AN ASSESSMENT OF PHYSIOCHEMICAL PROPERTIES AND PUBLIC PERCEPTION OF WATER QUALITY IN KOHAT CITY

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A thesis submitted to the National University of Sciences and Technology, Islamabad, in partial fulfillment of the requirements for the degree of

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DEDICATION

To my beloved parents and family and my respected teachers!

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(Muhammad Hamza)

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LIST OF ABBREVIATION

Abbreviations	Definitions
APHA	American Public Health Association
AWWA	American Water Works Association
NSDWQ	National Standards for Drinking Water Quality
E coli	Escherichia coliform
F coli	Fecal coliform
NUST	National University of Science and Technology
IESE	Institute of Environmental Sciences & Engineering
SDG	Sustainable Development Goals
TDS	Total dissolved Solids
TSS	Total Suspended Solids
UN	United Nation
WHO	World Health Organization
PBS	Pakistan Bureau of Statistics
DTW	Domestic Tube Well
OW	Open Well
HP	Hand Pump

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ABSTRACT

Water is one of the most precious resources in the world, being both abundant and essential for life. Although it is impossible to exhaust the world's water supply altogether, water quality can be degraded, making it harmful or even lethal for human and animal consumption. This study aimed to assess the perception of drinking water quality in Kohat City. To achieve this, a physiochemical and microbial analysis of the drinking water was conducted, followed by a comparison with past data and a field survey to evaluate the results. Water samples were collected from various parts of the city and tested in Islamabad. The results were compared with past data to identify any changes since then. The results revealed a significant issue with microbial contamination in the water. A survey conducted among the residents of Kohat City showed that most people's perceptions of their drinking water quality were accurate, with a few exceptions. The greatest concern is the lack of measures taken to address microbial contamination. People do not treat their water before use, which may be a major cause of the spread of illnesses in the city. The data also shows dissatisfaction among the population regarding water availability and quality, especially in Jungle Khail and Behzadi Checkerkot, which are experiencing water shortages and quality issues, respectively.

CHAPTER 1 - INTRODUCTION

Introduction

Water is one of the most precious resources in the world. Water has the most numerous uses and it is necessary for life. Human beings use water in many ways such as drinking and hygiene and is a universal solvent. Every living thing in the world relies on water as it is the most drank fluid. Water has the potential for carrying bacteria and viruses becoming a medium for infection and leading to a variety of health risks in all living things. Groundwater plays an important role in the irrigation of agricultural land; it is also required for most industrial processes in varying capacities increasing its role in modern industrial growth. With the increase in importance, the amount of water that is being consumed as well as polluted from this industrial process has increased significantly in the past few centuries.

While it is unlikely that the world's entire water supply will be depleted, the quality of water can be severely compromised, rendering it unsafe and potentially deadly for human and animal consumption. Significant contributors to water pollution include direct discharge of domestic waste, untreated or inadequately treated industrial waste, poorly maintained septic systems, and mismanagement of agricultural waste such as manure and pesticides. These factors increase the risk of waterborne diseases. As the global population grows rapidly, along with urbanization and rising demands from sectors like agriculture, energy, and industry, the demand for water continues to increase. This has led to decades of over-extraction and inefficient use of water, placing immense pressure on water-related ecosystems. Additionally, the contamination of surface and groundwater further intensifies the water crisis. Consequently, more people are likely to face water scarcity in the future.

The global community has made progress in providing people with clean water services, the proportion of the global population using safely managed drinking water services has increased from 70 percent in 2015 to 74 percent in 2020 (The Sustainable Development Goals Report, 2022). Despite the efforts of the international community, 2 billion people lacked clean drinking water in 2020, 1.2 billion of which did not even have access to basic-level services. Continuing at the current rate, the international community will be able to provide safely managed drinking water to approximately 81 percent of people in the world leaving 1.6 billion people without any safe drinking water. Currently, around 829,000 people die annually to diseases attributed to unsafe water, poor sanitation, and hygiene, to decrease this number down to zero the current rate of increasing the world's access to safe drinking water needs to be increased fourfold. The figure below shows the Global coverage of drinking water, safely managed drinking water, and future projections as per data acquired from 2015-2020.

