcar et al., 2009).

Water pollution problem has cause problem worldwide. About 1 billion people worldwide have been affected by contaminated water. Water sampling was done in Bholakpur Hyderabad India to know the quality of water. This city has few tanneries, people deal with hides and have low hygienic conditions. These factors may cause the contamination of water. Study was done when many people suffered from diarrhea. Samples were collected from municipal taps. pH, TDS, EC and DO were measured by Thermo Electron Corp. Orion 5 star. Chemical analysis was done by ICP-MS. It is a spectrometer. Samples were collected and then HNO_3 was added in it. Standard Plate count, membrane filtration technique, thermo tolerant coliforms and most probable number techniques were used to identify the microbiological content. Sampling for identifying microbes was done in 24 hours. Agar plates were made at 37 centigrade temperature. Samples were analyzed, and it was found all the physical and chemical properties were within limit except of DO. Level of dissolved oxygen was low. The concentration of Fe, Pb, Cu, Ni, Al and Na were beyond the permissible limit. The most problematic thing was water was contaminated with microbiological content. Many colonies of bacteria were found in the samples showing water was contaminated with sewage. This pose a great threat on human health and many gastrointestinal problems were also reported due to this contamination (Abdul et al., 2012).

Not only the surface and ground water are contaminated, but now contamination has been observed in bottled waters as well. The consumption of bottled waters is increasing day by day because people consider it safe, social status, consider it remedy, proper promotion and consumers rejected other municipal source of water due to objectionable taste and odour. Because of the trust built among the people many new brands have been developed of mineral water. In the last decade about 5000 new brands have been built in the world of mineral water. The consumption of bottled water has been increased from 130956 million liters in 2002 to 188777 million liters in 2007. The annual global consumption is 28.8L per capita average of 2007. The average European Union consumption of bottled water was 104.2 L per capita, and US bottled water market per capita consumption was 110.9 L in 2006. Nothing is added in bottled water artificially except fluoride and other required elements if required. The study of analyzing the water quality of bottled water was performed in Lebanon. 32 samples of different brands were collected. Samples were from 5 to 10 liters and were placed in ambient conditions. Physical parameters were analyzed, and metals were assessed by spectrometry. Microbial content present in water was analyzed by membrane filtration techniques and hetrotrophic bacteria was analyzed by HPC spread plate method. The results showed that values of almost all contents were within ranges of national and international standards except of calcium, hardness and pH (Semerjian, 2011).

The problem of water pollution with heavy metals is not only problem of Pakistan but also problem of whole world. India is suffering from arsenic problem. Arsenic concentration is 30 times greater than WHO guidelines in India. People suffer from various diseases due to arsenic

especially who are already immune compromised and suffering from lung diseases. Assam in India is heavily polluted with lead and iron. Their values exceed the values of WHO. Iron concentration is high due to iron industries nearby settlements. Concentrations of Mn, Cd, Cr, Ni, Co, Zn and Fe is extremely high and far above the limits of WHO in Musi River near Hyderabad in India (January et al., 2013). Uranium that is extremely toxic is also high in concentration in India, Bangladesh and Finland. Many people in Bangladesh drink contaminated water. Uranium content is very high in waters of Central Asia and Kazakhstan. Renal failure cases are reported here as well. Water in Skardu and Muzaffargarh in Pakistan are also heavily polluted with heavy metals. Natural and geological factors are responsible for groundwater contamination in Vietnam. 2 million people living there are at great risk especially young ones. The highest concentration is of cadmium in Siri Lanka due to excessive use of cadmium phosphate fertilizers. It results in cadmium toxicity and chronic problems. Concentration of mercury is near to guideline in Indonesia. Health of many people is at risk in Africa due to high concentration of As, Mn, Pb and Hg. Ghana has same scenario. Even the bottled waters in Canada are not free from pollution. Cu, Ni and As concentration is high in some provinces of Canada. Upper Midwest USA has high concentration of arsenic naturally which poses threat to public health. Tuskegee lake in USA parameters does not match with standard ranges. Levels of As, Pb and Hg are at concerning levels in Mexico. Chili and Brazil have high concentration of As, Au and Hg due to gold mining process. Arsenic is released due to gold mining, soils, rocks and ores in drainage system, water reservoirs and atmosphere. But luckily population is not exposed to much higher level. Bolivia has high concentration of arsenic due to deep bed rock weathering, soils and tropical weathers. About 4.5 million people are exposed to arsenic resulting chronic diseases in Latin America. Antarctica is fully covered with snow and receive little precipitation making it a dessert. Substances produced by anthropogenic activities are transported here through atmosphere, organisms, water, land and birds. The concentration of heavy metals in this snowy region is low. Levels were measured in snow through a long period of time. In Europe in Greece, Eastern Thessaly have water that is contaminated with As and Sb. Their values exceed from Serbian and European standards. 3% of Croatian is at serious health risk due to arsenic contamination. In Italy the water quality in inner parts is worse than the main source because of leaching metal pipes. Same is the case with Spain in context of lead. Water in Greece is contaminated with As, Fe and Mn. In Australia and New Zealand strict guidelines have been made for aquatic environment protection. Heavy metals are due to natural and anthropogenic factors. Naturally occurring radium isotope is found due to seepage. Cu, Pb and Zn are present due to fluvial sediment and sewage disposal system. Coal processing facilities is also involved in contaminating water. Cu, Ni, Co and Cr are added due to this facility. Rainwater is used as well for drinking purposes. Microbial content and heavy metals content is higher in some regions. So, it is advised not to use water in Oceania before treatment.

Many people have suffered from poisoning by drinking contaminated water. To prevent this, proper guidelines should be made and implemented. Water should be treated, sampled and analyzed before treatment. Special attention should be paid to drinking water. Like oxygen it is also extremely important for life. Proper awareness should be done about consequences of

drinking contaminated water and use of safe water. Cheap, fast and effective technologies should be made for treatment of water (Fernández-Luqueño et al., 2013).

1.7 Problems caused by polluted water

Heavy metals and pollutants present in water not only pose threat but had caused various problems among human population. Low energy level in body, damaged or reduced mental ability, damage of organs like damage to kidneys and liver, irregular blood composition and damaged nervous system are the consequences of excessive heavy metal concentration. Long term exposure to heavy metals through oral contact has severe results. It causes extreme problems like Alzheimer disease, Parkinson disease, neurological degeneration, multiple sclerosis, enzyme inhibitor physical, different types of cancers, shortness of breath and muscular problem. Cadmium is highly toxic. It causes problems even in small amounts like renal damage and endocrine damage. It has a very long half-life in human body of 10 to 33 years and it bioaccumulates. Lead has the ability of removing calcium from bones and adjust itself in bones instead of calcium. It is a neurotoxin as well. It accumulates in bones as well as in soft tissues of body. It is also involved in causing delay in development among infants, kidney problems and high blood pressure problems. Death can be caused by failure of kidney, lungs and nervous system, heart problems and anemia due to excessive copper compounds ingestion. Excessive concentration of copper causes liver cirrhosis, problems in infants, problems in people suffering from certain metabolic problems and growth inhibition as well. It can also cause vomiting, diarrhea, nausea and abdominal pain. Exposure to low level of copper for long period of time can cause problems as well. Copper in excessive amount had shown toxicity in human body (Mohod and Dhote, 2013). Small amount of molybdenum is required for proper functioning of enzymes, but high amount causes mineral imbalance. Cases of cardiovascular, reproductive, renal, dermal, lungs, nasal cancer and immunological problems have been reported from high amounts of nickel. Nickel was known as allergen of year 2008. Large dose of zinc causes fatigue, neutropenia and dizziness among humans. Arsenic is involved in leukemic and carcinogenic effects in human body when taken inside body through drinking water. Long term ingestion of arsenic leads to skin lesions and cancers of bladder, skin, lungs and other internal organs. It also causes various non-caner diseases due to ingestion of arsenic for a long term in excessive amount. Arsenic causes problem at concentration of $\leq 50 \mu g/l$. Barium released from drilling industries and refineries caused increase in blood pressure. Iron is required for proper and normal functioning of body, but large amount causes tissue damage and haemochromatosis. Molybdenum is involved in causing osteoporosis when limit exceeds (January et al., 2013). Mercury's permissible limit is very minute. But its concentration has been increased as well. It is involved in causing neuro problems, decrease in production of hormones including testosterone and thyroid. Large amount of fluoride in water cause bone and teeth problems including bone softening and deformation (Azizullah et al., 2011).

