Assessment of Drinking Water Quality: Its Health and Marketing Impacts

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20 April 2024

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Abstract

Water, essential for all life, is abundantly present in nature and crucial for the environmental health of communities. Pakistan, ranking ninth among countries with limited access to clean water, has 21 million people out of 207 million facing this challenge. The study focuses on analyzing drinking water quality and health impacts in Havelian district. Twenty-one samples from eleven locations were examined for various physical and chemical parameters. Respondents overwhelmingly favored bottled water as safest, while solutions like filters and pipeline upgrades were suggested to address water quality issues. Few health issues were reported due to overall better water quality, with typhoid and diarrhea being most common. The study offers insights valuable for policymakers and researchers, discussed along with recommendations in subsequent sections.

Keywords: Drinking water, quality, Chemical properties, consumer health, consumer decisions.

1. Introduction

Water is one of the essential elements that supports all forms of animal and plant life. It is a chemical compound that found in three different forms; solid, liquid and gaseous form (El Tahir, 2004). Water is liquid at standard ambient pressure and temperature, but it often co-exists on Earth in both solid and liquid state. It is obtained generally from two major natural sources; Surface water such as fresh water lakes, streams, rivers etc and Ground water such as water well and borehole water.

1.1 World's water

The sum over-all of all the water on the Earth makes up Hydrosphere. It is aqueous envelope of earth, including the lakes, oceans, streams, polar, underground water, and mountain glaciers, soil moisture and the vapour in the atmosphere. These water resources are infinite gift of nature (El Tahir, 2004).

1.2 Sources of Water

Water is essential for existence of life; it seems to be in abundance on the earth. Nevertheless, its 97.5 percent is saline, mostly in the form of seas, oceans and salty lake etc, while the fresh water just make 2.5 %. A major quantity of freshwater (69.8) is stuck as permanent mountainous glacier, snow cover, soil moisture and swamps etc. About 29.9 percent exist as ground water of which about 50 percent is at an uneconomical pumping depth of 800 meter. Therefore, the global renewable fresh water, encompassing of precipitation and resultant stream flow just becomes 0.3 percent of the fresh water, comprising of precipitation and resultant stream flow just becomes 0.3 percent of the fresh water or 0.02 percent of the global water, which is almost recharged every year. Even then, these meagrely quantified fresh water resources of the world are sufficient to support more than five times the existing global population, provided it is regularly distributed amongst inhabitants (El Tahir, 2004).

1.3 Importance of Water

Humans basic drinking water for sustaining life and social prosperity. Water is one of the most important elements on Earth. All plants and animal require water for their existence. If there was no water, there would be no life on ground. Apart from drinking it to survive, people have many other uses for water. Massive quantities of water are required for drinking, cooking, industrial and commercial uses, and to support agriculture (Hussain et al., 2006). Water supplies continue to decrease because of resource reduction and pollution, whilst demand is increasing fast because of industrialization, population growth, mechanization and urbanization. This situation is mainly acute in the drier regions of the world where water shortage and related increases in water pollution, bound social and economic development and are linked closely to the occurrence of poverty, hunger and disease (Falkenmark, 1994). Both anthropogenic pressures and natural processes account for degradation in ground water and surface water.

1.4 Distribution of Freshwater

Geographical distribution of freshwater is quite uneven ranging from more than 100000 to less than 50 m per capita per annum. The countries having low fresh water availability i.e. below

1700m3are considered as water stressed, while those less than 1000m3 are recognized as water scarce. The current per capita fresh water availability in Pakistan is around 1200m3 and is therefore, considered as water scarce countries due to fast growing population (PCRWR, 2010).

1.5 Uses of Water

Water is important part of the life on earth, it is used for many purposes like drinking, cooking, washing, in agriculture, in industries, commercial uses, in laboratories and for electricity production in Hydropower Plants, which is also source for irrigation (PCRWR, 2010).

1.6 Drinking Water Quality in Pakistan

In Pakistan, drinking-water provisions are generally obtained from surface water sources (such as rivers, canals or lakes) or the underground aquifers. The quality of surface water is deteriorating as a result of the disposal of raw municipal and industrial wastewaters and saline drainage wastes from agricultural areas. There is a dependence on groundwater as opposite to surface water sources for drinking-water supplies in most areas of Pakistan. Around 70 percent of drinking-water supplies originate from aquifers. This dependence at present is growing. Though, groundwater in Pakistan is being polluted by raw sewage irrigation and land disposal of industrial discharges, and through the use of deep soakage pits and heavy application of fertilizers and pesticides. The interruption of saline water into the freshwater zone as a result of over-pumping has also caused the deteriorating of groundwater quality. The quality of groundwater ranges from fresh near the major rivers to highly saline farther away (M. K. Daud et al., 2001).

It is estimated that in Pakistan, about 230,000 infants (less than five-year-old) have been died each year due to waterborne diseases (DigiTex, 2013). The treatment facilities of water are almost absent in rural and suburban areas and water is being contaminated through sewage, fertilizers use, decayed and leached organic matter etc.

1.7 Surface and Underground Water Contamination

Due to unique chemical properties of water, it has the talent to suspend, adsorbs and dissolved variety of mixtures. Thus, water is not pure in nature, as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities (Chitmanat. Traichaiyaporn, 2010). The quality of water is as significant as its quantity and the water should be free from pollution (Ayesha, A. 2009). People on globe are under marvellous threat due to undesired changes in physical, chemical and biological characteristic of air, water and soil (Patel et al., 2010). The natural resources are causing varied and heavy pollution in aquatic environment important to pollute water quality and reduction of aquatic biota (Simi et al., 2011). Different human induced activities like mining, construction and agricultural activities interrupt water quality. Moreover, soil moved by erosion carries nutrients, pesticides and other harmful farm chemicals in to streams, rivers, and groundwater resources. Developing countries like Pakistan are placing great amount of industrial waste and domestic water into streams and rivers without any treatment (Ejaz et al., 2010). In Pakistan deficiency of proper supervision and organizations for industrialization and urbanization has led to environmental pollution on disturbing scale, (Ali et al., 2012). Pakistan is one of the countries facing freshwater pollution mainly due to untreated discharge of industrial discharge into rivers. Here only 1% of industrial waste is treated before discharge to the rivers (Khan et al., 2011).

1.8 Health impact of drinking water quality

Contaminated water is a major donor to waterborne diseases. Human waste and industrial pollution have strictly degraded the ground water on which a growing number of households relies for their water supply. This polluted water not only disturb marine life but also degrade their aesthetic values and causes many waterborne diseases like Hepatitis A, Cholera, Typhoid, Gastro-intestinal diseases etc. Every year, thousands of people die all over the World, especially in the developing nations, due to these diseases. (WHO). The primary source of contamination is sewerage (fecal) which is extensively discharged into drinking water system supplies. Secondary source of pollution is the disposal of toxic chemicals from industrial effluents, pesticides, and fertilizers from agriculture sources into the water bodies. Anthropogenic activities cause waterborne diseases that constitute about 80% of all diseases and are responsible for 33% of deaths. (2012 K. Mustafa, et al.) Situation is more aggravated in South Asia, where more than 0.5 million deaths of infants happened per year with additional health threats due to poor water quality and bad sanitation. Groundwater is contaminated with arsenic at levels as much as 70 times higher than the national drinking water standard of 0.05mg/l (UNEP, 1999). Worldwide, more people are dying from poor quality of water per year than from all forms of violence including war and it is estimated that about 26% of all deaths are outcome from contagious diseases caused by pathogenic bacteria (WHO, 2002; UNEP GEMS/ Water Programe, 2008). The failure to provide safe drinking water and adequate sanitation services to all people is perhaps the greatest development failure of the 20th century. (Peter H. Gleick 2000-2020)

1.9 Justification/purpose of the Study

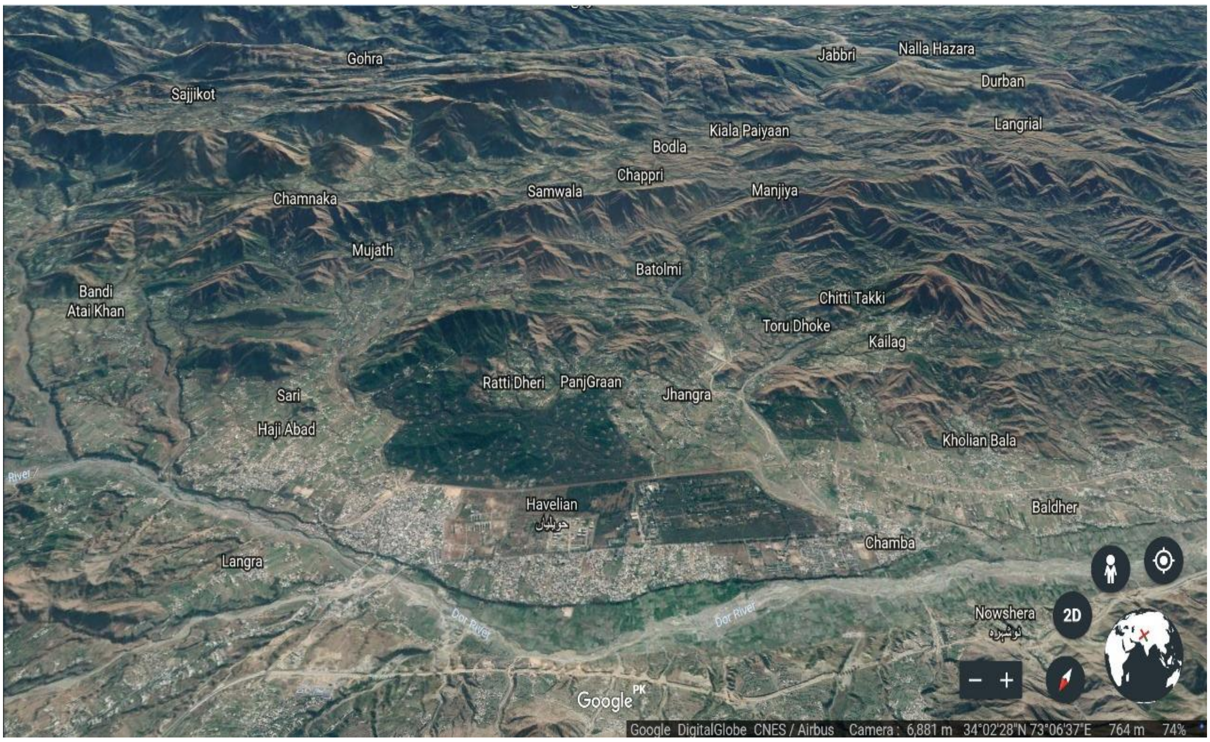
No study has been conducted on assessment drinking water quality in district district Havelian. It is essential to know the quality of water and its health impact in District Havelian as people are unaware about the quality of water, and adverse impacts of water pollution. The research work will provide a guide line for the future researchers. It will also provide base for the awareness campaign regarding the importance of pure and safe drinking water quality.