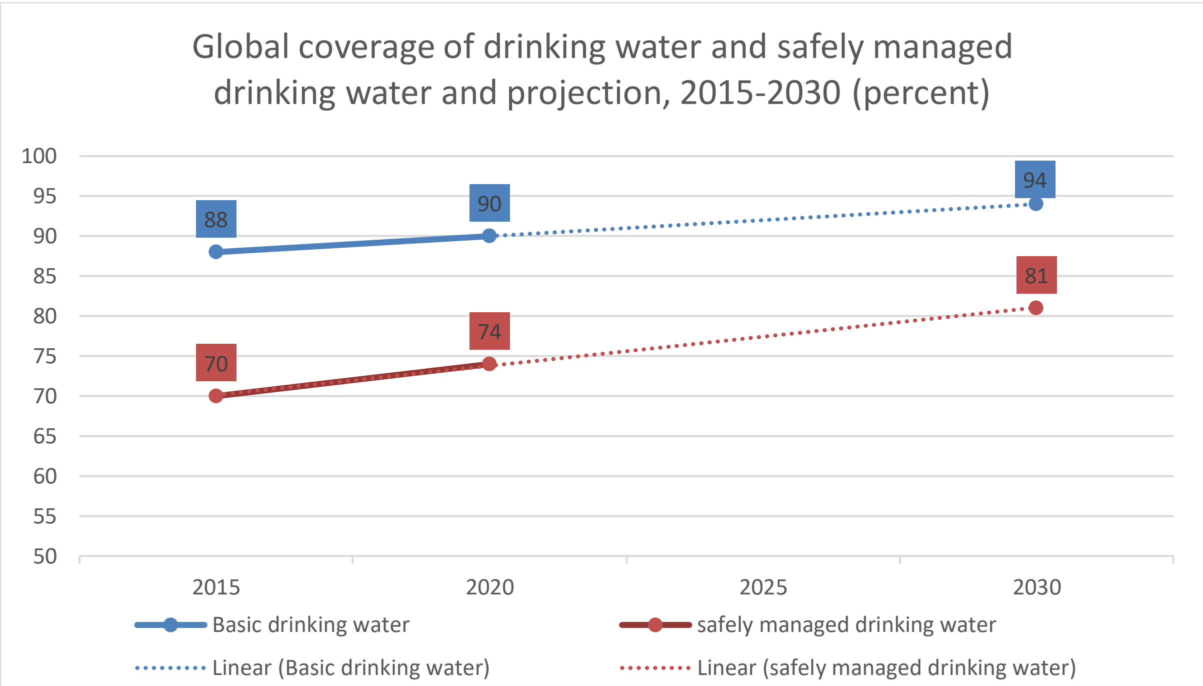

Figure 1: Global coverage of drinking water and safely managed drinking water

Water stress occurs when the rate of freshwater withdrawn from a water source is greater than 25 percent of the rate of replenishment of the water source. High levels of water can have detrimental effects on the environment as well as its users and may lead to a reduction in socio-economic growth or extreme cases may cause a reversal of growth, such conditions also lead to increased competition further leading to conflicts. In 2019, the water stress level of the world was at 18.6 percent which is below 25 percent, however, regional variations in the data show that North African and West Asia's critical water stress was at 84.1, an increment of 13 percent from 2015. 733 million people, approximately 10 percent of the world's population live in countries where the water stress is considered critical or high. Increasing the efficiency of the use of water can relieve water stress, an increase in efficiency of 12 percent is recorded from 2015 to 2019. Pakistan is included as one of the countries with critical water stress conditions. The figure below shows the level of water stress across the world in 2019.