The high concentration does not pose threat but has caused various health problems like arsenic has causes diabetes, hypertension, hyperpigmentation, developmental problems in children, chronic cough and lungs problem in Bangladesh. In India and West Bengal people had suffered

from skin problems, cancers, weakness, genetic problems and circulatory problems due to arsenic exposure. China, Iran and Inner Mongolia suffered the same consequences due to drinking of arsenic polluted water. Taiwanese suffered from black foot disease, skin, lung, bladder and urinary tract cancer due to arsenic polluted water.

5 million have people died in world due to toxicity and poisoning caused by heavy metals poisoning. The problem of water pollution has occurred and is increasing day by day due to improper waste management and waste disposal (Mohod and Dhote, 2013).

1.7.1 Water borne diseases

Water borne diseases are those diseases that are caused by pathogens present in water. Diseases are caused when polluted water is drunk. Microbes present in water are responsible for various diseases like gastrointestinal problems, nausea, vomiting, diarrhea, typhoid and dysentery. This is one of the biggest public health especially among children and immune compromised patients. About 0.5 million deaths of infants have occurred in South Asia due to poor water quality and lack of sanitation. Diarrhea is one of the water borne disease which is the leading cause of death among infants and causing illness in every fifth person of Asia due to poor water quality.

1.7.2 Water privation diseases

Diseases in this category are caused by large quantity of contaminated water. It is related to quantity of water. Such diseases are also caused by contact with infected materials and infected person. Example of such diseases include skin and eye infections.

1.7.3 Water-based diseases

These types of diseases are caused by pathogens that spend their life in intermediate organisms living in water. Then pathogens gain entry in the body by ingestion or through skin. Schistosomiasis is water-based disease.

1.7.4 Water- related disease

This category includes the diseases which are caused by organisms living in insect vectors in water. They complete their life cycle in insect vectors and when they gain entry inside the human body, they cause disease. Example malaria.

1.7.5 Water dispersed infection

It includes those diseases which are caused by pathogens that can proliferate in fresh water and then enters human body through respiratory tract. This category is the 5^{th} category of diseases caused by contaminated water having pathogens in it. Example of water dispersed infection is legionella (WHO).

1.8 Scope

This thesis assessed the physical, chemical and biological parameters of drinking water quality of H-11 sector of Islamabad to know about the water quality. Risks were analyzed due to

consumption of contaminated water and human health risk assessment was done.

1.9 Objectives

Study was done with the objectives:

- To analyze physico-chemical characteristics including pH, TDS, temperature, turbidity, conductivity, salts, chlorides, sodium, calcium, carbonates, sodium carbonate, sodium bicarbonate, bicarbonate, alkalinity, calcium, magnesium and total hardness and biological parameter in drinking water of H-11 sector of Islamabad, Pakistan.
- To generate the baseline for drinking water quality of H-11 sector Islamabad, Pakistan.

Chapter 2

Methodology

Water quality has a significant effect on human health. Water is used not only for drinking purposes but for other activities as well. The activities which are directly involved in effecting the health of human from contaminated water are drinking, using contaminated water for drinking, washing and for sanitary purposes.

To see the water quality of H-11 sector of Islamabad sampling was done. Samples were collected from different areas of H-11 of Islamabad. Drinking water samples were collected in sterile bottles for physical, chemical and biological assessment.

2.1 Study area

20 samples were collected from different areas in H-11 sector in Islamabad including educational institutes which include school, college, universities, government offices, public place and slum areas.

2.2 Sample collection

Water samples were collected from different locations. Source of water was also asked from the residents. In case of pumped water, the depth of water at which it was being pumped being was also asked. For physical and chemical properties water sample was collected in one bottle. It was rinsed first with the sample water and then water was filled in it. For biological assessment water was filled in a separate bottle. It was dipped and washed in the source and then filled with the water.

2.3 Data collection and analysis

Primary and secondary data was collected. Primary data was collected at the spot by collecting the samples and the required information. Secondary data includes standards and permissible limits of different parameters given by WHO as standards of drinking water and NEQS for drinking water.

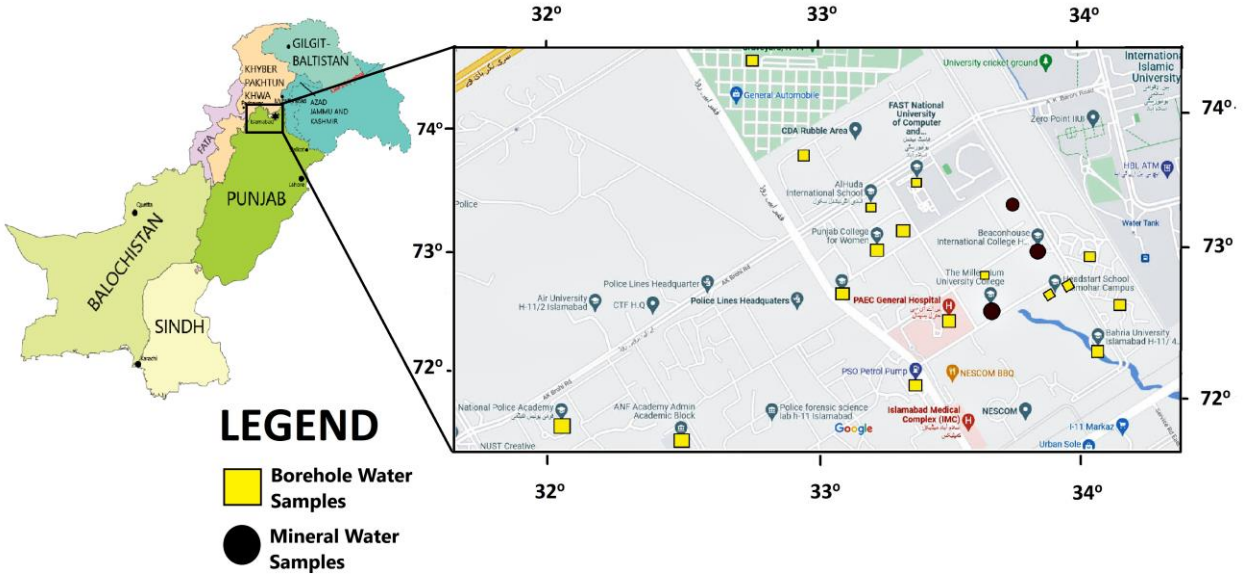
2.4 Sample size

20 samples were collected from the sample sites When the samples were collected, they were labelled and exact location which includes latitude and longitude were determined with the help of google maps.

After collection of samples different physical, chemical and biological parameters were assessed. Physical, chemical and biological parameters were assessed in Bahria University Islamabad campus environmental lab. Location from where samples were collected along with their coordinates and source of water are described in the table 2.1.

Serial No	Sample No	Name (location)	Source	Depth	Latitude	Longitude
1	1	Headstart school (front)	Borehole	130 ft	33.61 °	73.02 °
2	2	Headstart school (rear)	Borehole	130 ft	34.6 °	74.0 °
3	3	Beaconhouse international college	Mineral water		36.1 °	75.0 °
4	4	FAST	Borehole	680 ft	33.6 °	73.01 °
5	5	Al-Huda international	Borehole	200 ft	33.65 °	73.01 °
6	6	National institute of fire technology	Borehole	200 ft	33.66 °	73.01 °
7	7	Punjab college	Borehole	200 ft	34.0 °	73.2 °
8	8	Islamabad science school and college	Borehole	220 ft	34.1 °	73.3 °
9	9	EMS high school	Borehole	150 ft	34.1 °	73.3 °
10	10	The millennium university college	Mineral water		34.2 °	73.4 °
11	11	PSO H-11/1	Borehole	150 ft	33.64 °	73.01 °
12	12	Anti-narcotics force academy	Borehole	200 ft	33.64 °	73.00 °
13	13	National police academy	Borehole	480 ft	33.64 °	74.00 °
14	14	Slums H-11/2	Borehole	160 ft	33.6 °	73.00 °
15	15	Graveyard	Borehole	275 ft	33.66 °	73.00 °
16	16	PAEC general hospital	Borehole	300 ft	33.65 °	73.01 °
17	17	Ibn-e-sina institute of technology	Mineral water		36.1 °	75.0 °
18	18	Slums H-11/4	Borehole	180 ft	33.6°	73.02°
19	19	Mosque H-11/4	Borehole	180 ft	33.6°	73.02°
20	20	Bahria University H-11/4	Borehole	400 ft	33.6°	73.02°

Table 2.1 Location of drinking water samples collected



Locations of sample sites of drinking water in H-11 Islamabad

2.5 Physical parameters

2.5.1 pH

pH of water samples was measured in Bahria University Islamabad campus environmental lab by using a water quality multimeter that measures pH, electrical conductivity, TDS, salts and temperature. pH was measured by dipping the probe in the solution. Before dipping the probe in the sample in the beaker both probe and beaker was washed with distilled water to avoid contamination and mixing of results with other samples. Probe was held in the sample for few minutes to achieve a stabilized reading. After the reading is taken and pH is measured, the probe was rinsed with distilled water to avoid contamination and mixing of different samples to know the exact value of pH of different samples (Akter et al., 2016).

