DRINKING WATER QUALITY ASSESSMENT OF GULRAIZ HOUSING SCHEME OF RAWALPINDI

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ABSTRACT

In this study, physical, chemical, and microbiological parameters of water samples gathered from Houses, filter plants and Boring wells of Rawalpindi, Pakistan were examined. Sampling was done at 12 different sites. Samples were collected in sterilized plastic bottles for analysis. The Physical parameters including pH, E.C (µs/cm), TDS (mg/l), Salt (mg/l) and Temperature (C°) were measured using a Multi Parameter Tester. Turbidity (NTU) was measured using Turbidity kit. Chemical parameters including Carbonate (CO_3^-), Bicarbonate (HCO_3^-), Na_2CO_3, (Sodium Carbonate), $NaHCO_3$ (Sodium Bicarbonate), Na^+ (Sodium), Cl^- (Chloride), NaCI (Sodium Chloride), Alkalinity and Hardness concentration were calculated by standard methods. Water Samples were analyzed bacteriologically for total viable count by heterotrophic plate count method in three media culture plates namely Nutrient Agar (NA), Eosin Methylene Blue (EMB) Agar and Macconkey agar. The Results for Electric Conductivity of samples shows that all the sample except FP7 were exceeding the permissible limits prescribed by World Health Organization (WHO) which is 400 µS/cm. Microbial Analysis showed that water samples contain microbial counts of different bacteria grown on nutrient agar. The quality of drinking water of Gulraiz Housing scheme of Rawalpindi must be monitored by relevant regulatory authorities. The government as well as public participation is needed to remediate and solve the problem.

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ABBRIVIATIONS

APHA	American Public Health Association
CFU	Colony Forming Units
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
EBT	Eriochrome Black-T
EPA	Environmental Protection Agency
EDTA	Ethylene diamine tetra acetic acid
E.M. B	Eosin Methylene Blue Agar
FP	Filtration plant
HAV	Hepatitis A virus
HEV	Hepatitis E virus
NaCl	Sodium Chloride
NA	Nutrient Agar
NSDWQ	National Standards for Drinking Water Quality
NTU	Nephelometric Turbidity Units
PEPA	Pakistan Environment Protection Act
PCRWR	Pakistan Council of Research in Water Resources
PSQCA	Pakistan Standard and Quality Control Authority
S.S	Salmonella Shigella
TA	Total Alkalinity
TC	Total Chlorides
TDS	Total Dissolved Solids
TH	Total Hardness
WAPDA	Water and Power Development Authority
WHO	World Health Organization

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CHAPTER 1

Introduction

1.1 Background

With increasing population and climate change, water born disease has been increasing worldwide. Pakistan, a country with population of 231.4 million people, has faced condition of diminishing natural resources. Poor sanitation, inappropriate water system, lack of health care facilities, social, political and environmental factors collectively lead a developing country like Pakistan into Health crises (Afshan Noureen 2022.) According to UNICEF report of 2008, approximately 1.8 million people die annually and 4 billion cases are involved with water related diseases which are becoming major root of mortality worldwide. In developing countries, 99.8% deaths occur due to such reasons and out of which 90% are children below five. In Pakistan, 30% people of urban areas live in slums. Majority of people who live near to open drains are effected by water born disease. Moreover, 14% of all expiries in children under five are because of diarrheal diseases. Pakistan is being hit by 112 billion rupees in cost of illness related hygiene factors (Zahid 2023.)

For this study particularly, Gulraiz housing scheme of Rawalpindi is selected. This study will assess the condition of drinking water in Gulraiz through chemical, physical and biological parameters of water quality. Data collection from Reliance hospital and Begum Akhtar Rukhsana Memorial Hospital briefed about severe conditions of health in Gulraiz housing scheme of Rawalpindi. Doctors said about the water born diseases' cases to rise in moon soon season. In moon soon time period, one out of three cases to be register in hospitals are of diarrhea. After realizing that disease spread through consumption of water, decision was made to assess house boring wells, in house filters, filter plants, water supply tankers, house tanks and ground water resources of tankers. At the end of the study, the results will be discussed about the variation of water quality among different segments of drinking water supplies.

1.2 World Water Distribution

Water is needed for the survival of all living things. Water makes up more than two-thirds of the human body, and without it, humans will perish in a matter of days. The mind of a human being is 95 percent water. Water makes up 82 percent of blood and 90 percent of lungs, respectively (Fine waters. 2006). In addition to the everyday care of the body water also performs a crucial part in the stoppage of syndrome. Research shows that intake of eight glasses of water in a day can reduce the threat of colon cancer by 45% and bladder cancer by 50% (APEC, 2006). About 70% of the whole earth is coated with water from which 97.5% is composed of brackish oceans. The left over 2.5% is freshwater. Out of this 2.5%, a smaller amount of 1% of freshwater is functional. Freshwater stock should be adequate to sustain the world's residents if maintained properly. Freshwater, however, is not supplied equally concerning people across the globe. Despite the fact that Asia is home to 60% of the world's population, it only has 36% of the world's total water supply. (Rice, 2017). Without even a small amount of water to drink, the human body gradually deteriorates and eventually dies from dehydration. However, the majority of people have access to a certain form of water supply that is adequate to meet the most basic human needs, despite the fact that these supplies may pose health risks due to poor quality in terms of basic hygiene.

1.3 Water crisis around the world

In the coming years, climate change and a growing inequity of freshwater supply, utilization of the water, and population increase will modify the water cycle significantly. Numerous districts of the world are as of now reserved by the sum and nature of accessible water. In the following 30 years alone, open spillover is probably not going to expand over 10%, yet the world's population is anticipated to ascend by around 33%. Except if the productivity of water use rises, this crisis will decrease freshwater biological community administrations, increase the number of aquatic species challenging extinction, and further segment wetlands, waterways, deltas, and estuaries. In the twentieth century, the total population increased, yet water usage for human dedications expanded six times. The extremely evident employments of water for humans are consumption, food preparation, laundry, and cleanup (William, 2014).

While predicting what is about to come is very difficult, one thing can be predicted with complete certainty: the world in the year 2025 will be inconceivably not quite the same as what it is today, similarly that the present reality is fundamentally unique as compare to what it was in 1975. The water segment is a basic element of the worldwide framework, and along these lines, it will experience real changes in the following 25 years (Biswas, 1999).

Waste disposal and land use are the most common reason for declining groundwater quality. The waste materials are stored in pits and mines. The water-soluble contaminants present in these wastes which are either dumped or are spilled on the ground ear accumulate and leachate into the groundwater. Another source of contamination of groundwater is the contaminated surface water which can infiltrate into the groundwater. The severity of the contaminations depends on the type of waste, the aquifer. The technique used for disposal of waste and climate. Another way the water quality is decreasing is by excessive pumping of groundwater. Due to this, the surrounding saline water is forced to take the place of pumped water to fill up the hollow space. Freshwater aquifers and its coastal areas are invaded by seawater due to excessive pumping (Cheremisinoff, 1998).

1.4 Drinking-Water Quality in Pakistan

Safe drinking water is described as water that does not signify any substantial threat to human strength over a life cycle of intake, containing any diverse sensitivity that may happen between lifetimes (WHO, 2017). Water is the most used fluid and is a known universal solvent therefore; it is the major source of transferring diseases (Aslam, 2018). Groundwater makes up about one-third of the total water resource in Pakistan and most of the water supplied to the community comes from groundwater. Pakistan will be facing major challenges associated with water in near future (Rubina, 2009).

Pakistan from being one of the water-abundant countries has now become a water-stressed country. The major source of economy its Pakistan is through irrigation. Indus basin is the most important source of water in the country and it provides water for 70% of the crop area. With the advent of advanced technologies and the rise in the population of Pakistan, the surface water came under stress to cover. In 1990, the water available per capita was 2172 cubic meters and since then it has declined to 1,306 cubic meters per capita in 2015. Annually 7.43% of drinkable water is extracted in Pakistan, which poses a lot of pressure on the resources. Waterborne diseases are very common among developing countries. The populace of Islamic Republic of Pakistan is now predictable to be additional than 160 million. With the current growing percentage of 1.8%, the residents of the nation are likely to have doubled over by the year 2025. Each head fall of water accessibility from 5600 m^3 to 1000 m^3 has critically increased the water quality and quantity matters.