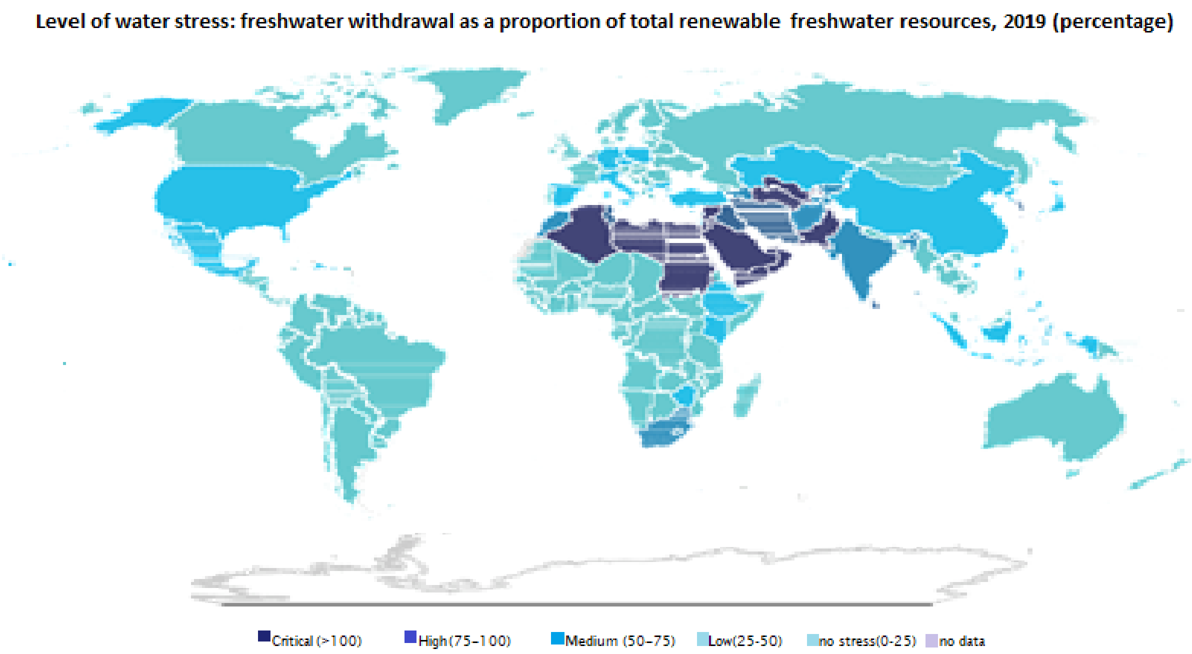

Figure 2: Global water stress levels, 2019 (percent)

(Source: (The Sustainable Development Goals Report, 2022))

Pakistan, located in South Asia, has a population of 241.5 million, making it the fifth most populous country globally. In terms of water quality, Pakistan ranks 80th out of 122 countries (Azizullah, 2011). Kohat City, situated in the Kohat district of Khyber Pakhtunkhwa province, lies at coordinates 33°35′N 71°26′E and an elevation of 489 meters (Wikipedia, 2012). The primary water source for the region is Tanda Dam, and the city itself has a population of 220,000 (Census-Internet, 2018). This study aims to evaluate the perception of drinking water quality in Kohat City by analyzing the physiochemical and microbial properties of the water, followed by a survey to understand the population's views on water quality.

Problem Statements

The rapid increase in urbanization causes immense pressure on urban services, one of the areas most affected by this is the provision of safe drinking water. As the region of Kohat continues to urbanize, this may become a serious problem for the city similar to other urban environments in the region. The country of Pakistan is already listed among the critical water-stressed countries in the world In the SDG Report of 2022. Many of Pakistan's urban areas are forced to transport water to its residents such as Rawalpindi where many parts of the city need to be supplied with water daily via water tankers.

Kohat's urban expansion is accompanied by the city's increasing reliance on underground water sources which may eventually lead to water stress causing the quality of drinking water to deteriorate. The drinking water sources in the Kohat district are contaminated, with the most affected areas being Shakardara, Lachi, and Ara Khail(Khan Naeem, 2012). Accompanying the risk of pollution is the increasing risk of water stress which is present throughout the region. Pakistan is placed in the critical category of water stress in the SDG (2022).

Justification for Research

The population of Pakistan is rapidly increasing and the increase in population causes an increase in urbanization.