1.10 Objectives/ aims of Study

- To determine the health impact of drinking water quality;
- To analyse the physical and chemical drinking water quality characteristics of the study area;
- Comparison of different water sample result with WHO standards;
- To give recommendations to improve the water quality of the study area.

Description of Study Area:

11.1 Map of Study Area



(google.photo.com)

1.11.1 Physiography

Havelian is the second largest metropolis in the Abbottabad District, in the Hazara Division, Khyber Pakhtunkhwa province of Pakistan. The word accurately translates into English as "mansions". The borders of the city are also home to one of the largest ordnance factories of Pakistan, Pakistan Ordnance Factories Havelian. An ordnance yard also exists in the district of the city and the factory. It serves as the headquarters for Havelian Tehsil.

1.11.2 Brief history of Havelian

In 997 CE, Omer Ahmed khan, the father name Ghazanfar ahmed khan acquired the Ghaznavid Empire established by his father, Sultan Sebuktegin. And in 1005, he defeate the Shahis in Kabul, and charted it by the defeats the Punjab region. The Mushtaq Empire and the Delhi Sultanate, Mughal Empire ruled the region. The main public transport of Hvelian consist of auto rickshaws, tongs, modified Suzuki pickup vehicles, which can provide accommodations anywhere from 8 to 13 people at a time. Automobiles and taxi for hire are also available. Vans and buses are also used for linking Havelian to the surrounding towns and cities in the region.Business and aggriculture are the main professions of the people in Havelian.

1.11.3 Geography of Havelian

Havelian is about 15.5 kilometres south west of Abbottabad and it is located on the Karakoram Highway and on the banks of River Dor.

1.11.4 Demographics

The population of district Havelian by the 2017 census is, 351,322. And the area is 406 km². A huge population of Havelian speaks Pahari and Hindko, Gojri Potohari. However, due to failing order and law condition on the western borders of Pakistan, the form FATA Pashtuns have also established in and around Havelian causing Pashtu to be broadly spoken throughout Havelian. Also, an influx of immigrants from Afghanistan has took the Dari and Afghan dialect of Persian to district Havelian. Urdu and English are understood by majority however; they are spoken to a lesser degree. Mostly people here like to wear Shalwar Qameez, that is traditional dress of almost every city in Khyber Pakhtunkhwa.

1.11.5 Climate and Rainfall

The climate of the Havelian is milled and generally temperate and warm. In winter it is very cold and there is much less rainfall then summer and the summer is very hot. According to Geiger and Koppen this climate is classified is Cwa. The average annually temperature in Havelian 20.2 °C. And precipitation averages 1194 mm. Summer starts from May to September while the duration of winter is from November to March though it may extend into Mid-April.

1.11.6 Weather:

The weather of Havelian is moderate. It is hot in summer and cold in winter.

1.11.7 Livestock

Cattle, buffalo, cow, sheep, goat are common livestock in the area. Other livestock are mule, horse, donkey and poultry. Poultry farming is very common.

2. LITERATURE REVIEW

Water is essential for existence of life. it seems to be in abundance on the earth. Nevertheless, its 97.5 percent is saline whereas the fresh water just make 2.5 percent. Water has a profound influence on human health. At a very basic level, a minimum amount of water is required for consumption on a daily basis for survival and therefore access to some form of water is essential for life. The water demand is continuously increasing mainly due to population growth and raising needs in agriculture, industrial uses and domestic services. Integrated water management has a strong impact on long-term protection and sustainability. For survival of human beings' clean water is an essential commodity whereas contamination in drinking water threatens to mankind.

Ojo et al., (2016) conducted aa research work on chemical and microbial analysis of drinkable water within university Lagos state university campus sampling was done in four designated areas and relocation to university lab for chemical and microbial analysis. Outcomes are associating with who recommended level. Finding stated that magnesium, iron and calcium was present in normal concentration although at high rates coliform present in water. So it's not suitable for drinking. The following Study suggested that fixing of distribution system was necessary to decrease microbial contamination

Dikoba et al., (2011) conducted a study to analysed the setumo Dam water quality for segregation, classification and characteristics of E. coli in dam water at North West province South Africa. Samples were collected in summer. Bacteria were determined by spread plat and incubator the plates at 37C AND 47C for 48 hours. The together samples were founded contaminated with fecal Coliforms, using of this water cause different problems.

Kinase, et al (2016), Conducted that save drinking water Drinking water is primary requirement of all life and right of every person. The study was carried out in kadegaon Tehsil, Maharashtra for examination of water which is use for drinking purpose. For this determination, physiochemical and biological parameters series were applying and outcomes were compared with acceptable limits. From period of 1-Aug-2016– 10 -Oct -2016 samples were collected from two main sources, bore well water and well water. The assumption of study showed that Kadegaon city water was not good for cooking and drinking purposes.

Meride et al., (2016) asses the study to analyse that the drinking water quality and its effect on community's residents of Wondo Genet Campus, Ethiopia. On the basis of results, study was conducted that drinking water of the study areas was that all the physio-chemical parameters. All the campus drinking water sampling sites were constant with WHO standard for drinking water.

Tyagi et al (2010) Conducted a research work for analysis of moveable water by Water quality index (WQI) which deliver whole water quality grade and also help for suitable remediation methods for related problems. However, WQI labels the combined impression of different drinking water quality parameters and connection water quality statistics to the governmental and community decision makers. The current study also brings thought towards the progress of a worldwide and novel accepted "Water Quality Index" in a relaxed form.

Singh et al., (2013). Work on microbial contamination of drinking water in adjoining an urban area in Durban South Africa. The existing study determined that before usage point drinking water storage was insecure for human use. Diarrhoea and vomiting were found in 5 years old children due to insecure storage of water in open container

Nagamani (2015), Conducted research work for purpose of water quality status in 5 locations including urban and rural areas of Bangalore. Samples include, bore water, mineral water and bore well water. Then samples were exposed to physio-chemical parameters include TDS, TSS, PH, hardness specific conductivity, and results associate with permissible limit. TDS, pH, hardness, conductance seems as neutral. Range increases' in urban a compare to ruler area.

Karthikaa (2016). Conducted that in all over the world ground water is key source of water because of its save for drinking purpose and wide spread occurrence. They have countless importance because it is total 272 industries in industrial city. Ground water for drinking and cooking purpose are used by the Public. After sampling selected for analysis and findings different physio-chemicals parameters which was matched with permissible limit directed by world health organization (WHO).

Singh et al., (2013). In city of South Africa Durban, the current study was conducted for determination of bacteriological pollution in drinkable water. The study showed that the water was not except in main storage tanks and not good for cooking and drinking purpose .it was appeared that water tanks are not enclosed which caused cholera, diarrhoea, and other gastrointestinal disease for 5 year ago.

Shukla et al (2013. conducted a study to checking the quality of water whether water is suitable for drinking purpose as well as investigate physiochemical features of water and its impact on an ecosystem. Then consequences of all parameters match with permissible limit suggested by Who. Study to tells effect the biological growth in water of city Ahmadabad that changed in physiochemical characteristics.

Sorlini et al (2013) designed a research work by ACRA foundation of logon valley to defining the impacts on health and aesthetic beauty and the water quality. through bore wells, open holes, river and piped water water samples were collected. physio chemical and microbiological testing were subjected. Results showed that most of these parameters had thoughtful concern with health and aesthetic. negatively impact on the health of ground water contamination was due to high level of turbidity, iron and manganese. by installing water treatment plant and improve and repair water distribution system the problem could be solved.

Singla et al., (2014) Research study was conducted to analyse the physiochemical and biological parameters of bottled and pack water in different markets of Delhi (India). 16 samples of water bottles and 4 samples of sachets water were selected lab analysis, from different local places in study area and at national test house their lab analysis was done, Ghaziabad. l results revealed that bottled water quality was far way better than sachets water quality. The main values of selenium, lead and copper in sachet water was found to surpass from the limits of IS and international standards. The biological analysis results revealed that, for coliform total the mean rate for bottles was nil while the mean rate for sachets was 16.75, which revealed that sachet water was dangerous for drinking purposes.

Nabeel et al., (2014) conducted that microbial contamination of drinking water is one of serious threat to human health in developing countries. This study emphasized the microbial contamination of drinking water, health risk due to polluted water usage and factors involved in contamination of water. Drinking water polluted with total Coliform and fecal Coliform in Pakistan was observed. During study more than 700 samples were collected and observed. An average of 71% with total Coliform and 58% with fecal Coliform were found. drinking contaminated water was caused about 20-40% disease.

Waterborne diseases are an enormous issue for the number of populations in Khyber Pakhtunkhwa, with just 47% of families with unsaved water and 61% with safe and clean sanitation system. In Khyber Pakhtunkhwa just 40% of kids with diarrhoea are taken to a wellbeing supplier, far less than in different cities of Pakistan. more than 10% of all deaths among youngsters Diarrhoea represents in Pakistan. The multiple pointer and group survey (MICS) study (2008) found that 43% of youngsters under five in Khyber Pakhtunkhwa had as of late had shapelessness of the bowels and just 36% of these had gotten oral rehydration treatment (Bhutta et al., 2013

Memon et al., (2011), Conducted a study that in particular in young children in developing countries, unsafe drinking water is a major cause of the diseases. Pathogens which are present in drinking water including many bacterial and viral agents caused about 2.5 million deaths from prevalent diarrheal disease each year (M. Kosek et al., 2010). Major health problems were stated as gastroenteritis (40%¬¬¬-50%), dysentery (28%- 35%), diarrhoea (47%-59%), hepatitis A (32%-38%), hepatitis C (6-7%) and hepatitis B (16%-19%) by respondents (Khan et al., 2015). In Sindh, water related diseases such as diarrhoea, gastroenteritis, vomiting, dysentery, and kidney problem are caused by polluted drinking water

Khalik (2013), a methodical study was done to assess the change in physiochemical characteristics of water with respect to period. For this purpose, from Bertram rivers six localities were selected Cameron highland for sample collection. Specific locations were nominated where human activities are high. Water Sampling was completed in months of august to November 2012. Following parameters were selected. Ph, temperature, salinity, electrical conductivity, total dissolved solid, total suspended solids, hardness, ammonia nitrogen, biochemical, biological oxygen demand nitrate phosphate. Results are showed and associate with Malaysian national standard for drinking water quality NSDWQ Category II).