2.5.2 Conductivity

Electrical conductivity of water samples was measured with the help of a same meter that was used for measuring pH. Before measurement probe and beaker was washed with distilled water to avoid contamination and mixing of different samples. When measurement was done probe was washed with a distilled water to avoid contamination among different samples and mixing of reading. Probe was dipped in the beaker having the sample and then reading was noted (ji and uddin, 2019).

2.5.3 TDS

Total Dissolved Solids present in water sample were measured with the help of same

meter. Beaker and probe was rinsed with distilled water to remove the contamination and mixing of different samples. Then probe was dipped in beaker containing sample and reading was noted down. After completion of measurement probe was rinsed with distilled water to avoid cross contamination among different collected samples (Akter et al., 2016).

2.5.4 Turbidity

For measuring turbidity, turbidity meter was used. It has a different procedure of measurement than the other parameters discussed above. For measurement of turbidity the sample was poured in the sample holder and kept inside for few minutes. 10 milliliters of sample was poured in the holder and was dried. The container was put in the turbidity meter. When the reading was stabled after pressing the test button, the value was recorded (Omar and MatJafri, 2009).

2.5.5 Salts

Salts present in water are measured by using a water quality multimeter. It is having a probe which is dipped in the sample. Beaker and probe were rinsed with distilled water to remove the contamination and mixing of different samples. Then probe was dipped in beaker containing sample and reading was noted down. After completion of measurement probe was rinsed with distilled water to avoid cross contamination among different collected samples (Akter et al., 2016).

2.5.6 Temperature

Temperature of water sample was measured with the same meter used to measure pH, conductivity and salts. When probe was rinsed in the sample, reading of temperature was displayed on the screen. Before doing the measurement, probe and beaker both were rinsed with distilled water to avoid contamination and cross contamination along with mixing of samples. After reading probe and beaker both were rinsed again with distilled water (Omar and MatJafri, 2009).

2.6 Methods for Chemical Parameters

Following chemical parameters were assessed in the samples:

1) Chlorides (Cl)
2) Sodium (Na)
3) Sodium chloride (NaCl)
4) Calcium (Ca)
5) Magnesium (Mg)
6) Total hardness
7) Sodium carbonate ($NaCO_3$)
8) Sodium bicarbonate ($NaHCO_{3)}$
9) Carbonate (CO_3)
10) Bicarbonate (HCO_3)
11) Alkalinity

2.6.1 Estimation of Carbonates

In carbonates $NaHCO_3$, Na_2CO_3, HCO_3 and CO_3 are determined by acid-base titration or standardization method.

For carbonates 0.1 M HCl is taken in burette. Initial reading is noted down of HCl level in burette. Plastic cylinder is washed with distilled water and 10 milliliter of sample was poured in it. Then the sample was transferred in titration in flask. 2 drops of indicator were added in it. Indicator used is methyl orange. Then drop by drop HCl was added in the titration flask till the colour changes. When the colour changes burette is closed and final reading is noted down. Difference is taken to know about the amount of HCl used. Same procedure is repeated 3 times and average is taken of difference for each sample (Northrop, 1908). Further calculations were performed according to the following formula:

Amount of HCl used * molar weight of $NaHCO_3$ (84)/1000 = amount of $NaHCO_3$ present in sample

Amount of HCl used * molar weight of Na_2CO_3 (105.9)/1000= amount of Na_2CO_3 present in sample

Amount of HCl used * molar weight of HCO_3 (61/)/1000 = amount of HCO_3 present in sample

Amount of HCl used * molar weight of CO_3 (60)/1000 = amount of CO_3 present in sample

2.6.2 Estimation of Chlorides

Chlorides include chloride, sodium chloride and sodium present in water sample.

For checking concentration of chlorides present in water sample first the titration flask, plastic cylinder and burette are washed with distilled water to remove contamination and mixing of samples. Then 10 milliliter of water sample is taken in plastic cylinder and shifted to titration flask. 3 drops of indicator are added in the sample. Indicator used here is K_2CrO_4. Standard solution is taken in burette. The standard solution is 0.01 M $AgNO_3$. It is added drop wise in the titration flask till the colour changes. Level of standard solution before and after dripping in the titration flask is noted. Difference is taken to know how much standard solution is used. Procedure is repeated 3 times and the average is taken of volume of $AgNO_3$ (District et al., 2012). The same procedure is repeated for all the samples. For every step and sample every equipment is washed with distilled water to avoid contamination and mixing of different samples.

For calculation of concentration of chlorides formula is used which is:

2.6.3 Determination of chlorides

Cl= Normality*volume*molar weight of chlorine*1000/sample volume

2.6.4 Determination of NaCl

NaCl= Normality*volume*molar weight of sodium chloride*1000/sample volume

2.6.5 Determination of Na

Na= NaCl concentration- Cl concentration

2.6.6 Estimation of hardness

For estimation of hardness of water sample standard, solution is taken in burette. Standard solution of 0.01 normality of EDTA (Ethylenediamine tetraacetic acid) is used. 50ml sample is taken in flask with the help of plastic cylinder. Buffer solution of NH_4Cl is taken with the help of syringe. 2ml is taken and added in flask. Buffer solution is added to maintain pH. pH changes due to oxidation reduction potential. pH is checked of solution. It should not be less than 9 and greater than 11. Then EBT is added in the solution and colour changes to red. Erochrome Black T is used as an indicator. Sample is titrated against EDTA. End point is blue colour (District et al., 2012).

In the start first test is performed with distilled water. Hardness of blank is checked first. Same procedure described above is performed. But as there are no salts in distilled water so colour is blue.

Hardness(mg/l) = A*B*1000/volume of sample

A= EDTA used for sample- EDTA used for blank

B= Normality of EDTA

2.6.7 Estimation of calcium

For estimation of calcium ions water sample, standard solution is taken in burette. Standard solution of 0.01 normality of EDTA (Ethylenediamine tetraacetic acid) is used. 50ml sample is taken in flask with the help of plastic cylinder. Buffer solution of NaOH is taken with the help of syringe. 2ml is taken and added in flask. Buffer solution is added to maintain pH. pH changes due to oxidation reduction potential. pH is checked of solution. It should not be less than 9 and greater than 11. Then EBT is added in the solution and colour changes to red. Erochrome Black T is used as an indicator. Sample is titrated against EDTA. End point is blue colour (District et al., 2012). In the start first test is performed with distilled water. Hardness of blank is checked first. But as there are no salts in distilled water so colour is blue. Same procedure and calculations described above are performed.

Calcium (mg/l) = A*B*1000/volume of sample

2.6.8 Estimation of magnesium

As hardness is caused by calcium and magnesium. We had calculated calcium, so magnesium can be calculated easily (District et al., 2012).

Magnesium (mg/l) = Hardness-Calcium (mg/l)

2.6.9 Estimation of alkalinity

For estimation of alkalinity 50ml of water sample is taken in the flask. It is titrated against standard solution of 0.02 molar sulphuric acid. If the water sample is basic then phenolphthalein is used as an indicator. If sample is acidic then methyl orange is used as an indicator. Sulphuric acid is added dropwise in sample when indicator is added in water sample. 2 drops of indicator are added in sample. For basic media it gives pink colour and for acidic it gives red to orange colour. The point where colour is changed reading is noted down (District et al., 2012).

Alkalinity= normality of acid*volume of acid*1000/sample volume

2.7 Bacteriological parameters

Microbial analysis was done of water samples that were collected. It was done of total bacteria, E.coli, shigella, salmonella and coliform bacteria.

For assessing microbes present in water samples first sterilization of equipments and hands is necessary. Bottles are taken and washed with water and then washed with distilled water. Afterwards required gram of medium of nutrient agar, EMB and SS is taken by measurement and put in bottle. Then water is added in bottle. It is cotton plugged and bottle is kept in autoclave for 2 hours at 120 centigrade.