Water pollution is caused when sewage water or industrial effluents are either mixed or leachates down in groundwater (Arora, 2007). As per the WHO report, 80% of diseases occur due to bacteriological contaminations in the water (Khan M. , 2013). Diarrhea, typhoid, intestinal worms, and gastroenteritis are the mutual water-borne diseases in Pakistan. In Pakistan, 25-28 billion Rs are annually spent in treating water-borne diseases, which results in about 0.6-1.44% of Pakistan's Gross Domestic Product (GDP). As per (WHO, 2017), 114 billion RS is the total health cost of Pakistan. It is expected that over 40% of entirely informed sicknesses and casualties in Pakistan are attached to inadequate water quality. Moreover, the important reason of mortality in babies and kids up to 10 years of age is that of polluted water. Each one-fifth resident endures from disease affected by hazardous water (A. Hisam, 2014).

1.5 Water Quality of Rawalpindi (Study Area)

Rawalpindi is a town in the Pothohar area of Islamic Republic of Pakistan beside Pakistan's capital city of Islamabad, in the state of Punjab. Rawalpindi is the 3rd-leadingmetropolis in Pakistan after Karachi and Lahore. According to the Water Quality Monitoring Report presented by PCRWR in 2005-06, the city faced the problem of Calcium, Hardness, Nitrate, TDS, and Microbiological contamination in drinking water. In 1993, an epidemic spread in the city due to poor water quality. This study is conducted to find out the current situation of drinking water quality of institutions (Ahmad, 2015).

Over a three-month period, microbial contamination and leftover chlorine were investigated in four different areas of Rawalpindi: Ratta Amral (R1), Satellite Town (R2), Westridge (R3), and Tench Road (R4). These areas receive treated water from the Khanpur and Rawal Lake Filtration Plants, which treat surface water using normal processes (coagulation, flocculation, and sedimentation). Eight sampling sites were chosen from each field to provide a comprehensive terrestrial study and, in turn, a comprehensive set of water residence times. Water samples from the water supply, overhead tank, and residential taps were used to assess the distribution network's drinking water quality. The consistency of the treated water has been determined to be insufficient. According to the results of the treated water quality assessment, the water is unfit for consumption and needs more traditional treatment, as well as testing and investigation of the distribution network. The finished water quality does not meet WHO potability requirements, mostly because of its microbial characteristics (Imran, 2012).

1.6 Filtration Plants

Filtration plants are utilized for a wide range of purposes: Pretreatment preceding other water treatment, circulation water, water restoration, heating water, cooling water, and wastewater, yet the principal use of the filtration plants is "water sanitization" and "Water decontamination". It is the way in the direction of clearing the undesirable synthetic mixtures, natural pollutants, suspended objects, and fumes from water. The goal is to provide water appropriate for a particular reason for example drinking, cultivation, and so forth. There are regulations for drinking water quality and are for the most part set by governments or as per the universal measures (Spellman, 2020).

(Marcuccia, 2001) Conducted a study that indicates that the membrane process is a modern technique for the treatment of fabric wastewater for reuse. The main approaches to the membrane filtration are RO (reverse osmosis) and NF (Nano-filtration) because they are technically and economically better than all other approaches. In addition, aside from the membrane filtration, another type of filtration is done in which Sand filters are used in the process of water cleaning. There are three major categories of sand filters which are rapid (gravity) sand filters, upward flow sand filters and third one is the slow sand filter. This method is mostly used in industries all over the world. In the first two methods, flocculent chemicals are used while in the slow sand filters are very effective which can produce a lot of clean water up to 90%.

A study was done by (Nitzsche, 2015) which presented that the effectiveness of the sand filters which were investigated were working efficiently and removing the unwanted particles from the drinking water even regardless of the usage practices and the sand usage duration. In addition, their research showed that there is a risk of growing E. coli Bacteria during the sand replacement process.

1.7 Water-Borne Diseases

Nearly All of the effects on human health are connected to both water condition and water capacity. The ingesting of water that is polluted by disease-causing representatives (or pathogens) or contaminated compounds can lead to health problems. These may be minor for example (diarrhea for one or two days), or very severe (including fatal effects). They may also be quick (termed acute) or extended (termed chronic) effects (Zahid, 2018).

Water quality is worsening in outmost areas and indication shows that the variety of freshwater species and environments is also undesirably influenced, quickly than continental and aquatic ecosystems. Poor water quality is the greatest reason of poor living and health. Worldwide, diarrheal sicknesses and malaria slew about 3.1 million people in 2002. 90% of these demises were of kids under the age of five (Zhu, 2017).

1.8 Key Facts regarding Drinking Water by WHO

- In 2017, 71% of the world populace (5.3 billion people) used a securely achieved drinking water carrier that is, one positioned on locations, obtainable when required, and free from infection.
- 90% of the international population (6.8 billion people) used at least a straightforward service. A fundamental provider is an upgraded drinking-water foundation in a spherical day journey of 30 minutes to accumulate water.
- 785 million human beings had no access even to a basic drinking-water service, together with a hundred and forty-four million human beings who are reliant on flood water.
- Worldwide, at least 2 billion individuals use a consumed water source polluted with feces.
- By 2025, semi of the world's populace will be existing in water-stressed parts.
- In least developed countries, 22% of Health care facilities have no water service, 21% no sanitation service, and 22% no waste management service (WHO, 2011).

1.9 Literature Review

Drinking water samples were obtained from schools and colleges in Islamabad to estimate the city's drinking water quality. Twenty of the thirty samples tested positive for faecal bacteria, making them unfit for human consumption. The most common and widespread hazard associated with drinking water is bacterial pollution. To examine microbial pollution in Rawalpindi and Islamabad's drinking water, 130 samples were obtained from thirty separate locations. Microbial contamination was observed in 56.1% of the water samples. Microbial pollution was 23.8 percent for faecal coliforms, 20 percent for E. coli, and 12.3 percent for total coliforms, respectively. Though thirty-two samples were collected from different water filtration plants throughout Islamabad city and found to be contaminated with total coliform, faecal coliform, and E. coli. The WASA supply lines were highly polluted, tailed by capital development authority lines and boring water, and less contamination was found in tanker water (A. Hisam et al., 2014).

For the first time in Pakistan's history, the Water policy was approved on April 24, 2018. The Policy aims at accomplishing the following objectives: to conserve and manage the present water resource, development of future resources to have optimal results, to remediate low water levels in low recharge areas and to increase extraction high recharge areas, to maximize crop production by drainage intervention, to advance flood control practices, to guarantee safe water quality and environmental hazards in irrigation areas to make responsible organizations more effective (Environment, 2005).

Water quality was also assessed in one of the oldest coastal village, of Pakistan, Rohri village. In the study, it was concluded that all the water samples were biologically contaminated. The water in the storage tanks was grossly contaminated due to unhygienic methods of handling. The water in all samples was unfit for drinking and could not be used without treatment (Hasnie et al., 2004).

Another study conducted cross sectional research in Peri urban community of Islamabad by filling questionnaire to assess the source of drinking water, its methods of disinfection and sanitary situation. The study comprised of 2,078 household. 76.4% household use water from CDA, 20% from ground water and 3.6% from other sources. 77% residents responded that they did not disinfect drinking water while only 23% did.

18.2% use boiling for disinfection and 1.9% use solar disinfection and 3.6% use aqua tabs (Ghazanfar et al., 2017.)

A case study conducted by Pak-EPA to examine the condition of water supply by filtration plants of Rawalpindi and Islamabad. For bacterial and chemical contamination, 26 filtration units were evaluated. Two plants were chemically contaminated, 14 were microbial contaminated and 16 plants were inefficient and providing unfit water to people (Ghalib et al., 2015.)

A study appraised the quality of potable water in Islamabad and Rawalpindi by analyzing physio-chemical and microbial parameters. The study reveals that drinking water was unsafe for human consumption as all samples were highly polluted with microbial contamination while Total dissolve solids, hardness and Calcium were also above the permissible limits of WHO and PSQCA (Mahmood et al., 2013.)

32 water filtration plants in Islamabad were analyzed for microbial contamination. Results showed that 23 samples were adulterated with E.coli and total coliform while only 9 samples were found to be free of contamination (Hisam et al., 2014.)

Research study for analyzing the water quality of rural areas of Rawalpindi was conducted. The results obtained were unacceptable because it exceeded the limits set by WHO. The most common parameters which surpassed the values were *E.coli*, Iron, total coliform, Nitrate, and Sodium. Due announcement of political agencies and policymakers of drinking water is the need of hour as recommended by the study (Tahir et al., 1998).

Unfortunately, in Pakistan agencies responsible for water supply are more focused on supplying enough to the public relatively than supplying safe water to the public. Since the country is a deficient strong legal framework for water quality, management and monitoring techniques, certified laboratories for testing, the condition of water is declining rapidly (Haydar et al., 2016).