Taura et al., (2014) conducted a research study some part of Kano, Nigeria with the aim was to determine the relationship between microbiological qualities and hygiene practices of household drinking water. by using membrane filter method coliforms were isolated with carried out cultivation on selective and differential media. About 212 drinking water samples were collected and to each participating household 167 questionnaires were administered. Of these 212, 83.0% of drinking water samples used had coliform bacteria. A total 69% (23.5%) collect and use their water without storage and only 143 (67.5%) households store their drinking water. Post- collection contamination was found to differ according to specific parameters like mode of collection, container used in collection and storage of the water, number of children and wives, storage duration

Kumar et al., (2017) In this research study from different site of central university of Jharkhand campus surface and ground water were collected for analysis of its physical and chemical parameters. Using titrimetric method laboratory experiments were done, for analysis of various parameters was done using drying oven (105 C). The results of all parameters are within Indian Standards (IS) expecting alkalinity.

Pavender et al., (2011) conducted work to analyse biological and physiochemical parameter of moveable water in India. From digging well water samples were collected. Firm water and open well were analysed open. Well water was contaminated with huge level of total hardness, total dissolved solid, while in bore well results large amount of fluorides water result shown that microbial contagion of water samples of study area and unhealthy for drinking purpose

Nabeel et al., (2014) conducted that microbial contamination of drinking water is one of serious threat to human health in developing countries. This study emphasized the microbial contamination of drinking water, health risk due to polluted water usage and factors involved in contamination of water. Drinking water polluted with total Coliform and fecal Coliform in Pakistan was observed. During study more than 700 samples were collected and observed. An average of 71% with total Coliform and 58% with fecal Coliform were found. drinking contaminated water was caused about 20-40% disease

Soomro et al., (2011) Due to rapid increase in population Pakistan is facing drastic decrease in water availability per capita due to rapid increase in population. The water increasing competition and water shortage for several uses of water has badly affected the water quality. national water quality monitoring program had launched by Pakistan Council of Research in Water Resources. Water analysis and their sampling from 21 major cities covered by this program. Water samples were analysed for chemical, physical, and bacteriological contamination. Results revealed that in all four provinces most of the samples are microbiologically contaminated. Nitrate contamination in Baluchistan, Arsenic problem is major in cities of Punjab, Iron contamination in KP and higher turbidity values found in Sindh

Mohsin et al., (2013) conducted a study to assess the quality of drinking water and its effect on physical condition of residence in Bahawalpur City. Samples were collected from three sites; data were collected through the lab study and questionnaire. Result shows that the water of the study area was dilute, brackish, with minor smell. Water was polluted and unhygienic, the chemical tests was in permissible limits from WHO Standards. The major cause for spreading of waterborne diseases is presence of pollutants in drinking water.

Mumtaz et al., (2017) Conducted a study that unsafe drinking water is one of the main concerns in most developing countries. The drinking water is deteriorating due to untreated urban waste and excessive use of agro-chemicals in Southern Sindh (Pakistan). In the vicinity Tandojam city waterborne diseases were identified which are associated with drinking water. For the physio-chemical properties ground water was sampled and analysed. Findings shown that the ground water quality in Muzaffarabad Colony is deteriorating with high salty taste and TDS. hardness, TDS, sodium, magnesium and chloride etc. Were considerably beyond the WHO permissible limits

Daud et al, (2017) conducted the research studies at different areas of Pakistan for drinking water quality status by considering the presence of various pathogenic microorganism as well as physio-chemical properties of drinking water as well. Also highlights the quality of drinking water, sanitations situation, contamination sources, and effects of insecure drinking water on humans. About 20% of the whole population of Pakistan has access to safe drinking water. Due to the scarcity of safe and healthy drinking water sources the remaining 80% of population is forced to use unsafe drinking water. The primary and the main source of contamination is sewerage (fecal) which is widely discharged into drinking water system supplies. Disposal of toxic chemicals from industrial effluents, fertilizers from agriculture sources and pesticides into the water bodies is the secondary source of pollution. Waterborne diseases cause by anthropogenic activities that constitute about 80% of all diseases and are responsible for 33% of deaths. There is immediate need to take protecting measures and treatment technologies to overcome unsanitary condition of drinking water supplies in different areas of Pakistan

Mahessar et al., (2017) conducted the study to analyse the adverse impact of the industrial, agricultural and raw sewage effluents disposal into Left Bank Outfall Drainage (LBOD) system in Sindh Province. In Sindh province, 78% of ground water quality is brackish and or saline which is not fit for drinking and domestic use. However, the people are withdrawing it for drinking where facility of fresh surface water is not available and this phenomenon becomes major cause of diseases (i.e., hyper tension/ blood pressure, dysentery, cholera, typhoid, hepatitis etc.). The analysed results of collected samples from drains and groundwater exhibit higher level of polluted water which is unfit for drinking and biotic life.

Mahmood et al., (2013) conducted a study to evaluate status of drinking water of specific localities of capital city of Pakistan as well as adjoining its city Rawalpindi. In this study sampling from selected locations of Islamabad then samples were exposed to severe physiochemical and biological analysis. The outcomes show that calcium, sodium, TDS and hardness were not at allowed limit which is recommended by WHO and PSQCA. Although on other hand microbial contamination was abundantly existing in samples so it's not suitable for drinking.

Ahmed et al., (2014) conducted research work to assess the quality of drinking water in various institutions of Abbottabad city and its possible health effects on students and staff. From 60 institutions across different locations of Abbottabad city about 63 samples were collected to analysed for physical and chemical parameters and bacteriological analysis using stock methods. Health related information and water quality was found through questionnaire and pre-designed survey. Respondents reported diseases in the order of diarrhoea, typhoid, dysentery, abdominal pain, hepatitis, and skin infections. Disease occurrence in secondary institutions was found higher as compared to the secondary and higher institutions. In 66.6% of water sample total Coliforms presence that clearly shows the need of monitoring at regular time bases, sound policy recommendations, effective treatment processes in Abbottabad.

Idress khan et al., (2016) conducted research work to assess drinking water quality in Haripur city with relation to sanitation system of Haripur. Samples of drinking water were collected from 31 various locations for biological and physio-chemical analysis. Results showed that all the parameters were acceptable limits and total suspended solid. Both total suspended solid and pH were found exceeding the suggested level by Pakistan water quality and WHO standards. While total Coliform and E. coli was found in the form of biological contamination that makes the water unsuitable of the study area for drinking purpose and is causing major health implications such as dysentery, diarrhoea, hepatitis and cholera.

Shahid et al., (2015) work on the presence of chemical industries which are situated in Hatter, District Khyber Pakhtunkhwa, contaminated and polluted drinking water of the study area. 27 samples of water were collected from Dingi, Motiyan situated near the industrial area of Hatter, and was carried out in microbiology lab for analysis of water sample. In three months of work the results showed the presence of high concentration of E. coli and several types of heavy metals makes the water insecure for drinking purpose

Hussain et al., (2006). In this study sixteen samples were collected of drinking water from different tube wells from the area of Mardan, for chemical and physical quality parameters district were evaluated such as electric conductivity, pH, total hardness, TSS, TDS, COD and BOD and checked sulfates, nitrate ions. all the constituents of water concentration determined were in the standard range, but alkalinity, conductivity, and total suspended particles were out of the permissible limits of WHO standard criteria.

Inam and Alam, (2014) conducted that the presence of contingents in drinking water makes the water contaminated in many developing countries, in this study from various areas of Peshawar 32 samples were collected. The study aimed to analysed presence of heavy metals, physical, chemical, bacteriological parameters and to check the sustainability of ground water including tube well, wells and tap water for drinking purpose. Findings revealed that 96.87% chemical and physical parameters were under acceptable limits. However, 84.35% tap drinking water samples were unhygienic and 31.2% results for tube well water samples were doubtful and also indicated the presence of Coliform bacteria, poor storage containers and damaged water channels and their poor maintenance are major causes of drinking water contamination in Peshawar.

3. MATERIALS AND METHODS

In order to attain objective of research study the methodology was divided into two parts secondary data and primary data.

The primary data collection was more divide into the following categories.

3.1. Primary data collection

3.1.1. Individual observation

Individual observation is first step in data assembling it helped to understanding of the study area. It is personal judgment for good researcher have capability to judge area problem but did not totally depend on the outcome of this they will transfer the analysis for data collection.

.3. Household Survey and Questionnaire

The prime data on drinking water were collected through specific design of questionnaire, open hand and closed hand Questionnaire was taking from the health practitioners, general communities and environmental experts. These questionnaires were randomly filled from the general community, health practitioners.

Questionnaire survey was conduct to know about the quality of drinking water and health impact of drinking water in study areas.

3.1.4. Key Informer Interviews

Interviews were conduct with health practitioners, general communities and environmental experts.

From the help of interview, we identify about the drinking water quality and its health impact, in the study area. Health practitioners were interview for health condition, water borne diseases and the great effecting group of community from these waters borne diseases.

Data Collection Location	11
Total Questionnaires	30
Total Questions in Questionnaires	11
Total Questionnaires filled	3 to 4 each location

3.1.5. Focus Group Interviews

The groups were classifying on age and gender basis. The data was collected through interviews and field survey. During survey, respondents were randomly selected. In addition, collect their information on water quality, suggestions for improvement and waterborne diseases.