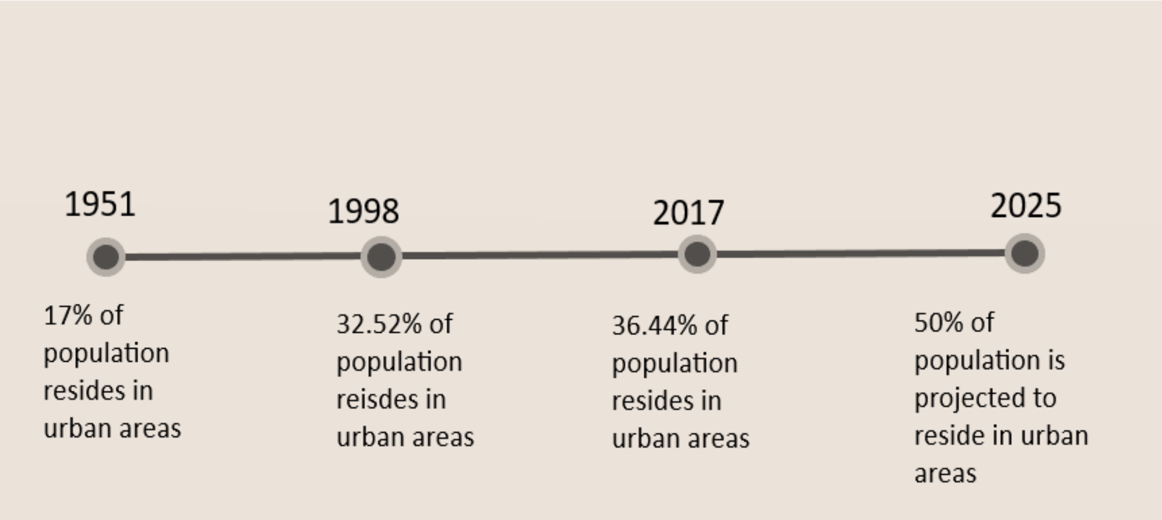

Figure 3: Urbanization over time

As the population increases, more houses are built, more roads are needed and every need is increased. Urbanization leads to many problems. One of the biggest problems that urbanization leads to is the deterioration of water quality. As the need for urban settlement increases, an increase in industrialization and agricultural produce is needed to sustain the growing demands of the population. To meet these demands aggressive expansion of the existing industrial and agricultural throughput is required, which may be in the form of an increase in the number or size of existing operations or in developing new means to expand the throughput by modernizing the current methods.

The increase in urbanization results in an increased use of water causing the rapid depletion of the water sources. The reliance on groundwater sources increases the water stress levels causing carious consequences for the environment.

Research Questions

The research aims to answer the following questions:

1. What is the current situation of the physiochemical properties of drinking water in Kohat city?
2. How have the physiochemical properties of drinking water changed compared to the past data?
3. What is the perception of the people of Kohat City regarding the state of the available drinking water?
4. What is the perception of the people of Kohat City regarding the changes that have occurred in the quality of drinking water?
5. What is the Level of satisfaction of the people of Kohat city regarding the quality of water and its availability?

Research Objectives

This research's objectives are to evaluate the physiochemical properties of drinking water in Kohat city, in order to assess the current situation of the water available in the different area of the city and highlight the changes that have occurred from the previous data to see how the properties of drinking water have changed and to investigate the perception of the people of Kohat City regarding the quality of drinking water available in the region, in order to observe the similarities and differences between the people's view of the drinking water and the actual state of the available water.

CHAPTER 2 - LITERATURE REVIEW

The increase in population requires an increase in resources to cater to the increasing needs of the urban population. The global population is increasing at an alarming rate and with it there is an increase in the urban population, increasing pressure on the environment and natural resources. The urban lifestyle has a high consumption rate of water gas and electric power which further adds to the existing strain on the available resources. This increased population has led to an increase in urbanization which resulted in the development of more paved roads, more houses, more pesticides, more buildings, etc.