Required amount of media is calculated by the following formula:

1 petri dish=20 ml

Total samples=20

Quantity required = 20*20= 400 ml

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

23 grams nutrient agar is added in 1 liter of water for making solution.

1 liter= 1000 milliliter

23g/1000= 0.023

0.023*400= 9.2g/400ml

2.7.2 Estimation of salmonella and shigella by using SS agar

52 grams SS agar is added in 1 liter of water for making solution.

1 liter= 1000 milliliter

52g/1000= 0.052

0.052*400= 20.8g/400ml

2.7.3 Estimation of E.coli and fecal coliform by using EMB agar

37.5 grams EMB agar is added in 1 liter of water for making solution.

1 liter= 1000 milliliter

37.5/1000= 0.0375

0.0375g *400ml= 15 g/400ml

After 2 hours nutrient agar, SS agar and EMB agar are taken out. Petri dishes are half filled with these solutions. Petri dishes are kept in vertical laminar flow cabinet. Filling is done inside it to avoid contact with bacteria. Before filling hands are sterilized with methylated spirit. When solidification occurs petri dishes are covered with the lid. Sample is taken with the help of micropipette. Amount of sample taken is 100 microliter. Sample is sprinkled over petri dish and spread with the help of glass spreader. Spreading is done at the angle of 45 degree. Before spreading it is sterilized with methylated spirit and then heated over spirit lamp. After spreading is done petri dishes are sealed with tape sample number, time and medium name is written over for identification purposes. Then petri dishes are kept in incubator for 24 to 48 hours at temperature of 36.6 °C. Petri dishes are kept inverted inside the incubator so that excess moisture stays on lid. Excess moisture is not given to bacteria otherwise bacteria may slip (Brenner et al., 1993).

Chapter 3

Results and discussions

This chapter includes the discussions and results obtained after experimentation. Results and discussion of physical, chemical and biological parameters of water samples collected from H11 sector.

3.1 Physical properties of water samples colleceted

S.No	Name (location)	pH	EC (µS/cm)	TDS (mg/l)	Salt (mg/l)	Temp (°C)	Turbidity (NTU)
1	Headstart school (front)	7.87	695	496	354	9.7	0
2	Headstart school (rare)	8.16	634	450	322	9.7	0
3	Beaconhouse international college	8.38	399	283	199	9.2	0
4	FAST	8.46	721	512	367	9.2	0
5	Al-Huda international	8.43	661	469	336	9.7	0
6	National institute of fire technology	8.41	646	460	329	9.5	0
7	Punjab college	8.87	398	281	197	8.9	0
8	Islamabad science school and college	8.74	538	383	272	9.5	0.11
9	EMS high school	8.77	682	485	347	9.6	0
10	The millennium university college	8.88	322	229	158	8.7	0
11	PSO H-11/1	8.72	727	517	370	8.7	0
12	Anti-narcotics force academy	8.85	752	534	384	9.0	0
13	National police academy	8.85	672	478	342	9.3	0
14	Slums H-11/2	8.77	701	498	356	9.3	0
15	Graveyard	8.78	655	465	332	9.2	0
16	PAEC general hospital	8.77	352	250	175	9.4	0
17	Ibn-e-sina institute of technology	8.81	639	455	324	8.9	0
18	Slums H-11/4	8.74	712	506	362	9.0	0
19	MosqueH-11/4	8.77	656	466	332	9.3	0
20	Bahria University H-11/4	8.82	729	517	371	9.0	0
21	WHO standard	6.5-8.5	1000	1200	Not specified	25	5

Table 3.1 physical properties of drinking water sample

3.1.1 Value of pH of drinking water samples

Figure 3.1 shows values of results of pH. This shows sample 10 which was collected from The millennium university college has the highest value of pH i.e. 8.88 and lowest value is of sample 1 which was collected from Headstart school i.e. 7.87. The value of pH of water samples only from sample 1 to sample 6 is within the permissible limit that is 6.5 to 8.5. The average value pH value of samples is 8.6. pH does not affect the health directly. But change in pH provide the habitat to different microbes and provide medium for various chemical reactions. It also shows pollution level. It is an indicator of acidity or basicity of substance determined by free hydrogen ions. Higher level of pH causes nausea, vomiting, diarrhea and kidney stones. Few samples from 7 to 20 have little higher pH than the permissible limit.

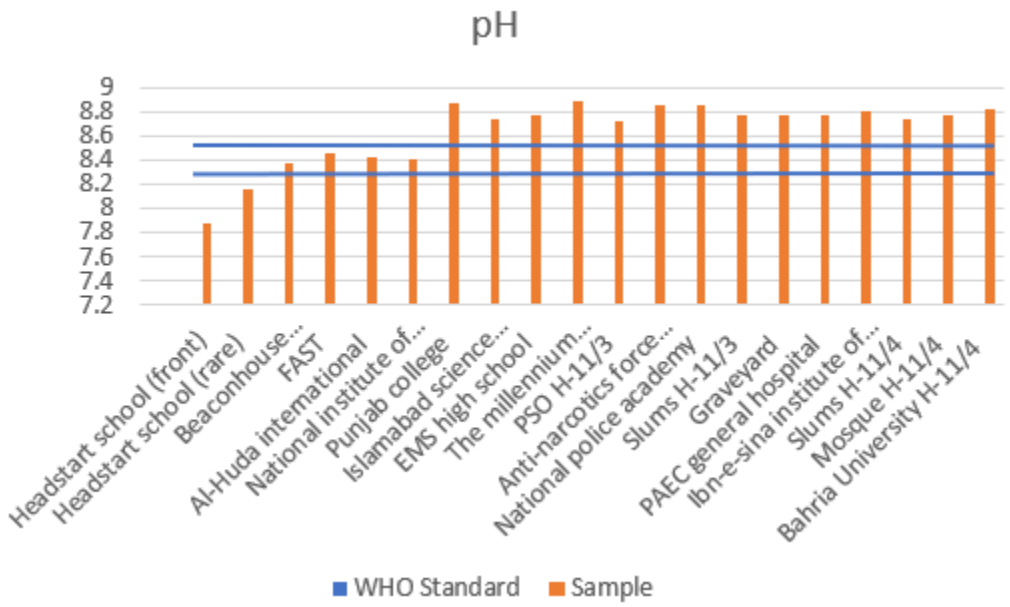
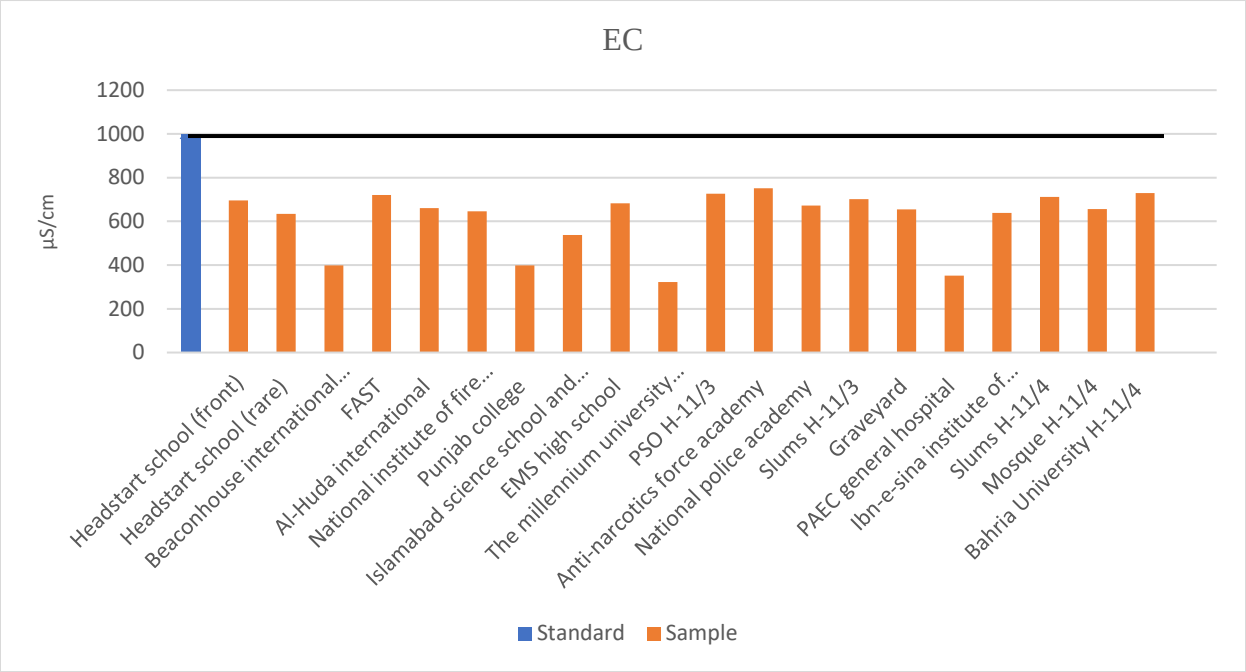