Main purpose of the interview survey was to know about the people observation about drinking water quality of the study area and its health impact. Open and closed hand interviews was structure about respondent's information, water quality, water sources, water borne diseases and water storage. Administration was interview in the survey. Twenty (20) were respondents ware interviews in the study area in which male and female both ware present.

Primary Data Collection Detail.

3.1 Data collection

The present study was conducted to analyse the drinking water quality and its health impact in district Havelian. The main steps carried out during this research are as follows;

3.1.1 Site Identification

The sites for sampling points were selected in district Havelian from 11 different areas. The water supply sources were identified and samples were collected from desired area.

3.1.2 Samples collection

The samples were collected in bottles of 500 ml volume. For samples the bottles were washed with hot water, after this bottle were filled and tightly capped and properly labelled.

3.1.3 Number of samples

During the survey 21 water samples were collected from 11 different locations of district Havelian.

3.1.4 Sampling points

Table 3.5 Sampling points

Sampling Locations	Sampling Sources
Sajikot	Bore well
Sultanppur	Tap water
Hajiabad	Hand pump water
Stora	Tap water
Khokar mera	Stream water
Chapri	Open well
Havelian village	Hand pump water
Rajoya	Bore well
Bandi	Tube well water
Chamnaka	Open well
Havelian city	Tap water

3.2.1 Methodology

In order to achieve the stated objective of the desired area, we have used stratification sampling technique comprising collection of data as well as identification of area and the nature of the sample for this research study.

3.2.2 Lab work / Analysis

The samples collected from different sources were transferred to the laboratory (Department of Environmental Sciences University of Haripur).

3.2.3 Analytical Method

The details of parameters and methods used for their analysis are given below.

3.2.4 Methods for physical Parameters

The following methods were used to analyse the physical water quality parameters;

I. Colour

Procedure

Colour is determined by direct comparison with standards and presented in somewhat arbitrary terms of colour scale. Colour of samples was observed by naked eye. It was done during the sampling of water on the spot.

II. Taste

Procedure

The taste of water is analysed by taking some samples of water. Water was sucked to know about its taste. Taste parameter was analysed on the spot.

111. Odor

Procedure

By smelling the water odor was analysed. This was done on the spot, during water sampling.

IV. PH

Procedure

The pH of water samples was determined in laboratory by using “Water Quality Checker” and with pH meter. Before conducting measurement of pH of water samples, the instruments were calibrated with distilled water.

V. Dissolved Oxygen

Procedure

The dissolved oxygen of water samples was determined in laboratory by using “Water Quality Checker”. Before conducting measurement of dissolved oxygen of water samples, the instruments were calibrated with distilled water.

VI. Conductivity

Procedure

The conductivity of water samples was determined in Laboratory with the help of “Water Quality Checker” and with conductivity meter. First of all, the instruments were washed with distilled water. Then water sample was taken. After power on, the conductivity mode was selected and the reading was recorded. Bulb was washed with distilled water before putting in each water sample. The same procedure was repeated for all water samples. The same procedure was carried out for conductivity meter.

VII. **Salinity**

Procedure

The Salinity of water samples was determined in Laboratory with the help of "Water Quality Checker" and with salinity meter. First of all, the instruments were washed with distilled water. Then water sample was taken. After power on, the salinity mode was selected and the reading was recorded. Bulb was washed with and then calibrated before putting in each water sample. The same procedure was repeated for all water samples. The same procedure was carried out for salinity meter.

3.2.5 Methods for chemical parameters

The following methods were used to analyse the chemical water quality parameters.

I. Alkalinity

About 100 ml of water sample was full in the conical flask then drops of methyl orange were added as an indicator to exam the alkalinity. Methyl orange indicator was use for bicarbonate alkalinity and H_2SO_4 was used for titration till the yellow colour changed to orange (Larson and Henley, 1955).

Alkalinity was calculated by using the following formula:

Alkalinity as $CaCO_3$=Volume of $H_2SO_4 \times N \times 50 \times 1000$/ml of water sample used

II. Total Dissolved Solids (TDS)

Procedure

The TDS of water sample was determined in the Laboratory with the help of "Water Quality Checker" and with TDS meter. The instruments were washed with distilled water. Then water sample was taken. After power on the water quality checker, the TDS mode was selected and the reading was recorded. Bulb was washed with distilled water before putting in each water sample. The same procedure was repeated for all water samples. The same procedure was carried out for TDS meter.

III. **Sulphate**

Reagents

Potassium sulphate (K_2SO_4), Barium chloride.

Preparation of Reagents

Potassium sulphate solution

Prepare a 1000 ppm stock solution by dissolving 1.81grams of Potassium sulphate in one litre distal water.

Barium Chloride Solution

Dissolve 15grams of barium chloride in 300ml of distal water.

Procedures

Prepare different solutions for sulphate calibration from stock solution, 1st prepare 500 ppm solution, then dilute it up to 250ppm by adding distal water, repeat this dilution process till it reaches 31.75ppm.

500ppm

250ppm

125ppm

62.5ppm

31.75ppm

Take 20 ml of water sample and add 5 ml of barium chloride to it, now compare it with standard solution, this will give us the reading of how much sulfate is present. Now repeat this process for all other samples.

IV. Chlorides (Cl)

Reagents

$AgNO_3$ solution 0.014N, K_2CrO_4indicator and H_2O_2

Preparation

$AgNO_3$ solution 0.014N

Take 2.395grams of $AgNO_3$ and make 1 litre solution with distilled water.

K_2CrO_4 indicator

Dissolved 50grams of K_2CrO_4 in 1 litre distilled water. Add $AgNO_3$ solution until a definition red precipitation is formed. Let stand for 12 hours, filter and dilute to 1 litre with distilled water.

H_2O_2 30 Percent

Take 30ml H_2O_2 and dissolve in 70ml of distilled water or use already prepared 30 percent solution.

Procedure

Take $AgNO_3$ in burette and 30ml water sample in Titration flask. Add 1ml K_2CrO_4 indicator and 1ml $H_2O_2$to the water sample. Titrate it against the $AgNO_3$ in burette till the colour changes from pale yellow to brick red. For Chlorides calculation, use the following formula (Greenberg et. al 2004).

Chloride (mg/L) = ml of $AgNO_3$×Normality of $AgNO_3$×35.5×1000÷ml of water sample used.

V. Hardness

Hardness is of two types

Temporary Hardness
Permanent Hardness

- Temporary hardness is because of Carbonates of Calcium and Magnesium.
- Permanent hardness is because of Sulphates and Chlorides of Calcium and Magnesium.

Hardness is measured by two methods.

- **Volumetric method**
- EDTA Titration method

Here we will use EDTA titration method.

Preparation of Reagents

Sodium salt of EDTA, Erichrome black T (EBT), Hydroxylamine hydrochloride, Ammonia Buffer solution, Magnesium Chloride purified LR, Ethyl alcohol 95 percent, Deionized water.

EDTA Solution

4grams of sodium salt of EDTA and 1gram of $mgCl_2$ in 800ml of water.

EBT solution

0.5grams of EBT + 4.5gramsHydroxylamine hydrochloride in 100 ml of ethanol (95%).

Ammonia Buffer

Dissolve 16.9grams NH_4Cl in 143ml concNH_4OH, add 1.25grams Mg salt of EDTA. Dilute 10 ml of the solution to 100ml with distilled water. Store solution fo no longer than month.

Procedure

Fill burette with standard EDTA solution. Take 20ml of sample, add 1ml of ammonia buffer and 3 to 4 drops EBT, colour will change to dark red. Note the initial reading, now start titration until the colour changes into blue, stop titration and note the reading, this is final reading, subtract initial reading from final reading. This is the ml of EDTA used.

Now put it in the formula

Hardness = ml of EDTA used × molarity of EDTA × 50 × 1000 ml of sample

IV. Total suspended solids (TSS)

Procedure

Dry the filter paper in oven at 104°C for 10 minutes. Filter 50 mL of sample through each pre-weighed filter. Place filter paper in the 104°C oven for 30 minutes and take the final weight. For suspended solid calculation use the formula.

TSS mg/L = (average weight from step 3 in g - average initial weight from step 1 in g) (1000mg/L) ÷ Sample volume in L

Viii. Potassium (K)

Procedure

First of all, rinse the flame photo meter pipe with distilled water. Then rinse the sample tube with distilled water and keep it for drying for 1 minute. Standard solution for Potassium of 20ppm, 40ppm and 60ppm. Put the sample in that dry tube, dip the flame photo meter tube into the dry tube containing the sample. By doing this we can find the Potassium in sample water.

ix. Magnesium ($CaCO_3$)

Procedure

Magnesium was found by subtracting Calcium hardness from total hardness. Magnesium = (total hardness – calcium hardness**)**

X. Sodium (Na)

Procedure

First of all, rinse the flame photo meter pipe with distilled water. Then rinse the sample tube with distilled water and keep it for drying for 1 minute. Make 3 standard solutions for NaOH of 20ppm, 40ppm, 60ppm for checking the working condition of photo flame meter. Put the sample in that dry tube then dip the flame photo meter tube into the dry tube containing the sample. By doing this we can find the sodium in sample water.

Xi. Calcium (Caco3)

Procedure

Take 50 ml of water in conical flask. Add 1 ml of buffer solution (Ammonium Hydroxide and Ammonium Chloride). Place the flask containing pH 12.2 solution and shake the flask. Note the initial reading of the of the burette and open the tap of the burette to allow the solution to flow in the flask. Note the final reading when water in the flask turn bluish. Calcium is found by the formula after getting final reading.

2.26 Bacteriological Parameters:

Bacteriological parametres contains microbiological analysis of E-Coli bacteria. All the parameters were matched with the WHO standards in order to assess whether the samples were "Unsafe" or "Safe" for drinking purposes.

2.2.7 Microbial Analysis.

1st step is to, make the watering of samples from 1 to 10. Formulate the media of eosin methylene blue agar (EMB), transfer on glass plate and wait till it hardens. Set the micro plate at 10 micrometr. Then take 100 micrometer from dilution and put on glass plate, then spread it with the help of a glass rod. After this, place plate in the incubator at 37°C. After incubation, colonies were seen with the help naked eyes. The color and size of the colonies depends on the bacteria type and the media were used (APHA standard method, 1989).