- **Population Growth**: The global population is rising rapidly, leading to an increase in the urban population. This surge places immense pressure on environmental resources.
- **High Consumption Rates**: Urban lifestyles are characterized by elevated consumption of:
    - Water
    - Gas
    - Electric power
- **Infrastructure Development**: The need to accommodate a growing population results in:
    - More paved roads
    - Increased housing
    - Additional buildings and infrastructure
    - Greater use of pesticides and fertilizers
- **Water Pollution**: Although the hydrological cycle continuously recycles water, the quality can deteriorate significantly due to:
    - Direct discharge of domestic and industrial effluents

    - Leaks from poorly maintained septic tanks
    - Inadequate management of agricultural waste
- **Global Context**: The decline in drinking water quality is a prevalent issue worldwide. Many countries' drinking water does not meet WHO standards (A, 2007; Gupta DP, 2009; Gyamfi ET, 2012).
- **Pakistan's Standing**: Pakistan ranks 80th out of 122 nations based on water quality (Azizullah, 2011).
- **Reliance on Groundwater**:
    - Approximately 70% of Pakistan's drinking water comes from underground aquifers, with this percentage rising.
    - Major freshwater sources include glaciers, rivers, and lakes.
- **Challenges**:
    - The country faces water shortages due to:
        - Reduced rainfall and snowfall
        - Pollution affecting freshwater supplies

Groundwater Usage

- **Current Consumption**: Groundwater is the most extensively used natural resource for human activities, comprising over 70% of water consumption (Prasad BG, 2004).
- **Quality Issues**: Many areas in Pakistan do not meet WHO or local drinking water quality guidelines due to:
    - Untreated disposal of municipal and industrial wastewater
    - Saline drainage from agricultural areas (Tahir MA, 1998; Chilton PJ, 2001)

The rapid urbanization and population growth in Pakistan and globally present significant challenges for water resource management. Addressing water quality deterioration and ensuring sustainable usage of available resources are critical to mitigating water stress and safeguarding public health. The need for effective treatment of wastewater, better management of agricultural runoff, and improved infrastructure is paramount in overcoming these challenges.

Water Stress

Water stress occurs when the ratio of freshwater withdrawal to total renewable freshwater resources exceeds 25%. High levels of water stress can have severe environmental impacts and hinder economic and social development, while also heightening competition and potential conflicts among water users. In 2019, global water stress reached 18.6%, remaining below the critical threshold. However, this global average hides significant regional differences. Northern Africa and Western Asia experienced critical water stress levels of 84.1%, a 13% increase since 2015. Over 733 million people, or 10% of the world's population, live in areas with high or critical water stress (above 75%). Improving water-use efficiency helps alleviate water stress. From 2015 to 2019, water-use efficiency increased by 12%, rising from $17.4 to $19.4 per cubic meter. However, in agriculture, which is the largest consumer of water, efficiency was only $0.63 per cubic meter in 2019. Enhancing the productivity of water in agriculture is crucial for boosting overall water-use efficiency, especially in arid regions dependent on farming (The Sustainable Development Goals Report, 2022). Pakistan is included as one of the regions with a critical water stress situation. The effects of water stress are not only limited to the decrease in water quantity but also have a deteriorating effect on the physiochemical properties as well, a common effect is the increase in salinity.

There are two ways to prevent/mitigate water stress; the first is to increase the replenishment rate of the water source, this can be achieved in multiple ways such as by expanding the water replenishment means for example in the case of a reservoir, we can increase the size of its tributaries and the second is to decrease the consumption rate, this is done mainly by increasing awareness of the problem via campaigns using different mediums such as social media, mainstream media and newspaper etc.

Another factor contributing to the rise in water stress is the presence of transboundary water sources. Rivers, lakes, and aquifers that cross national borders are shared by 153 countries globally. Managing these shared water resources equitably, sustainably, and peacefully, especially amid the challenges posed by climate change, requires countries to establish effective operational frameworks for water cooperation.

Based on data from 129 countries, 32 nations reported that 90% or more of their transboundary water resources were covered by operational agreements in 2020, an increase from 22 countries in 2017. In Europe and Northern America, 24 out of 42 countries achieved this level of coverage, compared to only 5 out of 42 countries in sub-Saharan Africa and a mere 3 countries across the rest of the world. To accelerate progress, countries need to address data gaps, particularly regarding transboundary aquifers, enhance capacity building and funding, leverage global water conventions and draft articles on transboundary aquifer laws, and strengthen political commitment.(The Sustainable Development Goals Report, 2022).