Therefore, in the light of prevalence drinking water quality issues in Rawalpindi, the present study is conducted to analyze various parameters of drinking water in Gulraiz housing scheme of Islamabad.

1.10 Objectives

The study was designed with the following objectives.

1. To assess the drinking water on the Physical parameters of Gulraiz Housing Scheme of Rawalpindi
2. To assess the drinking water on the Chemical parameters of Gulraiz Housing Scheme of Rawalpindi
3. To determine the microbial counts of the water samples

CHAPTER 2

MATERIALS AND METHODS

2.1 Description of Study area

Figure 2.1 Study area map

Gulraiz is a housing colony located in city Rawalpindi, it is bordering to the capital of Pakistan, Islamabad. Rawalpindi is the fourth major city of Pakistan. It is in the northernmost part of Punjab, with a latitude of 33.626057 and a longitude of 73.071442. Rawalpindi is also known as twin cities along with the capital Islamabad. Water supply in Rawalpindi consists of the groundwater source, which is being utilized each day by a total population of 2.098 million people. Rawalpindi topographies a moist semi tropical weather with warm summers and comparatively drizzly monsoon and cold winter season. The environment is highly inconsistent due to the closeness of the town to the hills of the Himalayas (Imran et al., 2012).

The normal yearly rain is 1,200 mm maximum of which occurs during the summer monsoon season. Yet, the western breeze also brings important precipitation in the winter. In summers, the recorded extreme temperature is 48.4°C noted in June 1954. Although it can drop up to a lowest of a -3.9°C which was recorded in January 1967 (Sara Qaiser, 2012).

The study was conducted in the Gulraiz Housing Scheme of Rawalpindi. After selecting the housing scheme, then collected water samples from House boring wells, in house filters, filter plants, water supply tankers and ground water sources of tankers. These samples were selected to check all the possible means of drinking water to be assessed. This will also create a clear comparison about quality of water at filter plants, in house filters and ground water resources of tankers.

2.2 Sample collection

Water sampling was done to analyze microbial and physio-chemical parameters in the drinking water source of Gulraiz scheme of Rawalpindi. 12 samples were collected from the sites:

No. of samples	**Collection point**	**Sample ID**
3	House boring well	(S1, S2, S3)
3	In house filters	(S4, S5, S6)
2	Filter plants	(S7, S8)
2	Water supply tankers	(S9,S10)
2	Ground water source of tankers	(S11, S12)

Table 2.1 showing sources of sample collection

Sampling Points	Latitude	Longitude
S1	33.5591236	73.1046062
S2	33.5608368	73.1036463
S3	33.5640075	73.1084813
S4	33.5583234	73.1057203
S5	33.5591970	73.1060877
S6	33.5654286	73.1050464
S7	33.5649959	73.1085363
S8	33.5627933	73.1068984
S9	Mobile	Mobile
S10	Mobile	Mobile
S11	33.5499903	73.1218984
S12	33.5662846	73.1192728

Table 2.2. Sample points from where collected

Water could flow for 2 to 3 minutes before pouring into the labeled bottles that were then transported to the laboratory of Bahria University under recommended conditions. Samples were collected according to standard protocols in polyethylene bottles of 150ml that were carefully cleaned by the distilled water thoroughly. For the analysis of biological parameters sterilized bottles of 100ml were used. The source of sample for biological testing and analysis of physio-chemical testing was filtration plants of institutes. The microbial analysis was carried out within 24 hours of collection of the water samples.

After the collection of samples, these parameters were measured.

- Physical parameters
- Chemical parameters
- Biological parameters

2.3 Physical Parameter

The parameter, which was calculated were pH, Temperature, Electrical Conductivity, Salts, Total Dissolve Solids and Turbidity for the water sample collected from filtration plants. Physical parameters were measured using a multi-parameter device. Apparatus was adjusted earlier usage and the probe was rinsed with distilled water before usage to obtain the appropriate results. To prevent any variation in outcomes, samples were well shaken and let the sample to become stable till no air bubble was left. Probe was sunk into the sample water and swirled constantly until the values for EC and pH was become stable.

2.3.1 pH

2.3.1.1 Principle

The pH, which is an evaluation of the hydrogen and hydroxyl ion action of the water structure, reveals whether the water is acidic, neutral, or alkaline in reaction. The pH of the pure water is 7. In typical, water along with a pH lesser than 7 is measured acidic, and along with a pH more than 7 is considered basic. The pH value has no health normal but a value of 6.5 to 8.5 is safe for use (Aremu et al., 2011).

2.3.1.2 Apparatus used

- Beaker
- Measuring cylinder
- Multi-Parameter Analyzer

2.3.1.3 Chemicals used

- Distilled water
- Water sample

2.3.1.4 Procedure

pH was measured using the device called Multi-Parameter Device. Firstly, a beaker was taken and washed carefully with distilled water. Then, 50 ml of water sample collected from the institute was measured in a measuring cylinder and the sample was discharged into the beaker. pH meter was taken, and its tip was washed with distilled water first, when washed thoroughly dipped it in the beaker comprising the sample. After waiting for 1-minute reading was taken and noted for each sample (Karanth et al., 1987).

2.3.2 Temperature

2.3.2.1 Principle

The temperature of water is a physical property that explains how hot or cold it is. Temperature may also be distinguished as a sum of an element's daily warm air energy, since hot and cold are mutually uninformed words. Temperature affects the average kinetic energy of atoms and molecules because thermal energy is the dynamic energy of atoms and molecules. The movement of temperature will transport this energy among the elements. The temperature of water may be affected by heat transfer, whether from the air, sun, additional water basis, or warm air pollution. When assessing water quality, temperature is an important factor to consider. (Ezeribe et al., 2012). Temperature has several additional limits and can affect the physical, chemical, and biological properties of water in addition to its individual components.

2.3.2.2 Apparatus used

- Beaker
- Measuring cylinder
- Multi-Parameter Analyzer

2.3.2.3 Chemicals used

- Distilled water
- Water sample

2.3.2.4 Procedure

Temperature was measured using the device called Multi-Parameter Device. Firstly, a beaker was taken and washed carefully with distilled water. Then, 50 ml of water sample collected from institutes was calculated in a measuring cylinder and the sample was emptied into the beaker. Multi-Parameter meter was taken, and its tip was washed with distilled water first, when washed thoroughly dipped it in the beaker comprising the sample. After waiting for 1-minute reading was taken and noted for each sample (Gupta et al., 2009).

2.3.3 Total Dissolved Solids (TDS)

2.3.3.1 Principle

A total dissolved solid (TDS) is distinct as entirely mineral and biological constituents confined in water that can permit over a 2-micron screen. In general, TDS is the summation of positive ion and negative ion in water. Particles and ionic compounds manufacture TDS frequently contain carbonate, hydrogen carbonate, chloride, fluoride, sulfate, phosphate, nitrate, calcium, and potassium, simply particle that is existing will subsidize to the whole. The biological ions contain impurities, weed killers, and hydrocarbons. Major causes for TDS in getting waters are agricultural and housing overflow, clay-rich foothill waters, leakage of earth pollution, and point source water effluent release from manufacturing factories or manure treatment plants (Sasikaran et al., 2012).

2.3.3.2 Apparatus used

- Beaker
- Measuring cylinder
- Multi-Parameter Analyzer

2.3.3.3 Chemicals used

- Distilled water
- Water sample

2.3.3.4 Procedure

Total Dissolved Solids (TDS) was measured using the device called Multi-Parameter Device. Firstly, a beaker was taken and washed carefully with distilled water. Then, 50 ml of water sample collected from institutes was calculated in a measuring cylinder and the sample was emptied into the beaker. Multi-Parameter meter was taken, and its tip was washed with distilled water first, when washed thoroughly dipped it in the beaker comprising the sample. After waiting for 1-minute reading was taken and noted for each sample (EPA, 2001).

2.3.4 Electrical Conductivity

2.3.4.1 Principle

EC or Electrical Conductivity of water is its capacity to conduct an electric current. The EC meter (electrical conductivity meter) measures in Siemens and the unit is µS, which means micro Siemens (one-millionth of a Siemens). Common salt or further substances that liquefy in water can breakdown into positively and negatively charged particles. These unrestricted particles in the water transmit electrical energy, therefore the water's electric conduction varies on the absorption of ions. Saltiness and total dissolved solids (TDS) are used to analyze the EC of water, which assist to specify the water's clearness. The pure the water is, the lesser the conduction (Khan et al, 2012). Main positively electric ions that disturb the conduction of water are sodium, calcium, potassium, and magnesium. Main negatively electric ions are chloride, sulfate, carbonate, and bicarbonate. Nitrates and phosphates are negligible suppliers to conduction, but they are very significant organically. The ordinary effects on EC in water are rain, geology, and evaporation.