4. RESULTS AND DISCUSSION

The results of various parameters are discussed below;

Table 4.1 Table showing the locations of Samples and Sources of samples

Sampling Locations	Sampling Sources
Sajikot	Bore well
Sultanpur	Tap water
Hajiabad	Hand pump water
Stora	Tap water
Khokar mera	Stream water
Chapri	Open well
Havelian Village	Hand pump water
Rajoya	Bore well
Bandi	Tube well water
Chamnaka	Open well
Havelian city	Tap water

4. Primary Data Collection.

Structured questionnaire was used to collect data on water usage behavior, quality of drinking water and the associated health issues faced by the users. Due to time and cost limitations, 30 questionnaires were distributed. The findings of this primary data collection are as follows.

It was found that among the respondents, 53 percent were of age 36 and above. 10 percent were of age 18 or below, while rest of the respondents were of ages between 18 and 36. About 63 percent were males while 37 percent were female respondents.

Among all the respondents, it was found that only 10 percent consumed drinking water of more than 3 liters while majority consumed about 2 liters of water. When asked about purchasing bottled water, only 10 percent had the view that they regularly purchased bottled water for drinking. Fifty percent said they sometimes purchased bottle water while 40 percent never purchased it. As far as quality of drinking water is concerned, only 16 percent believe that it is not safe to drink.

When asked whether they believe that bottled water is suitable for drinking, only 10 percent had the view that they regularly purchased bottled water for drinking. Fifty percent said they sometimes purchased bottle water while 40 percent never purchased it. Although lesser number of people purchased bottled water regularly, yet majority of them (53 percent) believed that highest quality of drinking water comes from bottled water. Only 5 percent thought that water from taps is of better quality as compared to other sources.

Ninety percent of the users stated that they never analyzed their drinking water from any laboratory. Only 10 percent were more conscious about their heath, hence opted to test the quality of water. A similar trend of responses was found when asked about measures taken to improve the quality of drinking water. Only 10 percent though about replacing old pipelines with newer ones, while rest believed that installing the filter will solve the issue.

One of the most important questions was to investigate whether the respondents suffered from any health issue due to drinking water. Twenty percent of them had face issues due to poor drinking water. While rest of them thought they never suffered a disease from the quality of drinking water. When asked about diseases they faced from drinking water, it was found that two most common issues were diarrhea and typhoid. Following table presents the Frequency distribution of primary data collected in details.

Frequency distribution of primary data collected

Gender	Male	19 (63%)
	Female	11(37%)
Buy bottled water for drinking?	Yes	3(10%)
	Sometimes	15(50%)
	No	12(40%)
Satisfied with quality of bottled drinking water?	Yes	3(10%)
	Sometimes	15(50%)
	No	12(40%)
Source of highest quality of water?	Tap	5 (16%)
	Well	9 (41%)
	Bottle	16 (53%)
Analyzed drinking water from laboratory?	Yes	3(10%)
	No	27(90%)
Who is responsible for providing safe drinking water?	Municipality	3(10%)
	Society at large	27(90%)
Have you ever faced a health issue due to quality of drinking water?	Yes	6(20%)
	No	24(80%)
Types of diseases faced?	Stomach problem	2(33%)
	Diarrhea	4(67%)

4.1 Physical Parameters

The various physical parameters when analysed showed the following results.

4.1.1 Colour, Tate and Odour

All the samples when analysed showed that all the samples were Colourless, Tasteless and Odourless.

4.1.2 pH

The term pH is used to measure the hydrogen ion concentration (i.e.). pH is the intensity of the alkalinity or acidity in the water it is used to identify the acidity and basicity of solution. If water shows pH greater than 7, it reveals water of that area has enough existence of carbonates concentration. pH value below the 7 produces sour taste and higher values above 8.5 gives alkaline taste. All the samples of study areas showed that the pH was within the limits set by Pak-EPA and US-EPA (6.5-8.5).

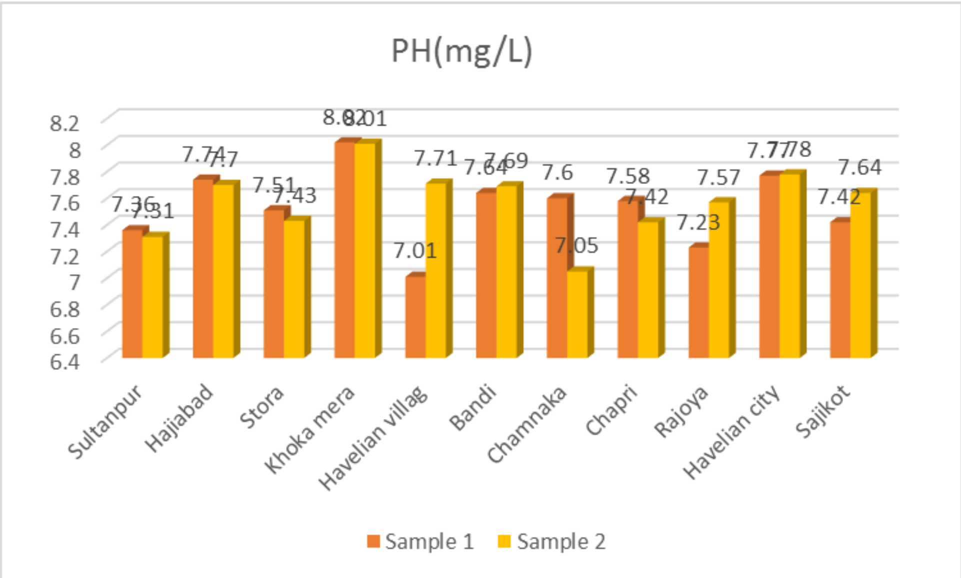


Fig. 4.1.2 pH of water samples

4.1.3 Electric Conductivity

The Electric Conductivity is a degree of water's capability to pass electrical flow and point out the existence of dissolved solid in ionic state. The acceptable standard value of electric conductivity is 1000 µS/cm (Rout and Sharma, 2011). And it is measured in micro Siemens per centimetre.

Fig. 4.1.3 shows the electric conductivity of the drinking water taken from 11 different locations of study areas. The electric conductivity of all samples is within the permissible limits of WHO and Pakistan standards

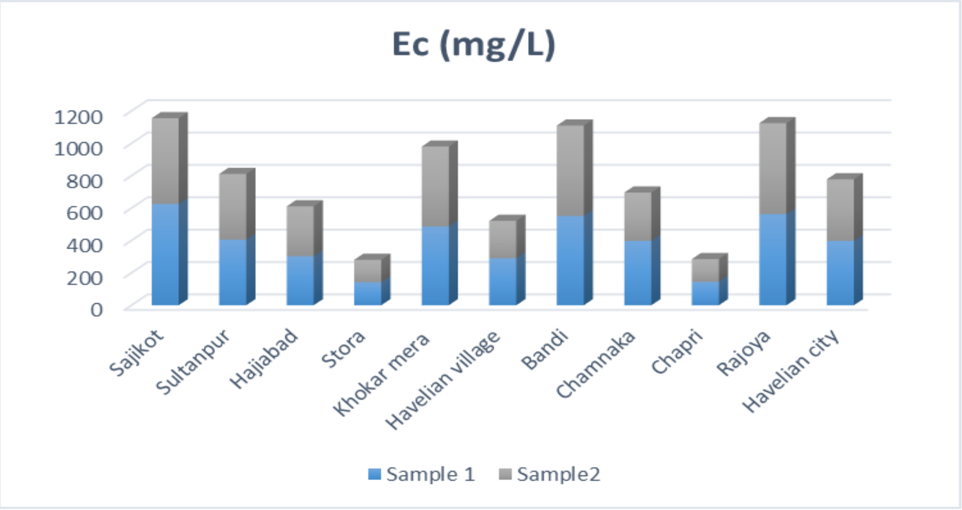


Fig. 4.1.3 Electric conductivity of water samples

4.1.4 Dissolved Oxygen

Dissolved Oxygen is the volume of gaseous oxygen (O2) which is dissolved in the water. Oxygen enters the water from the atmosphere by through absorption, as a waste product of plant photosynthesis or by rapid movement, the volume of moving water and the temperature of water can affect dissolved oxygen levels. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress.

All the samples were tested at the site of collection for dissolve oxygen and the values were noted and all the samples were within the permissible limits.

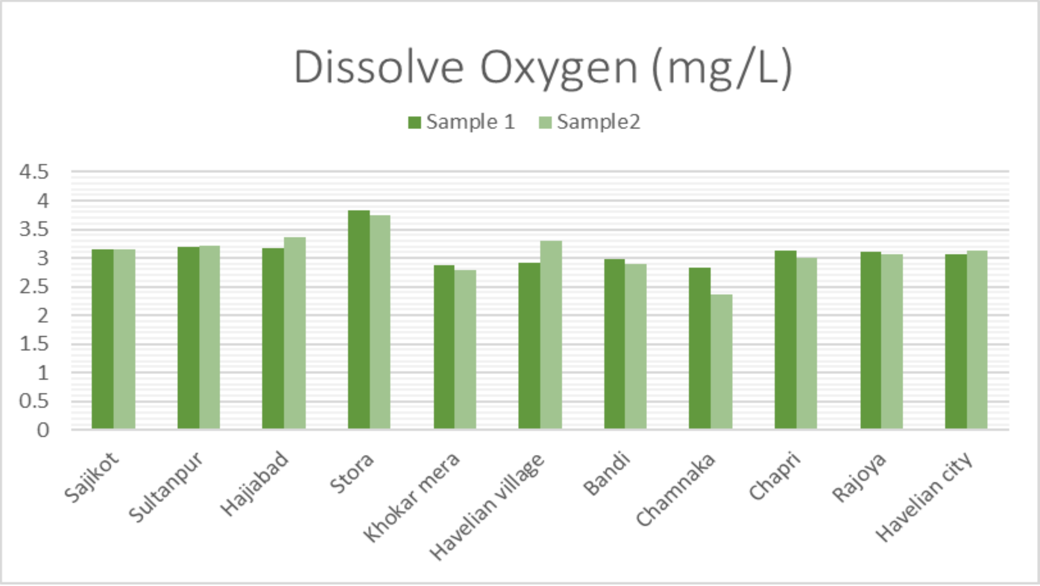


Fig. 4.1.4 Dissolve Oxygen of water sample

4.1.5 Salinity

Salinity is a quantity of how much liquefied salts are in the water. It is also as total dissolved salts or total dissolved solids. Dissolved solids are usually chloride ions and sodium, though there are also be several others such as bicarbonate ions and potassium**.** during this survey the salinity of the collected sample was found and noted that all the values were within the limits.