Figure 3.1 Value of pH of drinking water samples

3.1.2 Value of EC of drinking water samples

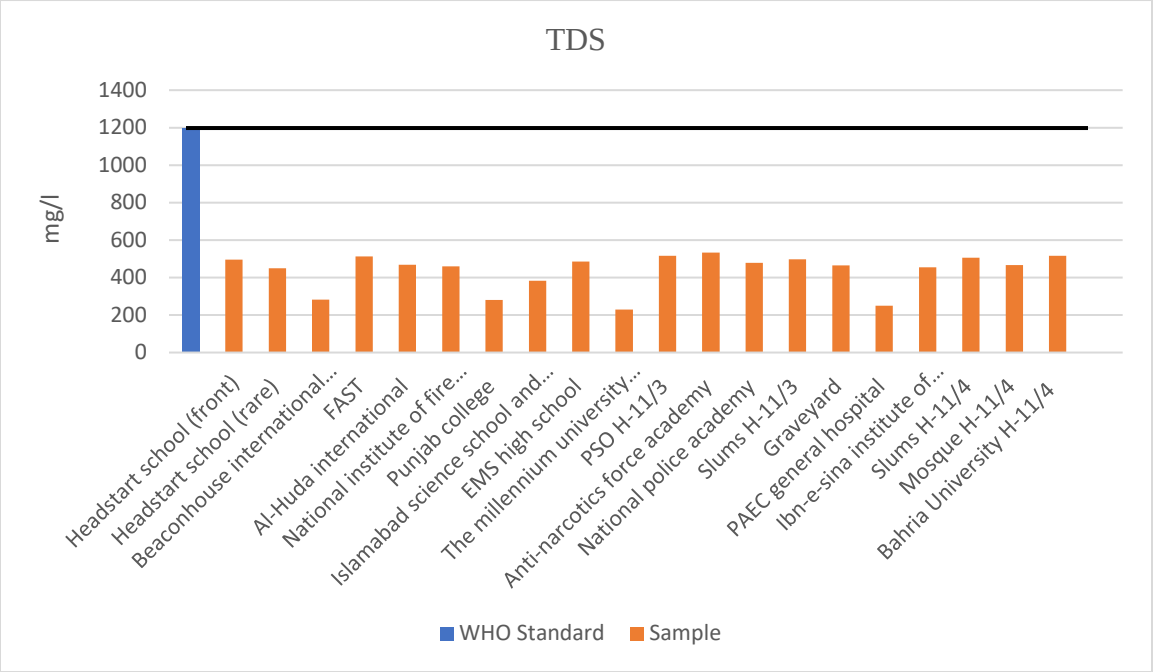
Sample 12 which was collected from Anti-Narcotics Force academy has the highest value of electrical conductivity i.e., 752µS/cm. The lowest value is of sample 10 collected from The millennium university college 322µS/cm. The average value of conductivity of samples is 614.55 µS/cm. The permissible value of conductivity is 1000 µS/cm. All the samples have value within the permissible limit. EC shows the presence of electrically charged particles present in water. Higher level of EC shows water is contaminated. High level of salts and inorganic ions present in sample gives high value of EC. High level of EC shows sewage intrusion in drinking water. It shows the ability of water to conduct electricity. But all the samples shown in the figure 3.2 have value within permissible limit.



3.2 Value of EC of drinking water samples

3.1.3 Value of TDS of drinking water samples

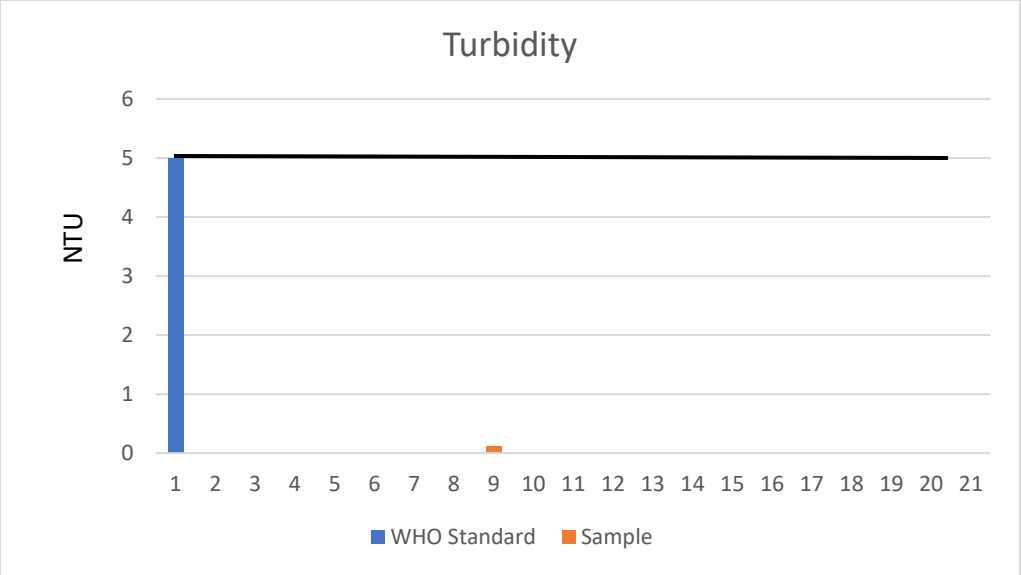
Highest value of TDS is 517 ppm of two samples collected from PSO petrol pump in H11/3 and of Bahria University H11/4. Lowest value is 229 mg/l of sample 10 collected from the millennium university college. Average value of TDS of samples collected is 436.7 mg/l. The standard value of TDS is 1200 mg/l. All the samples shown in figure 3.3 have value within the permissible limits. TDS include various materials dissolved in water sample. Certain materials like chlorides, carbonates, bicarbonates, magnesium and other inorganic ions are required. But their excessive concentration is harmful. All the samples have value within permissible limit. High level of TDS in water have negative effects on water which are vomiting, rashes, nausea and diarrhea. Exposure to high level of TDS for long period of time can cause chronic problems like lung cancer, liver and kidney problems.



3.3 value of TDS of drinking water samples

3.1.4 Value of turbidity of drinking water samples

Value of turbidity of all samples is zero except of Islamabad science school and college. It has the value of 0.11 NTU. The standard for turbidity is 5 NTU. But ideally should be less than 1 NTU. All the samples have value within the permissible limits. The average value of turbidity is 0.11 NTU. All the samples have value within the permissible limit. Turbidity is the cloudiness of water. It is caused by slit, clay organic material and microbes. Water having high value of turbidity is not acceptable. It can interfere with disinfection and can provide habitat to microbes and pathogens. Figure 3.4 depicts all samples were within the permissible limits.