2.3.4.2 Instruments used

- Beaker
- Graduated cylinder
- Multi-Parameter Tester

2.3.4.3 Chemicals used

- Distilled water
- Water sample

2.3.4.4 Procedure

Electrical Conductivity (EC) was measured using the device called Multi-Parameter Device. Firstly, a beaker was taken and washed carefully with distilled water. Then, 50 ml of water sample collected from institutes was calculated in a measuring cylinder and the sample was emptied into the beaker. Multi-Parameter meter was taken, and its tip was washed with distilled water first, when washed thoroughly dipped it in the beaker comprising the sample. After waiting for 1-minute reading was taken and noted for each sample.

2.3.5 Turbidity

2.3.5.1 Principle

Turbidity is the muddiness or fogginess of a liquid produced by many separate atoms that are in general unseen to the bare eye. Turbidity analyzing in drinking water is vital as of the chance that microorganisms utilize the suspended elements to hide from the substances that services use for decontamination. It is a cumulative visual stuff of the water and does not classify separate elements; it just declares something is there. Water generally encompasses suspended objects that contains many diverse elements of changing dimensions. Creatures like phytoplankton can donate to turbidness in vulnerable water. Corrosion and waste from extremely industrialized regions enhance the turbidness of waters in those zones. Building, excavating, and agricultural trouble the land and can guide to increase stages of deposits, which run off into channels through storms. Storm water from outsides like streets, bridges, and car park lots also contribute to turbidness. In drinking water, the higher the level of turbidness, the higher the chance that those using it could develop stomach sicknesses. Pollutants like bugs and infective germs can attribute themselves to the suspended solids (Kitchener et al., 2017).

2.3.5.2 Instruments used

- Turbidity Kit

2.3.5.3 Chemicals used

- Distilled water
- Water sample

2.3.5.2 Procedure

10 ml of sample was carried in the flask that arrived with the kit. Placed that sample in the Turbidity-measuring device. After positioning, the sample in the Turbidity measuring device pressed Test/CAL and permitted the beam to pass throughout the sample. The grains halted in the water will broaden a beam ray concentrated on them. The dispersed light is then calculated at different positions from the incident light path and readings were noted down.

2.3.6 Total Salts

2.3.6.1 Principle

Salts present in drinking water are because of the different dissolved salts for example NaCl. There are many types of salts present in drinking water like potassium salt, sodium chloride etc. The composition of salts is composed of ions for example in the case of any Cl, it contains sodium as a cations having a positive charge on it while chloride is considered as anions having a negative charge on it. The presence of salts in an aqueous solution is what makes it conducive for electric current. The concentration of salts is directly proportional to the electric current. The greater the concentration of salt greater will be the concentration of electric current. The acceptable maximum value for salts in drinking water is 200 mg/l (Stefanie, 2016)

2.3.6.2 Apparatus used

- Beaker
- Measuring cylinder
- Multi-Parameter Analyzer

2.3.6.3 Chemicals used

- Distilled water
- Water sample

2.3.6.4 Procedure

Total Salts was measured using the device called Multi-Parameter Device. Firstly, a beaker was taken and washed carefully with distilled water. Then, 50 ml of water sample collected from institutes was calculated in a measuring cylinder and the sample was emptied into the beaker. Multi-Parameter meter was taken, and its tip was washed with distilled water first, when washed thoroughly dipped it in the beaker comprising the sample. After waiting for 1-minute reading was taken and noted for each sample (EPA, 2001).

2.4 Chemical Parameter

The parameter that was calculated were Carbonate Test, Alkalinity Test, Chloride Test, and Total Hardness for the water sample collected from filtration plants.

2.4.1 Alkalinity

2.4.1.1 Principle

Alkalinity is an amount of the competence of water to defuse acid. Alkalinity of water is due to the existence of hydrogen carbonate (HCO_3), carbonate (Co_3^{-2}), and hydrated oxide (OH-). Salts of week acids, such as borates, silicate, and phosphate might to add to alkalinity. Salts of definite biological acids may donate to alkalinity in contaminated or an aerobiotic water, but their involvement is generally unimportant. Bicarbonate ions are most important supplier to alkalinity. Carbonates and hydroxide may be considerable when algal movement is extreme and in certain manufacturing water and Wastewater, such as reservoir water (Umer et al, 2015).

2.4.1.2 Instruments used

- Burette
- Burettes stand
- Beaker
- Dropper
- Erlenmeyer flask
- pH meter

2.4.1.2 Chemicals used

- Sulfuric acid (H_2SO_4 0.02 M)
- Sodium Carbonate (Primary Standard) Solution
- Phenolphthalein ($C_{20}H_{14}O_4$)
- Methyl Orange (Indicator Solution)

2.4.1.3 Formula Used

$$Alkalinity\frac{mg}{L} = \frac{N \times V \times 1000}{Sample\ Volume}$$

N = Normality of sulfuric acid

V=Amount of chemical used

2.4.1.4 Procedure

Took 50ml of a water sample in a titration container and measure its initial pH with pH meter. For phenolphthalein alkalinity add 1 drop of phenolphthalein to the container and spin to blend. Fill a 50 ml burette 0.02M H_2SO_4 average solution. Titrate the sample while spinning the bottle till the result changes from pink to pale. Note the capacity of acid utilized. For over-all alkalinity add 2 droplets of methyl orange indicator in the similar titration container and swirl to mix. Last the titration till end is reach. I.e., yellow to pink. Note the total volume of acid used (EPA, 2001).

2.4.2 Total Hardness

2.4.2.1 Principle

Hardness of water is the soap consuming ability or the capacity to form scale in the warm water channels, reservoirs, and extra components in which temperature of water is increased considerably; therefore, water that cannot produce lather soap easily is termed as hard water. Conversely water that produce lather with soap is termed as soft water (Joseph Cotruvo et al., 2010).

2.4.2.2 Instrument Used

- Burette
- Burettes stand
- Beaker
- Volumetric Flask
- 250 ml Erlenmeyer flask
- pH meter
- Pipette

2.4.2.3 Chemicals Used

- Standard EDTA solution (0.01 M)
- Eriochrome Black T (EBT) Indicator
- Ammonium Chloride (NH_4CL) Buffer Solution

2.4.2.4 Formula Used

$$Total\ Hardness = \frac{A \times B \times 1000}{Sample\ Volume}$$

A= EDTA used for Sample-EDTA used for Blank Sample

B=mg of $CaCO_3$ equivalent of 1 ml of EDTA titrant

2.4.2.5 Procedure

ln this assessment, the burette was occupied with Ethylene Diumine Triacetin Acid (EDTA) and poured 50 ml of distilled water in a measuring cylinder and emptied it in a conical flask. With a 1 ml nozzle add 2 ml of Ammonium chloride NH_4Cl in the absolute water sample and then check its pH with a pH meter. See if its pH was superior, then or equivalent to 10, afterward we added two droplets of indicator Eriochrome Black T (EBT), with the help of glass dropper which twisted the sample red, after titration it altered its dye to blue which was its finish point. The similar process was recurring for the water samples. The worth of EDTA used for blank sample was deducted from the value of EDTA used for water samples (EPA, 2001).

2.4.3 Carbonate

2.4.3.1 Principle

One of the major components of water is carbonates and bicarbonates ion, whose concentration in water is found to increase in places where minerals and rock bodies are found near the water source. Since rock-weathering results in the dissolution of bicarbonates and ions of carbonates in water. They contribute to hardness and alkalinity characteristics when bicarbonates and carbonates are present in water. About permissible limit of carbonates and bicarbonates in drinking water, no guidelines have been issued by WHO (Ming et al., 2017).

2.4.3.2 Instrument Used

- Burette
- Burettes stand
- Graduated Cylinder
- Erlenmeyer flask
- Dropper

2.4.3.3 Chemicals Used

- Hydrochloric acid (HCL 0.01 M)
- Methyl Orange

2.4.3.4 Formula Used

$$\frac{m1 \times v1}{n1} = \frac{m2 \times v2}{n2}$$

m=Molarity

v=Volume of Solution

n=Number of Moles

After finding Molarity, this value is multiplied by Molecular weight of the required carbonate by using the formula.

Amount per dm^3= m × Molecular Weight of Chemical Compound

By using this Formula, concentration of $NaHCO_3$, Na_2CO_3, HCO_3^- and CO_3 was determined.