Physiochemical Evaluation: A Case Study of Badin City, Sindh, Pakistan

Badin City, located in the Sindh province of Pakistan, is situated 210 km from Karachi, the provincial capital. Historically, Badin was a center of the ancient Indus Valley civilization due to its proximity to the Indus River (on the river's east side). The district experiences a mostly moderate climate, with a sea breeze blowing throughout the year, keeping the weather pleasant. Badin District consists of five Talukas: Badin, Talhar, Shaheed Fazal Rahu, Matli, and Tando Bago. For the assessment of drinking water quality, ten sites were selected in Badin City for sampling. These sites include Canal Water (Jamali Village), Hand Pump (Jamali Village), WSS Pond By-Pass, Hand Pump (Laghari Village), Tap Water (Chandia Nangar), WSS Pond (Ward No-04), Filter Plant (Bilawal Park), Civil Hospital Badin, Iqra School Badin, and Akram Canal.

Water samples were collected from ten randomly selected sites in Badin City, including Canal Water (Jamali Village), Hand Pump (Jamali Village), WSS Pond By-Pass, Hand Pump (Laghari Village), Tap Water (Chandia Nangar), WSS Pond (Ward No-04), Filter Plant (Bilawal Park), Civil Hospital Badin, Iqra School Badin, and Akram Canal. These samples were gathered from various drinking water sources using pre-sterilized, clear, clean, and dry polyethylene bottles, which were rinsed twice with the sample water prior to collection. All reagents utilized were of analytical grade, and double-distilled water was used to wash the glassware before use.

Sample Collection Process

- **Preparation of Vessels**: Cleaned vessels were filled carefully to eliminate air bubbles, ensuring the integrity of the samples. After filling, the bottles were sealed in airtight bags for subsequent analysis.

- **On-Site Observations**:
    - Observations such as color and odor were recorded at the sampling location.
    - In-Situ Measurements:
        - Electrical Conductivity (EC)
        - Temperature
        - pH
- **Geolocation**: GPS devices were used to record the latitude and longitude of each sampling site, ensuring precise location tracking for future reference.

The collected samples were analyzed in the laboratory to assess various physicochemical properties, including:

- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Hardness

The analysis revealed that certain water samples, specifically from the Hand Pump (Laghari Village) and Hand Pump (Jamali Village), exhibited contamination levels exceeding WHO standards. All tested parameters were found to be outside the permissible range, indicating that the water from these sources is unsuitable for drinking (Talpur, 2018).

Physiochemical Evaluation: A Case Study of Mardan City, KPK, Pakistan

The escalating pollution of drinking water sources in Pakistan poses significant risks to human health and the environment. Previous research has highlighted alarming levels of fecal coliform and *Escherichia coli* contamination in groundwater sources within the Mardan district. This contamination is primarily attributed to the vulnerability of drinking water sources to pollution from nearby human activities (Khan N, 2012).

A total of 39 groundwater samples were systematically gathered from a range of sources, including:

- Domestic Tube-Wells (DTW)
- Open-Wells (OW)
- Hand-Pumps (HP)

The samples were gathered across 13 densely populated union councils in the urban area of Mardan. Each sample was analyzed in triplicate, leading to a comprehensive dataset comprising a total of 117 samples.

Physical Parameter Assessment:

- **Temperature**: Recorded on-site using a centigrade thermometer.
- **Sensory Evaluation**: Color, smell, and taste of water samples were assessed through sensory perception.
- **pH Measurement**: Conducted using an electrometric method with a Mettler Delta 320 pH meter.
- **Electrical Conductivity (EC)**: Determined using a Jenway 4060 conductivity meter.
- **Total Dissolved Solids (TDS)**: Measured using drying filtered samples in a Memmert B 54 oven at a temperature range of 103-105°C.

Chemical Analysis

- **Total Hardness**: Calculated in mg $CaCO_3/L$ using the EDTA titrimetric method with Eriochrome black-T as the indicator alongside a standardized solution of ethylenediaminetetraacetic acid (EDTA).
- **Calcium Hardness**: Measured similarly using a murexide indicator.

- **Magnesium Hardness**: Derived by subtracting calcium hardness from total hardness.
- **Bicarbonate Levels**: Determined through titration with hydrochloric acid (HCl).
- **Alkalinity**: Expressed as mmol/L by dividing bicarbonate values by 50.