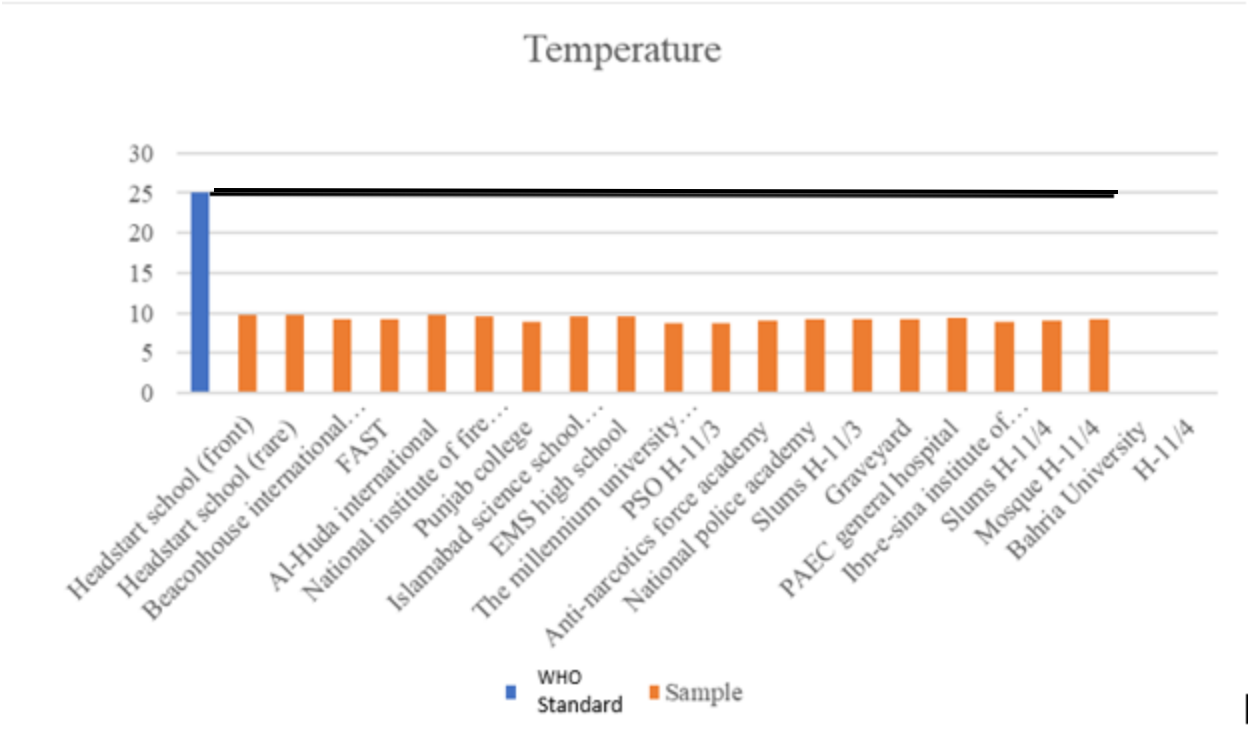
3.4 value of turbidity of drinking water samples

3.1.5 Value of salts of drinking water samples

Highest value of salts is of water sample collected from Anti-Narcotics force academy which is 384 mg/l. Lowest value is of sample from The millennium university college which is 158 mg/l. Average value of salts of samples is 311.4 mg/l. The standard value of overall salts is not given rather value of sodium permissible is given by WHO which is discussed in the chemical parameters. High level of salts in water are not good for health as it can cause muscle twitching, convulsion, vomiting and nausea. Long exposure can cause heart diseases. Low level of salts in water are also not good for health. It can cause headache, fatigue, drained energy and coma.

3.1.6 Value of temperature of drinking water samples

Value of temperature is highest of Al-Huda International and Headstart school. Value of temperature of both samples was 9.7°C. Lowest value of temperature was 8.7°C of PSO petrol pump and The millennium university college. Average value of temperature of samples is 9.24 °C. Permissible limit of temperature by WHO is 25°C. All the samples have value within the permissible limit. Temperature affects the water quality in such a way that it affects the various reactions and provide habitat to various organisms. These organisms can affect the health afterwards. Following figure 3.5 represents all samples have temperature within the permissible limit.



3.5 Value of temperature of drinking water samples

All the physical parameters except of pH for few samples from are within the permissible limit of WHO standards. Value of pH for few samples from locations Punjab College, Islamabad Science School and College, EMS high school, The Millennium University College, PSO H-11/1, Anti-Narcotics force academy, National Police academy, Slums H-11/2, graveyard, PAEC general hospital, Ibne-Sina Institute of Technology, slums H-11/4, mosque H-11/4 and Bahria University H-11/4 exceed only by few points.

3.2 Chemical properties of drinking water samples collected

S.No	Name (location)	$NaHCO_3$ (mg/l)	Na_2CO_3 (mg/l)	HCO_3- (mg/l)	CO_3 (mg/l)	Na^+ (mg/l)	Cl^- (mg/l)	NaCl (mg/l)	Hardness (mg/l)	Ca^{+2} (mg/l)	Mg^{+2} (mg/l)	Alkalinity (mg/l)
1	Headstart school (front)	0.0033	0.0041	0.0024	0.0023	213.9	330.1	544	5.1	3	2.1	3.8
2	Headstart school (rare)	0.0012	0.0015	0.0091	0.0009	44.39	68.51	112.9	3.4	1.8	1.6	4.4
3	Beaconhouse international college	0.0051	0.0064	0.0037	0.0036	163.3	252.0	415.3	1.9	1.5	0.4	1.2
4	FAST	0.001	0.0012	0.0007	0.0007	94.9	146.7	241.6	4.3	2.6	1.7	4
5	Al-Huda international	0.0092	0.001	0.0006	0.0006	74.75	115.9	190.7	3.2	2.22	0.78	3.8
6	National institute of fire technology	0.0092	0.001	0.0006	0.0006	134.15	206.9	341	4.66	2.36	2.3	4.04
7	Punjab college	0.0067	0.0084	0.0004	0.0004	31.28	48.2	79.5	2.44	1.76	0.68	2.2
8	Islamabad science school and college	0.0086	0.001	0.0005	0.0005	19.09	29.46	48.5	2.48	1.76	0.72	3.2
9	EMS high school	0.0028	0.0036	0.002	0.002	345	532.5	877.5	2.9	1.98	0.92	3.8
10	The millennium university college	0.0470	0.0593	0.0341	0.0336	57.5	88.7	146.2	1.62	1.4	0.22	1
11	PSO H-11/1	0.0003	0.0042	0.0002	0.0002	57.5	88.7	146.2	3.74	1.96	1.78	3.88
12	Anti-narcotics force academy	0.0092	0.0011	0.0006	0.0006	259.9	401.1	661	3.46	2.2	1.26	3.48

13	National police academy	0.0008	0.001	0.0006	0.0006	77.22	119.2	196.5	3.2	1.58	1.62	3.4
14	Slums H-11/2	0.001	0.0012	0.0007	0.0007	39.1	60.3	99.4	3	1.90	1.1	4.24
15	Graveyard	0.0924	0.0011	0.0671	0.066	40.48	62.4	102.9	4.72	2.02	2.7	3.84
16	PAEC general hospital	0.001	0.0012	0.0007	0.0007	42.15	64.9	107	3.32	2.42	0.9	3.8
17	Ibn-e-sina institute of technology	0.00006	0.0087	0.0005	0.0004	19.78	30.5	50.3	1.82	3.2	0.92	1.88
18	Slums H-11/4	0.0008	0.001	0.0006	0.0006	43.75	67.4	111.1	3.34	1.72	1.62	3.88
19	Mosque H-11/4	0.0008	0.001	0.0006	0.0006	48.35	74.5	122.8	4	1.92	2.08	4.12
20	Bahria University H-11/4	0.001	0.0013	0.0007	0.0007	39.1	60.3	99.4	4	2.26	1.74	4.2
21	WHO standard	150	20	400	400	250	250	Not specified	500	75	50	200

Table 3.2 chemical properties of water sample

3.2.1 Value of sodium bicarbonate in drinking water samples

Highest value is 0.047mg/l of The millennium university college. Lowest value is of Ibne-Sina institute of technology having value 0.00006972mg/l. Average value of all samples is 0.00477mg/l. Standard limit of sodium bicarbonate is 150mg/L. High level of sodium bicarbonate can cause muscle problems, headache, increased thirst and seizures. Small amount of sodium bicarbonate is safe to drink in water. However large quantities are not acceptable especially in children. But all our samples are within the permissible limit.

3.2.2 Value of sodium carbonate in drinking water samples

Highest value is 0.0593 mg/l of The millennium university college. Lowest value is of National police academy, slums H11/4 and of mosque H11/4. All the samples having lowest value is same that is 0.001059mg/l. Average value is 0.0046465mg/l. Standard limit of sodium carbonate is

20mg/l. High level of sodium carbonate can cause gastro problems, skin redness, stomach ache, nausea, vomiting, breathing problems, burns in mouth and throat and diarrhea. Small amount of sodium bicarbonate is safe to drink in water. All the samples have values within the permissible limit of WHO.