2.4.3.5 Procedure

In carbonate assessment, burette was jam-packed with reagent hydrochloric acid 0.1 M, 10 ml of water sample was measured in measuring cylinder and afterward emptied it in a flask and with the assistance of glass dropper added two drops of indicator methyl orange, after titration the sample changes, color from orange to pink, pink being its finish point (EPA, 2001).

2.4.4 Chloride

2.4.4.1 Principle

Chlorides (Cl-ions) is the main inorganic negative ion in Fresh water. It is present naturally in all types of water. The discharge of the domestic wastewater is the key foundation of chlorides in the receiving water bodies. Chlorides are generally dispersed as salt of calcium, sodium, and potassium in water. In drinking water, the salted flavor formed by chloride concentrations is unpredictable and reliant on the chemical configuration of water. The main flavor making salts in water are sodium chloride and calcium chloride. In some water which is having only 250 mg/L of chloride may have a detectable salty taste if the cations present (APHA, 2005).

2.4.4.2 Instrument Used

- Burette
- Burettes stand
- Graduated Cylinder
- Conical flask
- Dropper

2.4.4.3 Chemicals Used

- Silver Nitrate (Ag_2NO_3 0.01 M)
- Potassium Chromate (K_2CrO_4)

2.4.4.4 Formula Used

$$Chlorides\,\frac{mg}{L} = \frac{V\ \times\ N \times\ 35.54\ \times\ 1000}{Sample\ Volume}$$

N = Normality of silver nitrate

V =Amount of reagent used

2.4.4.5 Procedure

In this assessment the burette was occupied with chemical Ag_2NO_3 of molar concentration 0.01 M and the sample was restrained in the measuring cylinder about 10 ml which was then emptied in the Conical flask. Three drops of Potassium Chromate with the help of glass dropper are added which twisted the sample light yellow, after titration the end was a reddish color, which was its finish point (EPA, 2001).

2.5 Microbiological parameter

2.5.1 Total plate count

2.5.1.1 Principle

In several portions of the world, pollution of drinking water with infective microorganisms is considered as one of the extremely serious pressures to the individual’s resultant in thoughtful sicknesses. Some diseases like diarrhea, typhoid, paratyphoid, cholera, hepatitis A, enteric fever, dermatitis, and many everlasting health sicknesses are beginning due to the ingestion of water that is filthy with infective microbes. Aquatic diseases typically happen once water is polluted with fecal material, specifically humanoid feces that have infective bacteria (Johar et al., 2010).

2.5.1.2 Instruments used

- Petri dishes
- Funnel
- Graduated cylinder
- Beakers
- Autoclave
- Aluminum foil/newspaper
- Tape
- Weight apparatus
- Spatula
- Glass spreader
- Spirit lamp
- Nozzle
- Micro pipette
- Incubator
- Marker

2.5.1.3 Chemicals Used

- Nutrient Agar (NA)
- Macconkey Agar
- Distilled water
- Methylated Spirit

2.5.1.4 Procedure

Initially, three media culture plates were prepared in the lab: Nutrient Agar (NA), and Macconkey Agar. The plates were organised according to the sample size and covered with aluminium foil or newspaper using tape. The autoclave was used to sterilise the whole thing for 30 minutes at 121°C before being opened in the laminar flow. Each media was put in its own petri dish. On the same day, samples for biological parameters were collected and opened in the laminar flow, with each sample being opened one by one. After collecting the sample from the container, the pipette was used to pour the sample onto the media, and the water sample was spread evenly on the media with the aid of a glass spreader after each dish. The spreader was washed with spirit, which was then dried and cooled using a spirit lamp. After each sample was closed and labelled, the Petri dishes were turned upside down and placed in the incubator (30°C36°C), where they were observed after 24 hours. To count the bacteria, the Petri dish was divided into two sections with the aid of a marker. (Nitzsche et al., 2015).

Figure 2.1 Spreading of Water Samples on different media plates

CHAPTER 3

RESULTS AND DISSCUSIONS

In current study, different samples were examined water samples of the study area to determine their quality. The complete results of all the parameters were linked with the drinking water quality guidelines given by WHO and PAK-EPA.

3.1. Physical Parameters

After conducting tests for various physical parameters of water in lab, the results obtained were noted and are presented in the form of table. Total 12 samples were collected from Gulraiz scheme of Rawalpindi. All samples were collected from the house boring wells, in house filters, filter plants, supplier tankers and ground water source of water supplier tankers. The table 3.1 shows the results of physical parameters.

Table 3.1. Results of Physical Parameters of water samples

Sample ID	pH (pH)	TDS (ppm)	EC (µS/cm)	Salt (ppm)	Temperature (C°)	Turbidity (NTU)
S1	7.5	397	496	269	23.5	0.00
S2	7.8	352	473	237	23.5	0.00
S3	7.6	295	465	298	22.7	0.00
S4	7.2	397	381	198	23.6	0.00
S5	7.3	352	437	227	23.6	0.00
S6	7.4	485	421	238	19.6	0.00
S7	6.9	481	407	254	21.5	0.00
S8	6.8	471	423	253	22.4	0.00
S9	7.1	380	490	354	22.7	0.40
S10	7.1	484	444	250	22.4	0.00
S11	7.2	596	456	269	19.3	0.00
S12	7.2	580	450	245	19.4	0.00
WHO	**6.5-8.5**	**500**	**400**	**200**	**30**	**4**

3.1.1 Electrical Conductivity

Electrical conductivity is a physical parameter. It is basically measure of electrical current that water allows to pass through it. The permissible limit for EC is 400µs/cm. In this study it was analyzed that except sample ID S4 collected from water supply tankers in Gulraiz, all other samples were above the permissible limits. The maximum concentration was found in sample ID S1 and S9 i.e., 496 and 490, respectively. Only sample ID S10 was found within the permissible limits of WHO.

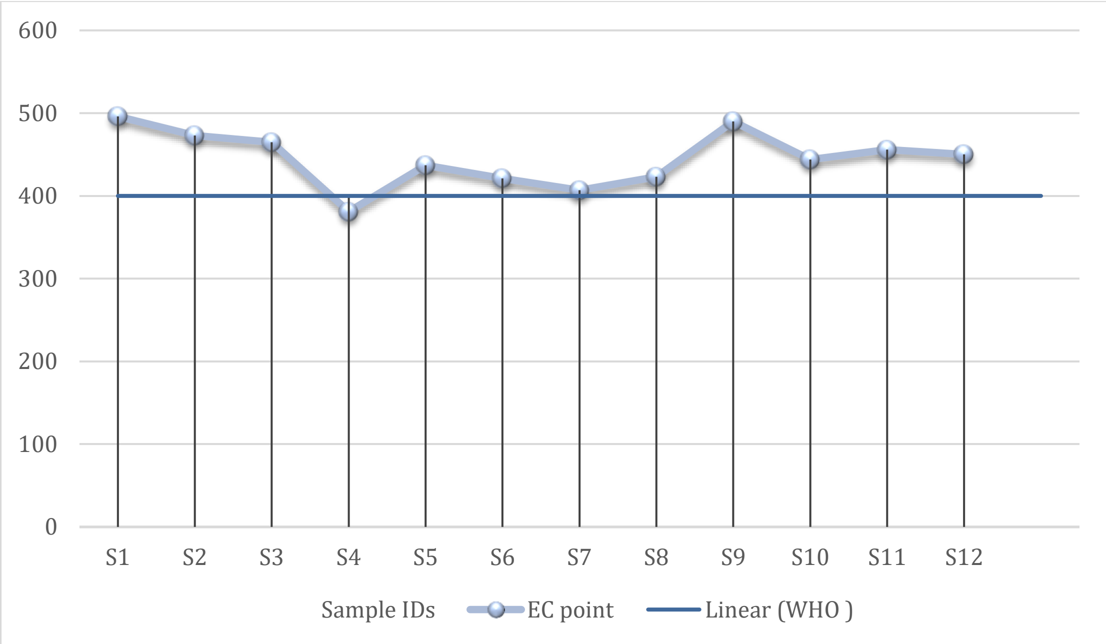

Figure 3.1. Results of EC of water samples

3.1.2 pH

pH is a vital parameter in estimating the acid-base equilibrium of water. It's additionally the indicator of acidic and basic condition of water status. WHO has given the permissible limit of pH 7.5 to 8.5.

In this study, pH analyzed was ranged between 6.8-7.8 pH. All the samples have shown the pH concentration within the defined limits of WHO. No sample was exceeding the permissible limit. The maximum concentration of 7.5, 7.6 and 7.8 were found at samples S1, S3 and S2 respectively.