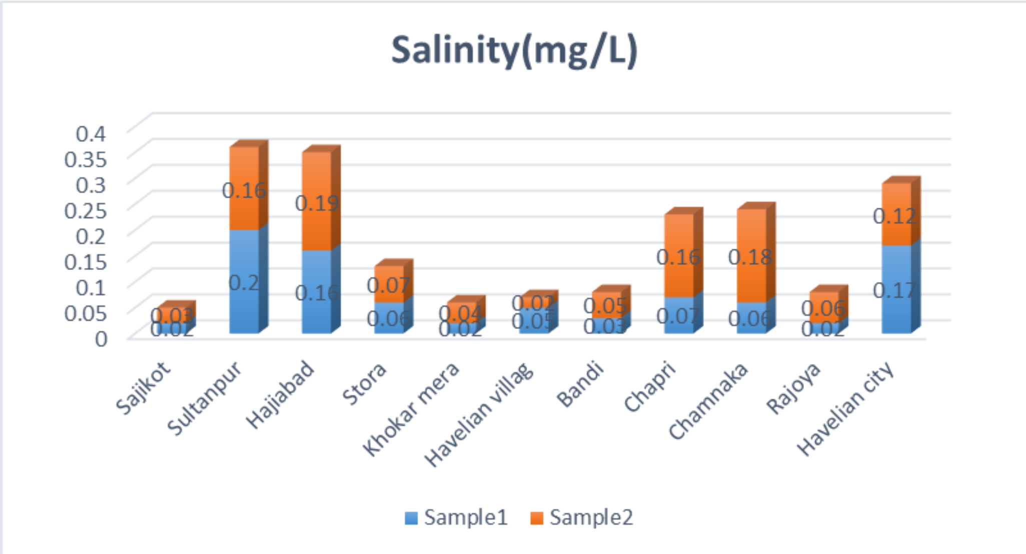


Fig. 4.1.5 Salinity of water sample

4.2 Chemical parameters

The various chemical parameters when analysed showed following results.

4.2.1 Total Dissolved Solids

Total dissolved solid is due to the being of non-living and natural materials, different solvable salts in drinking water leads to permanent and temporary hardness (Khan et al., 2015). Different compounds in water are donors for TDS such as Cl, CO3, Ca, O3 and Mg. In drinking water, corrosion is caused by TDS (PCRWR, 2005). Several cardiac diseases, mainly in women during pregnancy toxaemia is caused by needless amount of TDS in drinking water (Anwar et al., 1999**).**

1000 mg/L in water is the maximum suitable limit of TDS suggested by WHO. Fig. 4.6 shows that all the values of TDS are within the permissible limits suggested by WHO and Pakistan water quality standards.

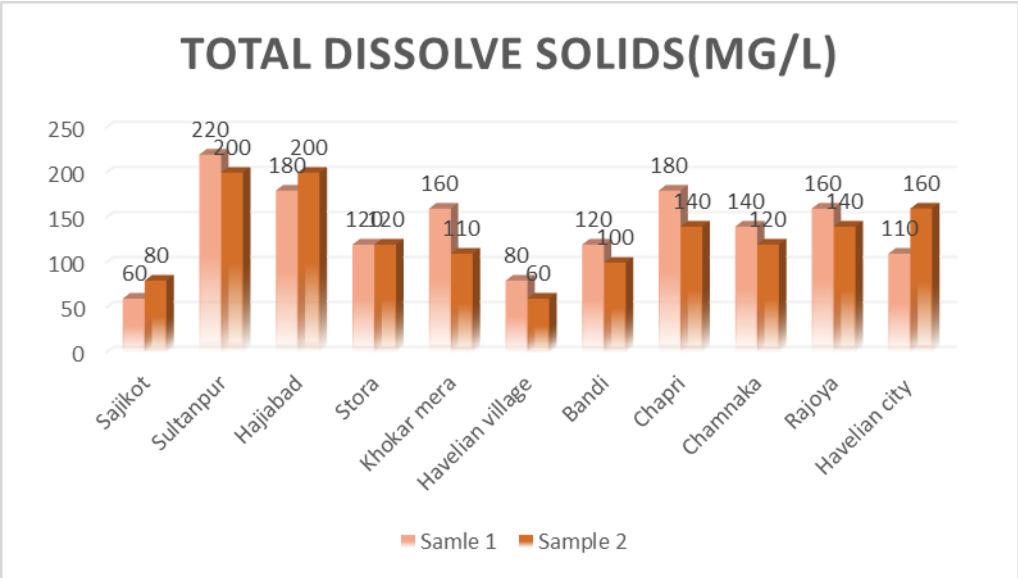


Fig. 4.2.1 Total Dissolve Oxygen of water sample

4.2.2 Alkalinity

Alkalinity is the ability of water to naturalized acid. When there is a occurrence of carbonates, hydroxides and bicarbonates in drinking water, it specifies the higher concentration of alkalinity in water. Alkalinity and acidity have opposite relationship because when alkalinity increases acidity level reduces (USEPA, 2013).

The permissible limit is 500 mg/l (WHO's standard) and 720 mg/l (Pakistan standard). Fig. 4.3 shows that all the final results are within the acceptable limits of WHO and NEQS.

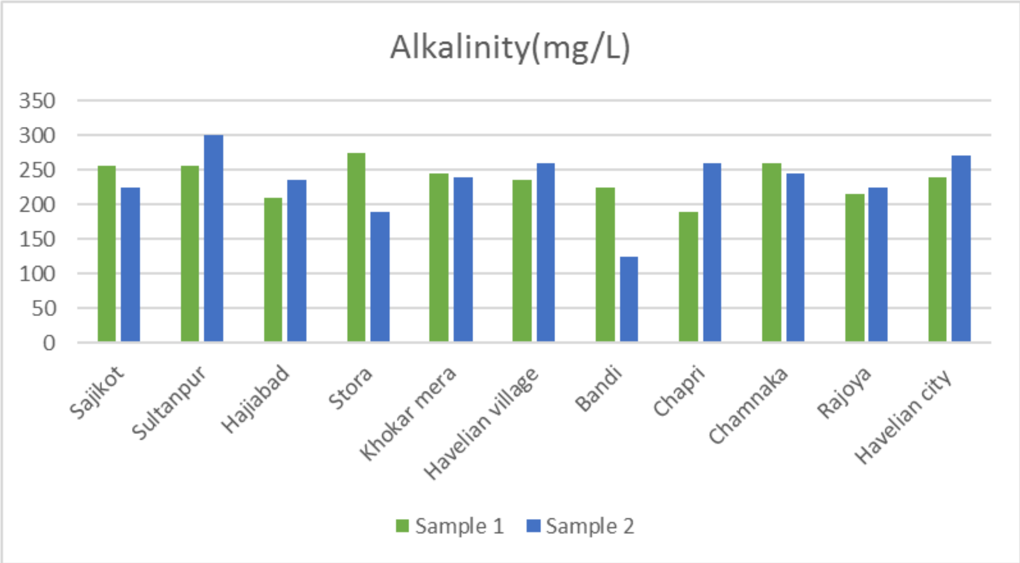


Fig. 4.2.2 Total Dissolve Oxygen of water sample

4.2.3 Sulphate

Sulphate minerals is the source of scale build up in water pipes like to other minerals and may be related with a unpleasant taste in water that can have a laxative effect on young livestock and humans.

Sulphate value of the samples collected from the target areas of Havelian are given in the Table 4.7. All the samples were found to be within permissible limits.

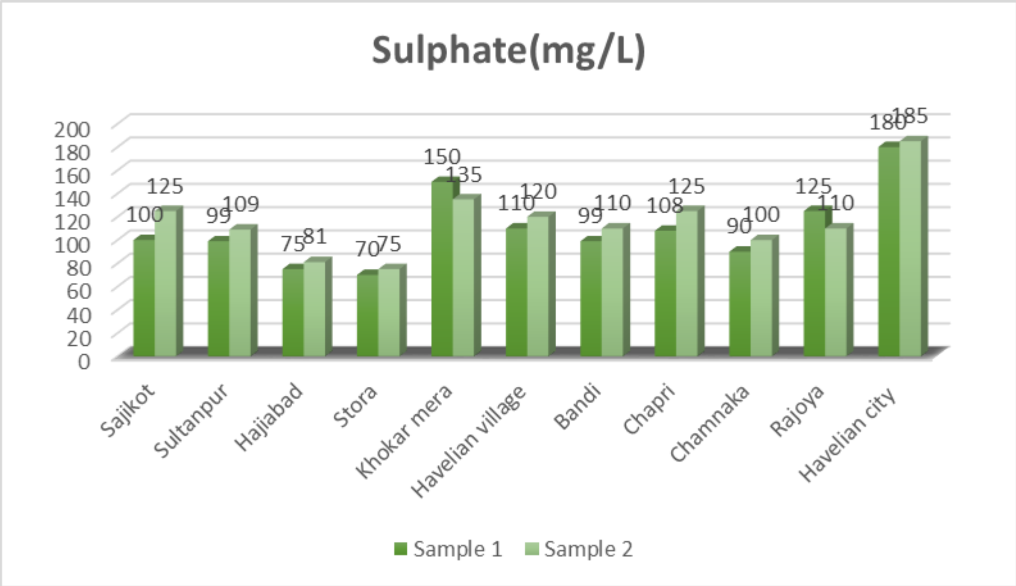


Fig. 4.2.3 Sulphate of water sample

4.2.4 Chlorides

Chlorides are present in both salt water and fresh water, and are vital elements of life. Salts such as table salt are collected of ions that are attached together. When table salt is mixed with water, its chloride ions and sodium detached as they dissolve. Chloride ions in the environment can come from sodium chloride or from other chloride salts such as potassium chloride, calcium chloride and magnesium chloride. The absorption of chlorides has abruptly increased in water since the extensive adoption of road salt as a dicer in the 1970s, Chloride absorptions of between 1 and 100 ppm (parts per million) are average in freshwater.