3.2.3 Value of bicarbonate in drinking water samples

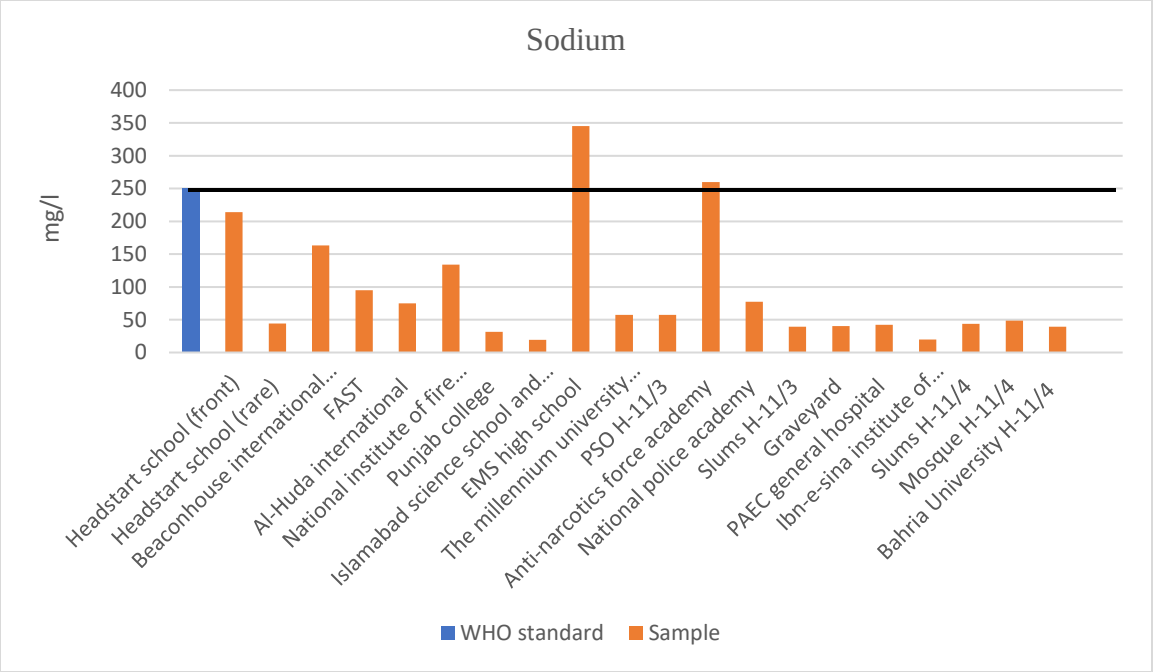
Highest value is 0.03416 mg/l of The millennium university college. Lowest value is of 0.000244mg/L of PSO petrol pump in H11. Average value is 0.002741g/L. Standard limit of bicarbonate is 400mg/L. Presence of bicarbonate in water gives water a good taste. High and low level than permissible limit is not good for health. All our samples are within the permissible limit.

3.2.4 Value of carbonate in drinking water samples

Highest value is 0.066 mg/l of graveyard of H11. Lowest value is of 0.00024mg/l of PSO petrol pump of H11. Average value is 0.0053817 mg/l. High level of carbonates can have negative effect. It can cause dryness and weaken the immune system. All the samples are within the permissible limit which is 400 mg/l.

3.2.5 Value of sodium in drinking water samples

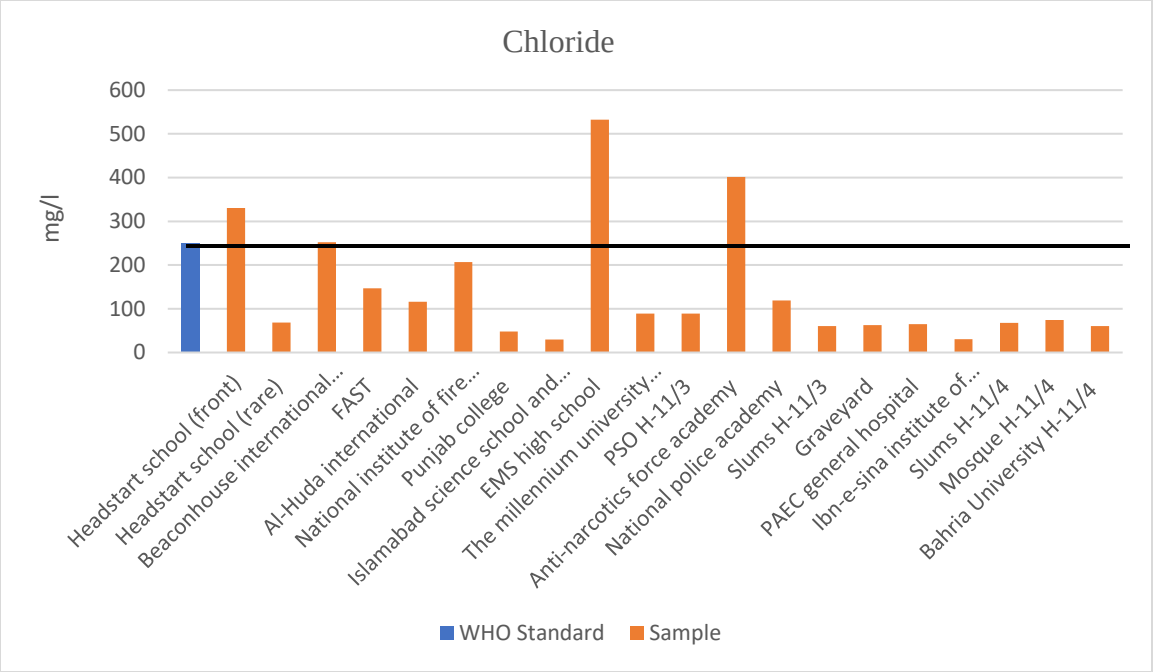
Highest value of sodium is of sample collected from EMS high school which is 345 mg/l. Lowest value is of Islamabad science school and college which is 19.009 mg/l. Average value is 95.99 mg/L. The standard limit of sodium is 250 mg/l. All the samples are within the limit except of EMS high school and Anti-Narcotics force academy. Sodium is required by human body for normal functioning, but excessive concentration causes various cardiovascular problems. As our all samples are not within the limit represented in the figure 3.6 so in long term it can cause problems in human body.



3.6 Value of sodium in drinking water samples

3.2.6 Value of chloride in drinking water samples

Highest value of chloride in water is from sample collected from EMS high school having the value 532.5 mg/l. Lowest value of chloride in water is 29.465 mg/l from sample collected from Islamabad science school and college. Average value is 141.094 mg/l. The standard limit of chloride is 250 mg/l. All the samples except one collected from Headstart school front side, Beaconhouse International college, EMS high school and Anti-Narcotics force academy have value within permissible limits. Chlorides value from these areas exceed the permissible limit. Chloride is required for normal physiology of body but large concentration in human body can cause problems like kidney stones and less ability to remove them. Unfortunately, our all samples are not within the limit as shown in figure 3.7 so in long term it can cause various health problems in human body.



3.7 Value of chloride in drinking water samples

3.2.7 Value of NaCl in drinking water samples

Highest value of sodium chloride in water is from sample collected from EMS high school. Value is 877.5 mg/l. Lowest value is 48.55 mg/l from Islamabad science school and college. Average value is 234.71 mg/l. Separate values of NaCl for standards is not set by WHO rather values for sodium and chloride are set within the limit.

3.2.8 Value of hardness in drinking water samples

Highest value of hardness is 5.1 mg/l of Headstart school front sample. Lowest value is 1.62 mg/l of The millennium university college. Average value is 3.18 mg/l. Standard value of hardness is 500 mg/L. All values are within limit. Hardness has both positive and negative value on health. However, it has negative effect on pipes and boilers. Hard water can cause dryness of body as well. As it causes deposition of salts decreasing their efficiency. Low level of hardness means low calcium meaning low pH which causes eye and nose irritation. But all our samples have value within the permissible limit, so it does not have negative effect.

3.2.9 Value of calcium in drinking water samples

Highest value of calcium is of Ibn-e-sina institute of technology front side i.e.3.2 mg/l. Lowest value is 1.4 mg/l of The millennium university college. Average value is 2.078mg/l. Standard value of calcium is 75 mg/l. All the samples have values within the permissible limit. Calcium is required for proper functioning. But their excessive concentration causes cardiovascular problems, stomach problems and nausea. Low level of calcium causes brain alteration, teeth

problems and osteoporosis. All the samples have values within the permissible limits. So, it does not have negative effects.

3.2.10 Value of magnesium in drinking water samples

Highest value of magnesium is 2.7mg/l of H11 graveyard and lowest value is 0.22 mg/l of The millennium University College. Average value is 1.357 mg/l. Standard value is 50mg/l. All the samples have values within the permissible limits. High level of magnesium can cause heart problems, fatigue, hyperventilation, muscle paralysis and low blood pressure. Low level of magnesium is not good as well. It causes osteoporosis, clogged arteries and high blood pressure. As all samples have high value within the permissible limit it cannot affect the health of people.