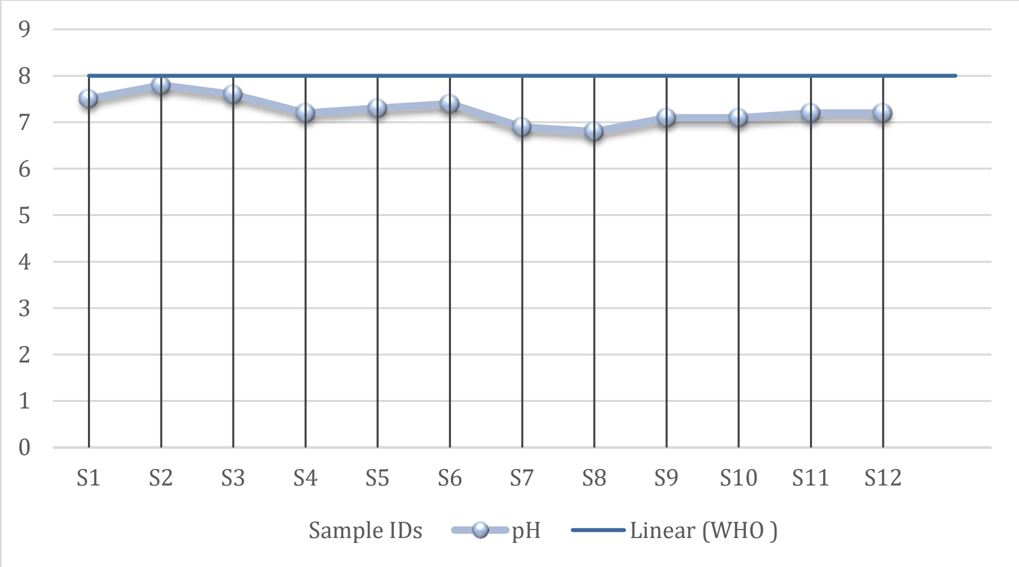

Figure 3.2. Results of pH of water samples

3.1.3 Salts

Sodium is important for normal functioning of the physical body. It will be found in whole body tissues and fluids. The permissible limit for NA is 200 mg/l. Na could influence the taste of drinking water at level higher than the permissible limit.

The sample ID from S1 to S12 except S4 have shown the results above the permissible limits of WHO. The highest concentration of salts was found in samples S9. The minimum concentration was found in sample ID S4.

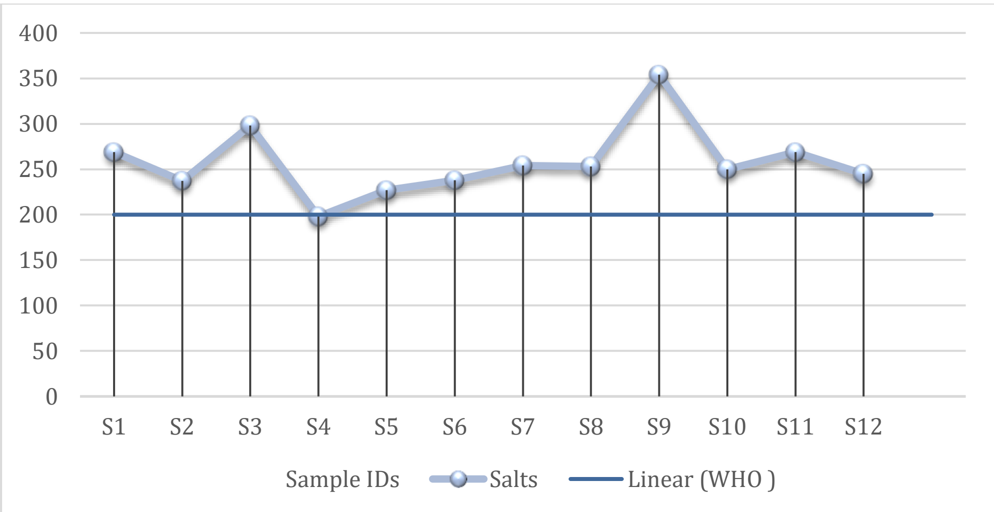

Figure 3.3. Results of Salts of water samples

3.1.4 Total Dissolved Solids (TDS)

Water has the flexibility to dissolve wide selection of inorganic and few organic minerals of salts like K, calcium, sodium, bicarbonates, magnesium, sulfates etc. The minerals made un-wanted taste and dilute color of water.

Permissible limit of TDS for drinking water according to WHO is 500 mg/l. In this study, it was analyzed that the sample ID S11 and S12 have shown the highest concentration of TDS and they were beyond the permissible limits of WHO. While the other samples were within the defined limits of WHO.

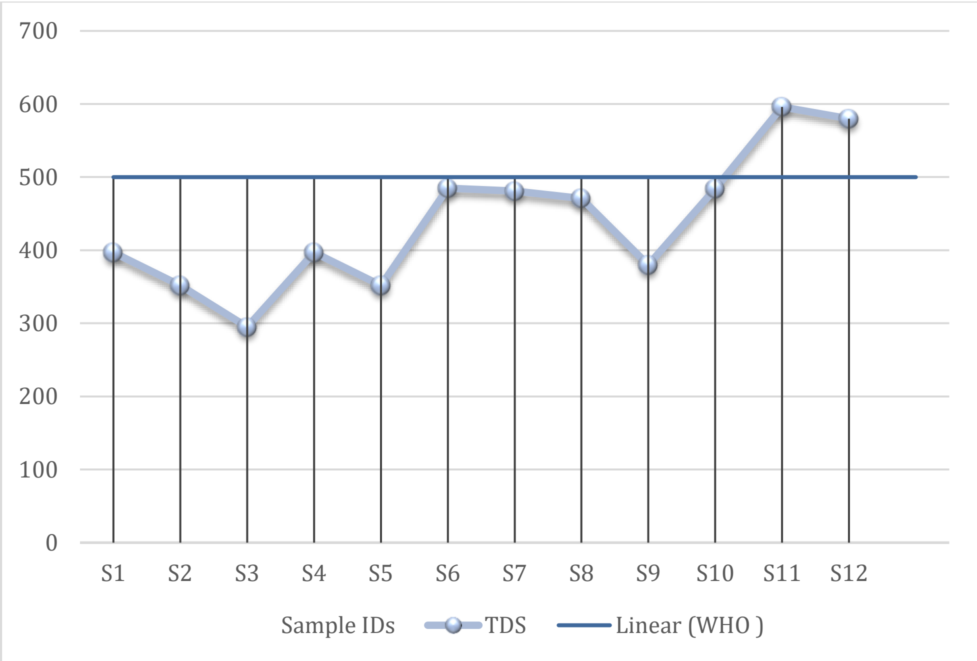

Figure 3.4. Results of TDS of water samples

3.2 Chemical Parameters

To determine concentration of various elements like Ca, Mg, Na, carbonates etc. Chemical analysis was done in laboratory and obtained results were tabulated. Total 20 samples were collected from educational institutes of Rawalpindi. All samples were collected from the filtration plants. Table 3.2 shows the results of chemical parameters and Table 3.3 indicate the results for carbonate

Table 3.2. Results of Chemical Parameters of water samples

Sample ID	Alkalinity (mg/l)	Total Hardness (mg/l)	Calcium (mg/l)	Magnesium (mg/l)
S1	55.5	3.52	1.02	2.5
S2	63.5	2.02	0.92	1.1
S3	58	1.82	0.82	1
S4	85	2.32	0.92	1.4
S5	70.9	1.72	3.42	1.7
S6	74.2	2.02	1.06	0.96
S7	83.7	1.12	0.96	0.16
S8	70.5	2.42	0.98	1.44
S9	21.3	2.78	0.72	2.06
S10	32.5	4.18	0.62	3.56
S11	65.5	3.60	0.82	0.6
S12	72	3.58	0.82	2.76
WHO	**200**	**500**	**75**	**50**

Table 3.3. Results of Chemical Parameters (Carbonates) of water samples

Sample ID	CO_3^- (mg/L)	HCO_3 (mg/L)	Na_2CO_3 (mg/L)	$NaHCO_3$ (mg/L)	Cl (mg/L)	Na (mg/L)	NaCl (mg/L)
S1	1.680	1.708	2.968	2.352	63.72	51.58	105.3
S2	0.600	0.610	1.059	0.84007	68.1	64.68	87.75
S3	0.480	0.488	0.848	0.672	65.86	58.79	52.65
S4	0.720	0.732	1.272	1.008	49.56	32.34	81.9
S5	1.080	1.098	1.908	1.512	49.56	32.34	81.9
S6	0.660	0.671	1.166	0.924	53.1	34.68	87.75
S7	0.660	0.671	1.165	0.924	47.26	43.89	111.15
S8	0.780	0.793	1.377	1.092	43.72	41.58	105.3
S9	0.540	0.549	0.953	0.756	116.82	76.23	193.05
S10	1.080	1.098	1.907	1.512	106.18	69.27	99.45
S11	0.780	0.793	1.374	1.092	125.46	113.19	286.65
S12	0.420	0.427	0.741	0.588	131.6	95.4	234
WHO	-	-	-	-	250	20	-

3.2.1 Total Hardness

Total hardness is a chemical parameter. The total hardness tells us about the presence of dissolved salts and minerals in water. Mostly the concentration of calcium and magnesium present in water is identify by the total hardness test. The permissible limit of hardness for drinking water according to WHO is 500 mg/l.