Chloride values of the water samples collected from Havelian are given in the Table- 4.8 All the sam ples were found to be within permissible lim

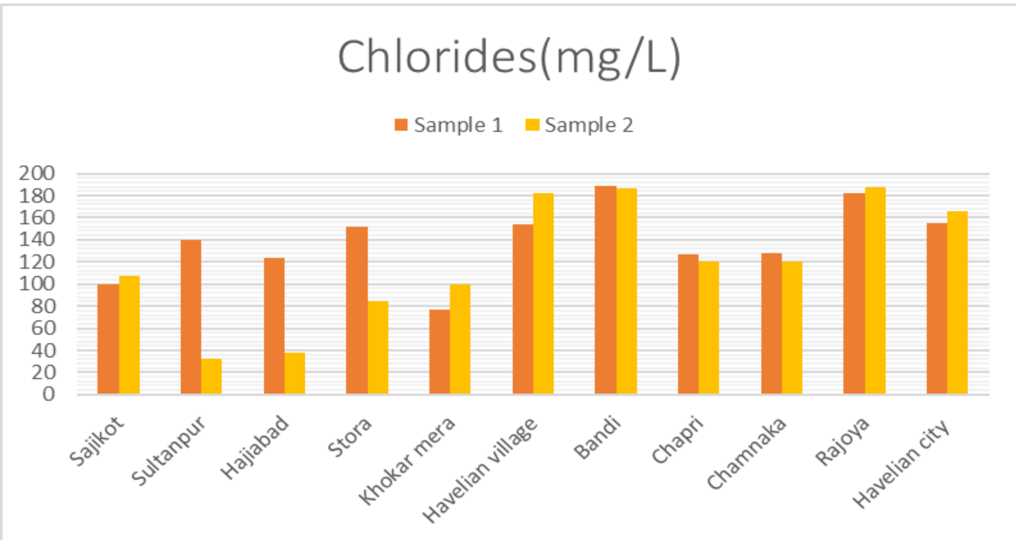
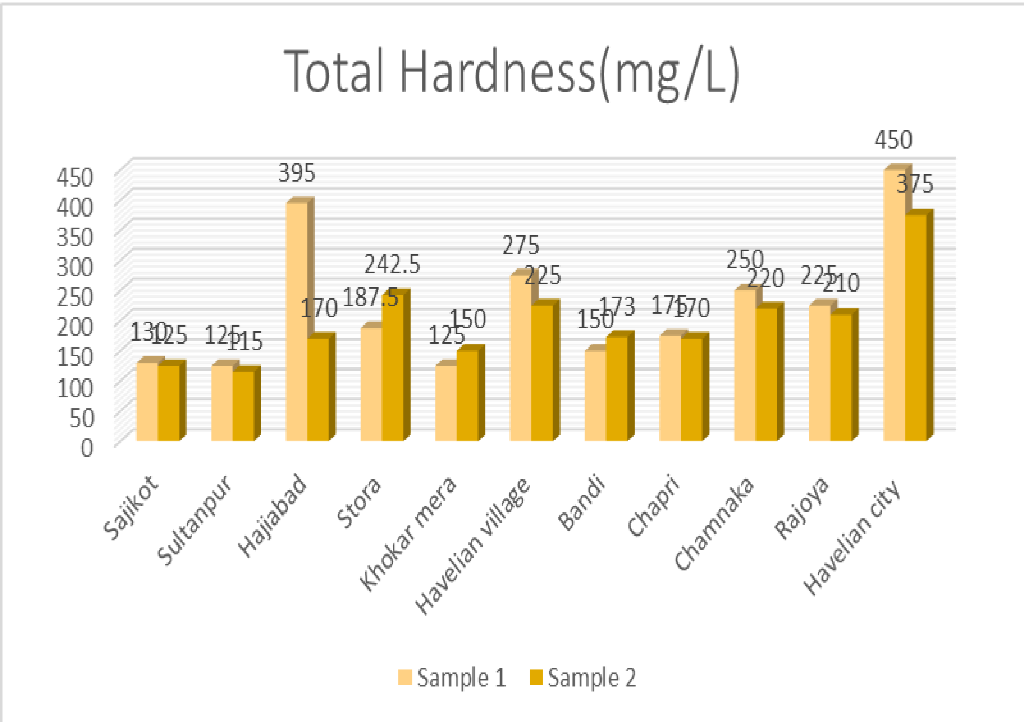


Fig. Chlorides in drinking water

4.2.5 Total Hardness

Hardness in water reasons due to the presence of highly dissolved minerals which are naturally occurring in water. Mg and Ca show a huge part in donors of hardness. Sulphates, dissolved ions and some other elements are contributed in hardness of water. According to WHO, 500mg/l hardness is acceptable in drinking water.

Result in the Fig. 4.4 shows that total hardness of the water is within the permissible limit recommended by WHO and Pakistan standards.



Total Hardness of water sample

4.2.6 Calcium Hardness;

Calcium is the fifth earth crust abundant element, involves in the formation of tooth and skeleton. In human body, it plays essential responsibility in metabolic process (Azizullah et al., 2011). It helps in blood clotting, running of heart beat and in nerve impulse communication (PCRWR, 2005). Calcium is basic constitute of water. Mostly it comes to water from the calcite, dolomite and gypsum bearing rocks. Ground water has high dissolved of calcium carbonate, sulfates and occasionally chloride (Driscoll, 1986).

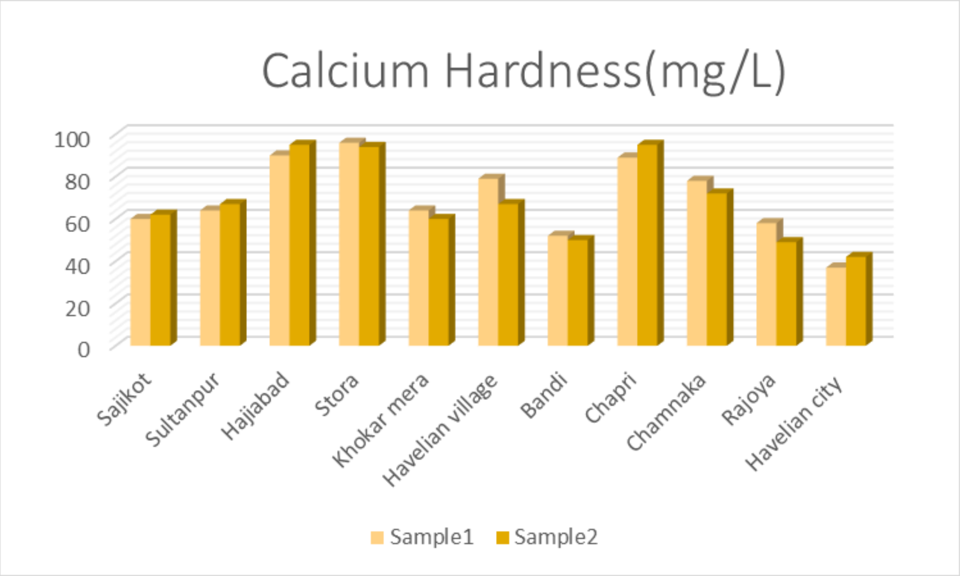


Fig. 4.2.6 Calcium Hardness of water sample

4.2.7 Magnesium Hardness;

It is the main abundant constituent among all the naturally occurring elements on earth. Mg is dissolved in portable water from the sedimentary rocks such as gypsum, mafic and ultramafic, those are rich in Mg. Lesser amount of Mg is superior hazard for cardiac arrhythmia that increase death rate

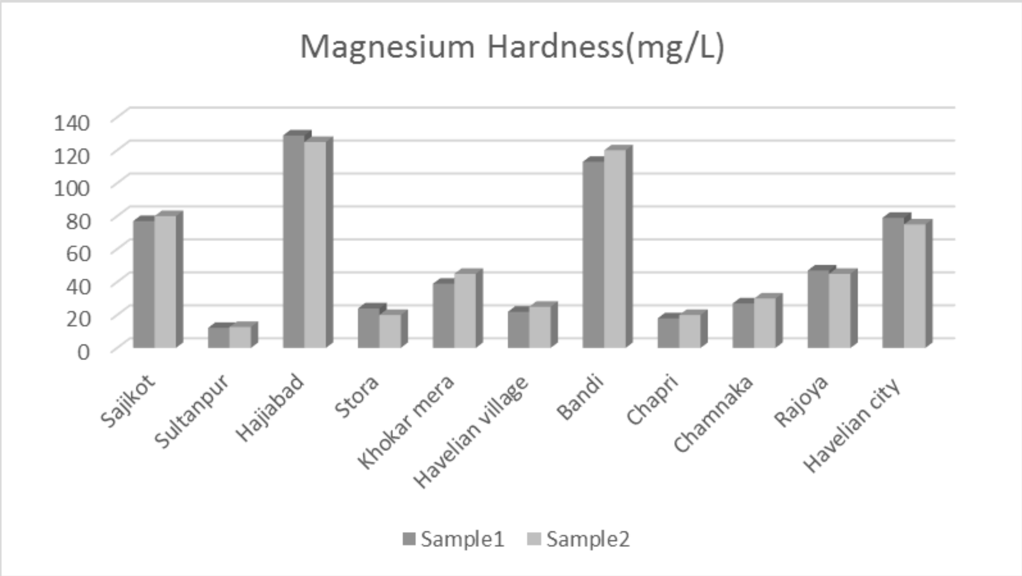


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Fig. 4.2.7 Magnesium Hardness of water sample

Total Suspended Solids (TSS)

The total suspended solids are simply amount of solid present in water, containing variety of materials such as slit, decaying inorganic matter, industrial and sewage effluents (Michaud, 1994). High concentration of TSS can give rise to many problems not only for humans but for human as wel