3.2.11 Value of alkalinity in drinking water samples

Highest value is of Headstart school rear side which is 4.4 mg/l and lowest value is of 1 mg/l of The millennium university college. Average value is 3.41 mg/l. The standard value for alkalinity is up to 200 mg/l. All the values of samples are within the permissible limit. Alkalinity is the ability of water to neutralize acid. High level of alkalinity is good for water because it keeps the water safe to drink. Our all water samples are within the permissible limits.

3.3 Biological properties

Serial no	Name (location)	EMB	SS	NA
1	Headstart school (front)	0	0	12
2	Headstart school (rare)	0	0	9
3	Beaconhouse international college	0	0	208
4	FAST	0	0	Uncountable
5	Al-Huda international	0	0	4
6	National institute of fire technology	0	3	Uncountable
7	Punjab college	0	0	70
8	Islamabad science school and college	0	0	Uncountable
9	EMS high school	0	0	2
10	The millennium university college	0	0	26
11	PSO H-11/1	0	0	Uncountable
12	Anti-narcotics force academy	0	0	Uncountable
13	National police academy	0	0	1
14	Slums H-11/2	0	0	151
15	Graveyard	0	0	14
16	PAEC general hospital	0	0	75
17	Ibn-e-sina institute of technology	0	0	82
18	Slums H-11/4	0	0	304
19	Mosque H-11/4	0	0	88
20	Bahria University H-11/4	0	0	3
21	WHO standard	0	0	100

Table 3.3 biological properties of drinking water sample

3.3.1 Result of estimation by EMB agar

E.coli and Coliform grow in EMB. All the samples have 0 growth of E.coli and Coliform bacteria which is in the permissible limit. Their presence indicates sewage contamination. This makes water unsuitable for consumption. But all our samples are free from E. coli and coliform.

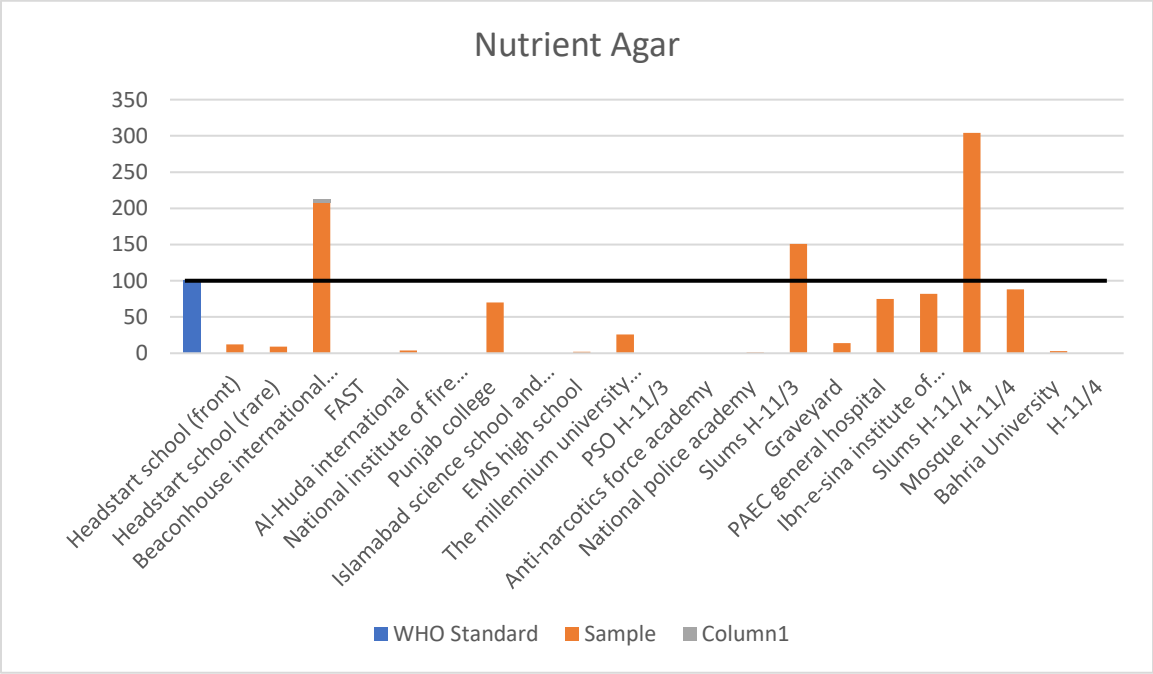
3.3.2 Result of estimation by SS agar

Permissible limit of salmonella and shigella is 0. All samples except National institute of fire technology have 0 growth which is in permissible limit. National institute of fire technology have

shown growth of 3 bacteria which is not in the permissible limit. They cause various gastro problems like cramps and diarrhea.

3.3.3 Result of estimation by NA

Total bacteria grow in NA. Water samples from slums in H11/4, H11/3, Anti-Narcotics force academy, PSO petrol pump in H11/3, Islamabad science school and college, National institute of fire technology, FAST and Beaconhouse international college have total bacteria greater than 100. So, these samples have bacteria greater than permissible limit. All other samples have total bacteria within limit. The water samples having total bacteria greater than permissible limit shown by the figure 3.8 will have negative effect on human health.



3.8 Number of all bacteria present in samples with standard

Conclusion

Water samples were collected from different educational institutes, graveyard, government offices and institutes and public places of H-11 sector of Islamabad. 20 samples were collected from H-11 sector of Islamabad. Physical, chemical and biological parameters were assessed of all samples. It was found out all the physical parameters except pH were within the permissible limit of WHO standards. pH of majority of samples was exceeding the normal value. pH of 14 samples was higher but not so much higher. pH of sample collected from Headstart school (front side), Headstart school (rare side), Beaconhouse international college, FAST, Al-Huda international and National institute of fire technology were within the permissible limit. While the pH of water samples collected from Punjab college, Islamabad science school and college, EMS high school, The millennium university college, PSO H-11/1, Anti-narcotics force academy, National police academy, Slums H-11/2, Graveyard, PAEC general hospital, Ibn-e-sina institute of technology, Slums H-11/4, Mosque H-11/4 and Bahria University H-11/4 was higher than the permissible limit. EC, turbidity, TDS and temperature values of all samples are within the permissible limits.

For chemical parameters the value of carbonates, sodium bicarbonate, bicarbonate and sodium carbonate of all samples was within the limit. The value of chlorides of all samples were within the limit except of EMS high school, Headstart school (front side), Beaconhouse International College and Anti-Narcotics force academy. While the value of chlorides of Headstrat school (rare side), FAST, Al-Huda International, National Institute of fire technology, Punjab College, Islambad Science School and college, The millennium university college, PSO H-11/3, National police academy, Slums H-11/2, Graveyard, PAEC general hospital, Ibn-e-sina institute of technology, Slums H-11/4, Mosque H-11/4 and Bahria University H-11/4 have values within the permissible limits. In regard of hardness, calcium, magnesium and alkalinity all values are within the standards.

In case of biological parameters all the samples were free from E.coli and coliform bacteria showing water is fit for consumption. Salmonella and shigella was only detected in National institute of fire technology. While all other samples from Headstart school (front and rare side both), Beaconhouse International College, Anti-Narcotics force academy, slums in H11/4, H11/3, PSO petrol pump in H11/3, Islamabad science school and college, Punjab College, EMS High School, The millennium university college, National police academy, Graveyard, PAEC general hospital, Ibn-e-sina institute of technology, FAST and AL-Huda International show no growth of salmonella and shigella. But in case of total bacteria water samples from slums in H11/4, H11/3, Anti-Narcotics force academy, PSO petrol pump in H11/3, Islamabad science school and college, National institute of fire technology, FAST and Beaconhouse international college have total bacteria greater than 100 exceeding the permissible limit, making it un-fit for consumption. All other samples Headstart school both front and rare side samples, Al-Huda International, Punjab College, EMS High School, The millennium university college, National police academy, Graveyard, PAEC general hospital, Ibn-e-sina institute of technology, Mosque H-11/4 and Bahria University H-11/4 show growth of total bacteria within the permissible limit.

On conduction of this study we came to know water samples from Al-Huda international and Headstart school sample from rear side are completely safe to drink. Their all physical, chemical and biological parameters are within the permissible limits set by WHO.

Recommendations

1) Water quality should be assessed regularly to know about the water quality.
2) Filtration plant should be installed, and water quality of filter should also be checked.
3) Water supply lines should be checked for leakages, blockages and breakages.
4) Management of institutes should provide hygienic conditions to students and staff by providing good water quality.

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