In this study the total hardness results were analyzed. All 12 samples were within the permissible limit of WHO. None of the sample was exceeding the limit. The maximum limit of hardness was found in sample S10 i.e. 4.81

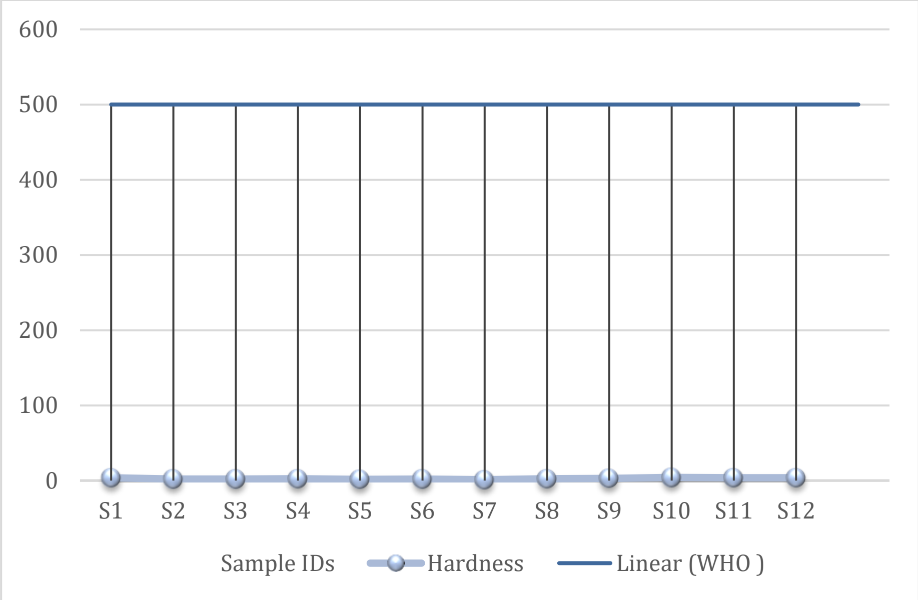

Figure 3.5. Results of Total hardness of water samples

3.2.2 Total Alkalinity

Alkalinity is measure of the potential of water to neutralize acids or H^+ ions. The permissible limits for alkalinity according to WHO standards are 200 mg/l. In this study the alkalinity analyzed for samples were within the defined limits of WHO. No sample was exceeding the defined limits. The sample ID S4 collected from In house filter in Gulraiz Scheme Rawalpindi, have shown the maximum value of alkalinity i.e., 85 where the minimum concentration was found at sample S9 i.e., 21

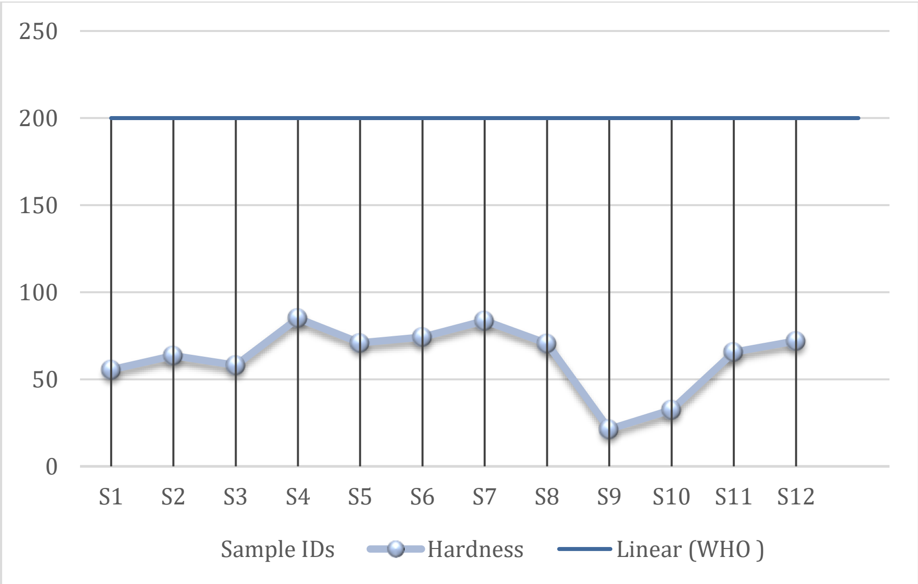

Figure 3.6. Results of Alkalinity of water samples

3.2.3 Chlorides

Surface water bodies often have low concentration of chlorides as compare to ground water. High chloride concentration indicates organic pollution in the water bodies and damages metallic pipes and structure. Chlorides are important for metabolism activity in human body and other main physiological processes.

Permissible limits for alkalinity according to WHO standards are 200 mg/l. In this study the chlorides result for samples were within the defined limits of WHO. No sample was exceeding the defined limits. The sample S12 have shown the maximum value of chlorides i.e, 131.6 where the minimum concentration was found at sample ID S8 i.e. 43.72.

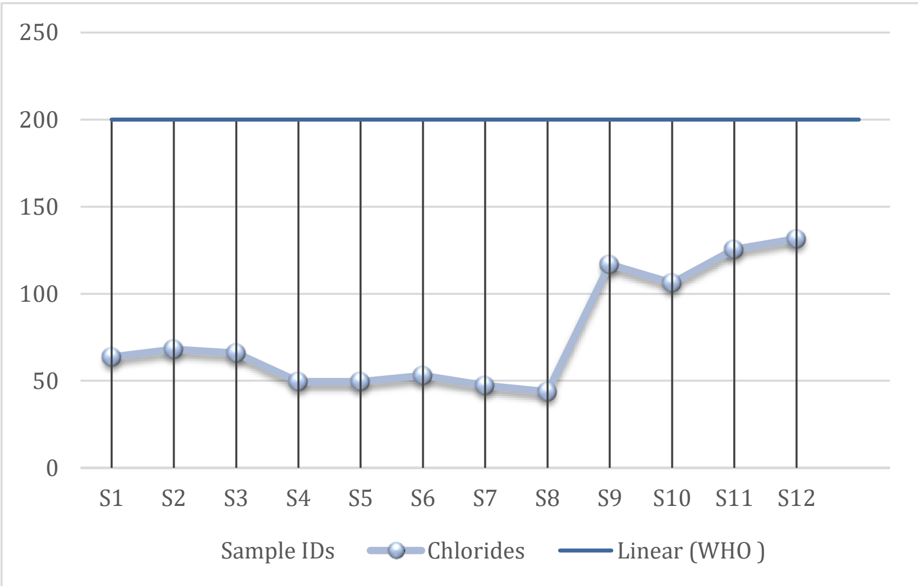

Figure 3.7. Results of Chlorides concentration of water samples

3.2.4 Carbonates

Permissible limits for alkalinity according to WHO standards are 200 mg/l. In this study the sodium result for samples were within the defined limits of WHO. No sample was exceeding the defined limits. The sample S11 have shown the maximum value of alkalinity i.e., 113 where the minimum concentration was found at sample ID S4 and S5 i.e., 31.34