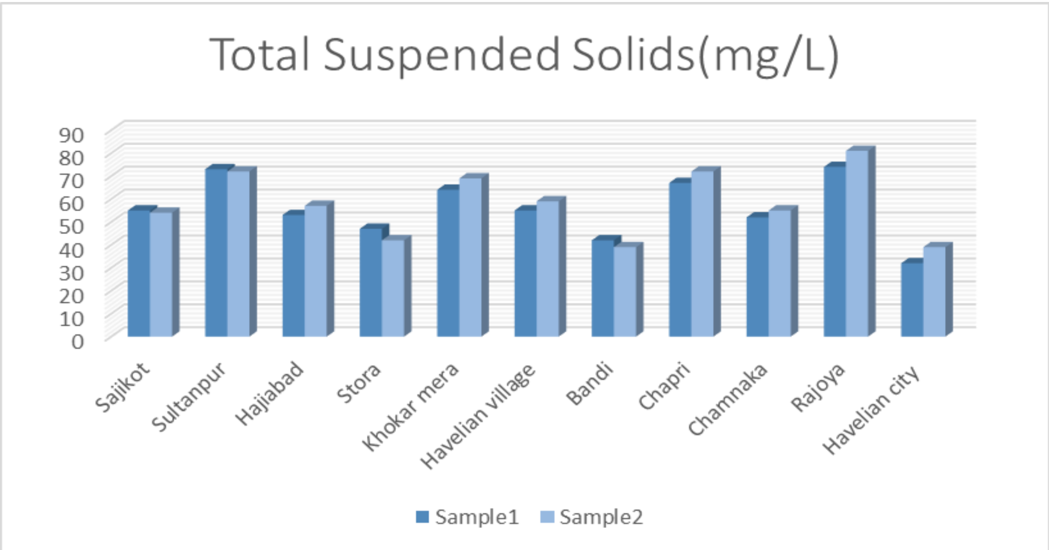

Fig. 4.2.8 TSS of water sample

4.2.8 Sodium;

Sodium is the abundant mineral and member of alkali metals. Mostly it is dissolved in water from the weathering of igneous rocks. The concentration varies from 1- 500 mg/L (PCRWR, 2005). Ground water and lakes have higher concentration of sodium as compared to running water (Azzizullah et al., 2011). Sodium is not dangerous for health but is dangerous for those who are suffering from heart diseases, hypertension and kidney diseases (Bacha et al., 2010).

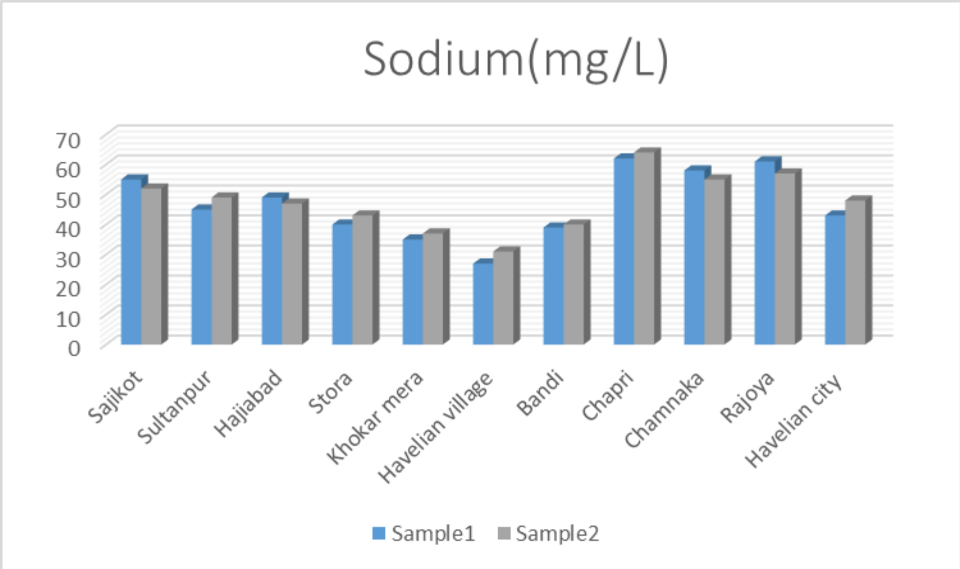

Fig Sodium of water sample

4.2.10 Potassium;

Potassium is less durable in water as compared to other minerals. Therefore, it is less found in drinking water. It entered into ground water from the decomposition of clay minerals. 4.7 gm/day potassium is necessary for health in adult age and deficiency of potassium leads to the generation of many diseases mainly causes hypokalaemia.

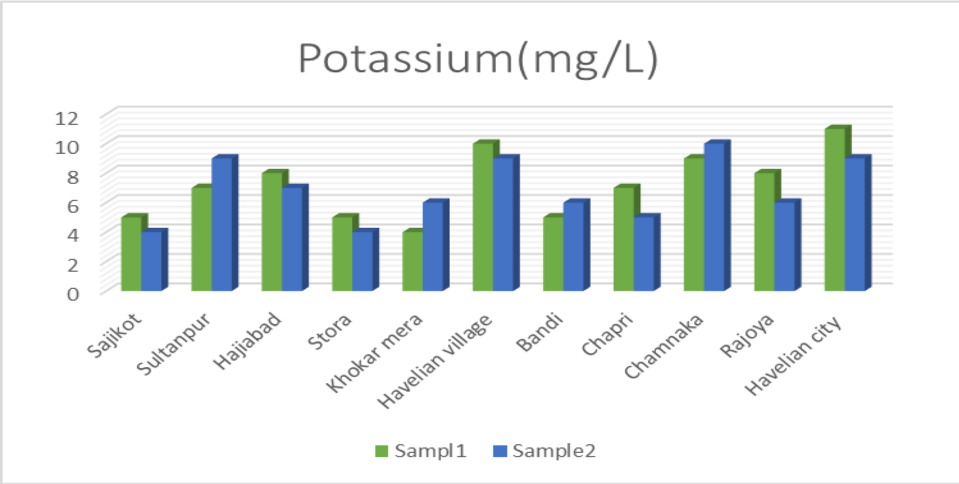

Fig. Potassium of water sample

Biological Analysis

4.9 Escherichia Coli:

For drinking water analysis, in order to recognize the disease sepreding organisms the *E.coli* has been chosen as the prime signal of bacteria. It is a prime symbol of suitability of water for use. In the water samples, if huge number of colonies of *E.coli* are originate, then there is a massive possibility of the occurrence of pathogenic bacteria or other organisms present in drinking water. The Pakistan and WHO Water quality standards require the proper absence in drinking water of *E.coli*. In this research, *E.coli* bacteria in all samples were not detected.

Table 4.2 show that all the samples have negative results, as no colonies were formed in any sample.

Locations of sample	**Results of *E.coli***
Sajikot	Negative
Sultanpur	Negative
Hajiabad	Negative
Stora	Negative
Khokar mera	Negative
Rajoya	Negative
Chapri	Negative
Havelian Village	Negative

Bandi	Negative
Chamnaka	Negative
Havelian city	Negative

A comparison of the determined values of Parameters in the study, with the permissible limits set by US-EPA, PAK-EPA and WHO

Water Quality Parameters	WHO, S standards (2001) (mg/l)	Standard values for Pakistan (mg/l)
TDS	1000 mg/l	1000 mg/l
EC	1000 µs/cm	1000 µs/cm
pH	6.5-8.5	6.5-8.5
TSS	200 mg/l	200 mg/l
Alkalinity	500 mg/l	500 mg/l
Total Hardness	500 mg/l	500 mg/l
Calcium Hardness	250 mg/l	250 mg/l
Magnesium Hardness	150 mg/l	150 mg/l
Sodium	150 mg/l	150 mg/l
Potassium	12 mg/l	12 mg/l
E.coli	No Relaxation	No Relaxation

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5. Conclusion and Recommendations.

5.1. Conclusion

The present research was conducted to analyse the drinking water quality in the district Havelian and their impacts on health. The final findings of physical and chemical parameters analysis and the questions asked in questionnaire were to a certain safe limit, there were no serious impacts from health point of view and water has to be found safe for drinking, there were slightly issue of stomach problems but that were not due to water that must be some hygiene problems and some due to eating disorders. All chemical and physical parameters were in accordance with the permissible values recommended by WHO and DWQS of Pakistan. Therefore, drinking water quality of district Havelian is "Safe" and "Suitable" for drinking purpose. So, there is no ill impacts on the consumers of study area.

5.2. Recommendation

- Physical, chemical and biological examination on a regular basis should be done by the concerned authorities so as to ensure the safe water supply.
- The existing water distribution system must be improved or replaced with safer system where necessary. Regular maintenance of water network is necessary to reduce breakages in pipelines.
- It is advisable to filter or boil the portable water before consumption.
- It should be ensured that the supplied water is meeting the WHO standards.
- The water supply should be from tube well, hand pump, or a spring, should be disinfected if it is from a surface water source.
- The well should be at least 25 feet away from the drainage lines, septic tanks, toilets, gutters and animal shed with proper casing.
- Government should take a keen interest in ensuring safe and clean drinking water to its citizens.
- Monitoring cells have to be established at village or district level.
- The well should be at least 25 feet away from the drainage lines, septic tanks, toilets, gutters and animal shed with proper casing.
- Public campaigns should be started to develop awareness in the local community.

5.3. Implications for marketers

Assessing the quality of drinking water in District Havelian, Abbottabad, Pakistan can have several implications for marketing.

This study suggests that marketing efforts transparently communicating water quality assessment results to consumers can significantly influence brand perception (Mazhar et al., 2014) and trust (Jamil et al., 2024; Zaman et al., 2016). Specifically, highlighting the measures undertaken to guarantee safe drinking water fosters a positive consumer perception and strengthens trust (Jamil & Qayyum, 2023) in the organization responsible for water provision.

Furthermore, if water quality assessments identify Havelian's water as superior to surrounding areas, this distinction can be strategically leveraged as a unique selling proposition and a significant positive change to marketing organization (Jamil and Shah, 2016). Marketing campaigns amplifying this water quality advantage can effectively differentiate the product from competitors and target health-conscious consumers who prioritize safe drinking water,

Marketing strategies can encompass educational campaigns using endorsements (Jamil et al., 2021) that illuminate the significance of clean drinking water and the potential health detriments linked to consuming contaminated water. By disseminating valuable information to consumers, organizations can establish themselves as industry thought leaders dedicated to safeguarding public health and well-being.

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