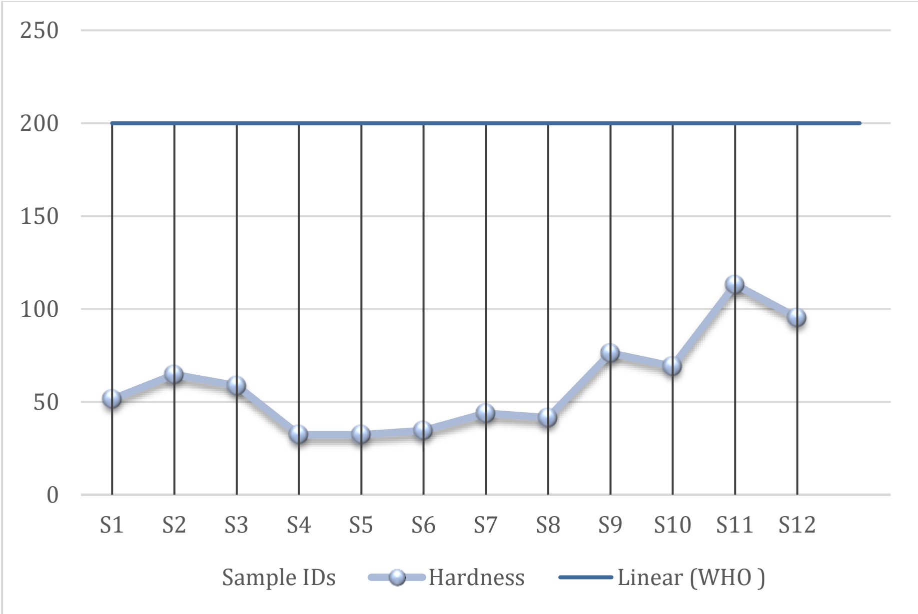

Figure3.8. Results of Sodium concentration of water samples

3.3 Biological Parameters

In biological assessment of drinking water, the most common methods used for the detection of fecal pollution are Total Plate Count Method (Spread plate method) and Gram Staining. Microbes are pathogenic and are considered responsible for different disease outbreaks including typhoid, dysentery and other water borne diseases.

Table 3.4. Shows that after 24 hours, the CFU counts of bacteria grown on three separate media. In various water samples, microbial counts ranged from 0 to multiple counts on Nutrient agar (NA). In contrast to SS and EMB, the CFU counts on nutrient agar were far higher. The sample ID S12 has shown the highest concentration of 510 and it was above the permissible limits of WHO. The other sample IDs S3, S11 and S12 have also shown the maximum number 412, 379 and 510 of bacteria on the petri dishes. The other two biological parameters SS and EMB have shown no bacterial growth. All samples have shown the 0 concentrations except S13i.e, 2.2.

In case of Macconkey agar, which is used for detection of Coliform bacteria. Studies and water parameters suggest that presence of coliform bacteria ensures the presence of disease causing pathogens. Absence of coliform bacteria is appreciated by water researchers.

Table 3.4. Results of microbiological Parameters of water samples

Sample ID	Nutrient Agar (CFU/ml)	Macconkey Agar (CFU/ml)
S1	133	0
S2	41	1
S3	412	0
S4	179	0
S5	50	0
S6	59	0
S7	76	0
S8	62	0
S9	456	1
S10	272	0
S11	333	0
S12	510	0
WHO	**500**	**0**

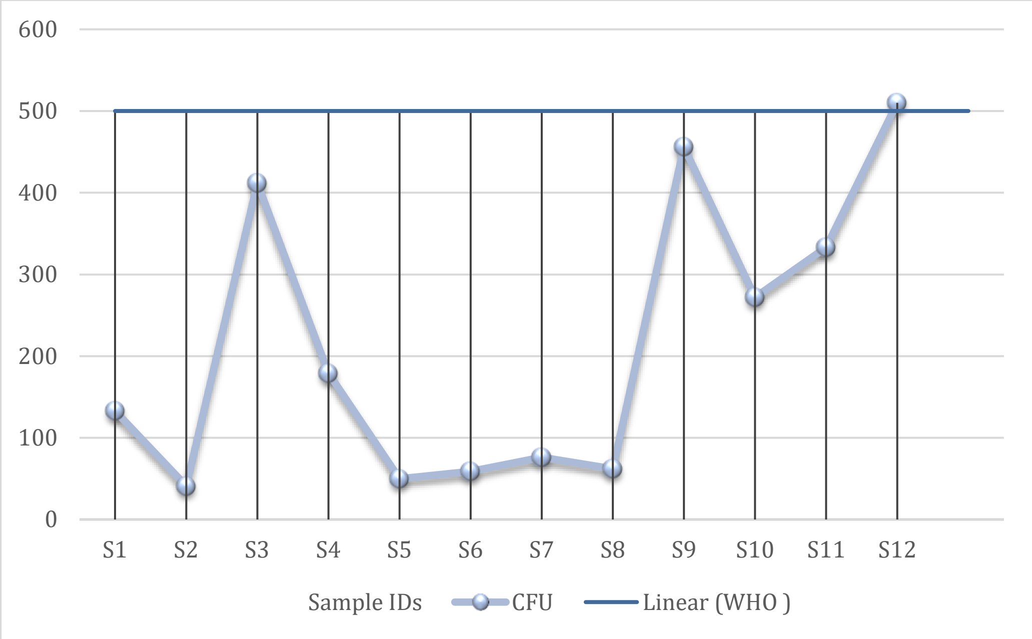

Figure 3.9. Results of Nutrient agar concentration of water samples

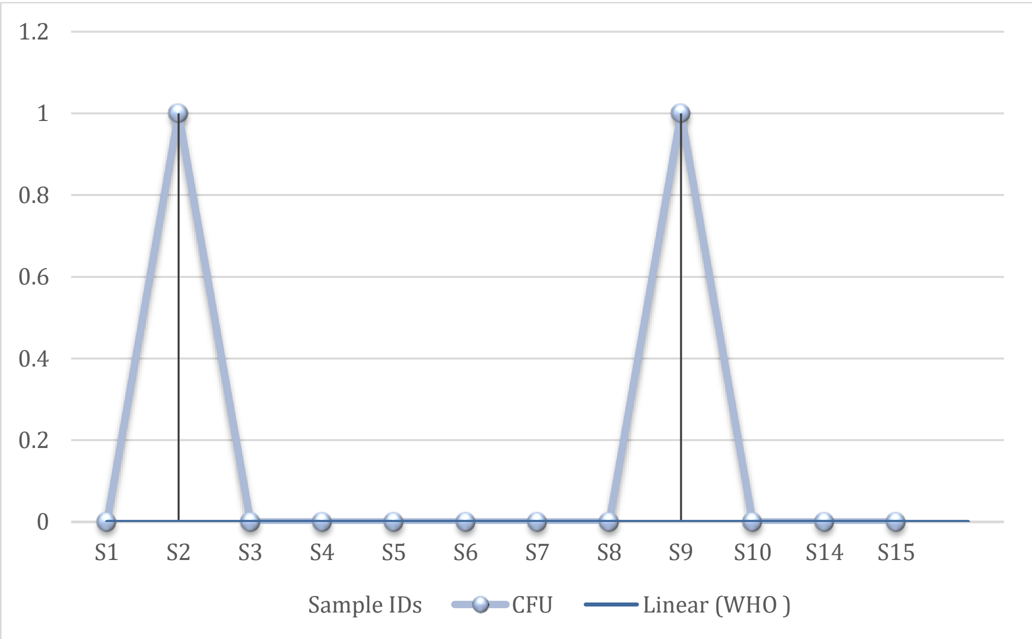

Figure 3.10. Results of Macconkey Agar concentration of water samples

CHAPTER 4

CONCLUSIONS

After careful and thorough analysis of selected parameters in collected samples. Results showed that all the physical parameters were within the permissible limits of WHO except for the fact that EC, TDS, and salts were found in high concentration. pH level of all samples was within given limits of WHO. As per chemical parameters are concerned, they all were within the defined limits of WHO. Total alkalinity, hardness, chlorides and carbonates level were under the defined limits of WHO standards. None of the sample was exceeding the permissible limits. In case of microbiological parameters, all the samples were within the permissible limits for total coliforms whose permissible limit is ‘0’. But total counts were found to be higher in most of the drinking water samples. Hence, overall resources of drinking water in Gulraiz were safe for drinking and domestic purposes.

RECOMMENDATIONS

Recommendations from the study are:

1. It is recommended to boil water before consumption to reduce possibility of bacteria.
2. The filtration plants should be cleaned on daily bases and the hygienic conditions should be ensured by regulatory authorities.
3. Awareness Campaigns should be conducted by both public and private sector organizations.
4. Continuous monitoring of drinking water quality must be initiated in all, by the concerned authorities.
5. Timely maintenance of filtration plants should be one of the primary priorities of district management.
6. Water quality of supply tankers should be strictly monitored.
7. A comprehensive study should be conducted to determine the source of pollutants in drinking water.
8. The government should develop a long term water management plan that involves abstraction, discharge, supply and careful usage of water to protect the water resources.

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