The comprehensive analysis of groundwater quality in the Mardan district provides critical insights into the ongoing pollution issues affecting drinking water sources. The findings underline the urgent need for effective water management strategies and pollution control measures to safeguard public health and ensure access to safe drinking water.

Many groundwater sources, such as open wells, hand pumps, and public water supply schemes, fail to meet the World Health Organization (WHO) and Pakistan's guidelines for safe drinking water. This deterioration in water quality poses significant health risks to the population relying on these sources. The failure of many groundwater sources to meet WHO and Pakistan guidelines underscores the urgent need for improved management and protection of these vital water resources. Addressing the contributing factors through better infrastructure, regular maintenance, and pollution control measures is essential for ensuring the safety and sustainability of drinking water in the region (Khan N. H., 2013).

Physiochemical Evaluation: A Case Study of Tehsil Lachi, KPK, Pakistan

Tehsil Lachi is situated in the Kohat district of Khyber Pakhtunkhwa (KPK) province, Pakistan. The primary drinking water sources in Kohat include tube wells, wells, streams, tanks, and hand pumps. Physiochemical evaluations indicated that Ara Khail, Lachi, and Shakar Dara are the most contaminated areas, with many drinking water sources exceeding WHO/Pakistan standards for safe drinking water (Khan Naeem, 2012).

A total of 22 samples were collected from various drinking water sources in Tehsil Lachi, comprising 19 samples from wells, tube wells, tanks, streams, and hand pumps across four selected population zones, along with three commonly consumed bottled water samples from the open market. The samples were collected in clear, clean, and dry polyethylene bottles of 1 L and 100 mL capacities. Initially, the bottles were rinsed with the sample water at the collection site, and care was taken to fill them without leaving any air bubbles. The filled bottles were then stored in a refrigerator for subsequent analysis of various quality parameters. The 1 L bottles were designated for physiochemical analysis, while the 100 mL bottles were used for testing heavy metals (Association, 1998).

The physical parameters of the water samples were assessed using the following tests: pH was measured using the electrometric method with a Mettler Delta 320 pH meter from England, while electrical conductivity was determined in the laboratory with a Jenway 4060 conductivity meter, also from England. Total solids were assessed by drying the samples in a Memmert B 54 oven (Schwabach, W. Germany) at a temperature of 103-105 ºC, with the increase in weight recorded as mg of total solids per liter of sample. For total dissolved solids (TDS), the well-mixed samples were filtered through Beckman filter paper and then dried in the oven at the same temperature. Total suspended solids (TSS) were calculated by subtracting total dissolved solids from total solids (Association, 1998).

The chemical parameters of the water samples were determined using the following methods:

- **Alkalinity** was measured through a titration method, utilizing methyl orange as an indicator and a standardized sulfuric acid solution.

- **Total hardness** was assessed as mg $CaCO_3$/L using the EDTA titrimetric method with Eriochrome black-T as the indicator and a standard solution of ethylenediaminetetraacetic acid (EDTA).
- **Calcium hardness** was also measured using the EDTA titrimetric method, employing a murexide indicator and a standard EDTA solution.
- **Magnesium hardness** was calculated by subtracting calcium hardness from total hardness.
- **Chloride** levels were determined by the argentometric method, using potassium chromate as the indicator and a standard $AgNO_3$ solution.
- **Sodium and potassium** concentrations were measured using the flame emission photometric method with a Flame Photometer (Corning 410, Germany) (Association, 1998).

Most of the analyzed samples were found to be contaminated based on one or more parameters. Only the pH, alkalinity, and potassium levels of all the samples fell within the permissible range. It can be concluded that the quality of drinking water in the Lachi area is significantly compromised, and it is recommended that drinking water undergo treatment before distribution.

Chemical And Bacteriological Evaluation: A Case Study of Peshawar, Mardan, Kohat and Swat Districts, KPK, Pakistan

For both bacteriological and chemical analyses, a total of 200 water samples were collected in 50 mL sterile polyethylene bottles from five different sources: bottles, wells, boreholes (ranging from 115 to 380 feet), taps, and hand pumps. The collection was carried out in a sterile manner (AHMAD, 2012; GWIMBI, 2011). Fifty samples were obtained from each district through purposive sampling to ensure comprehensive coverage. These samples were promptly stored at a temperature between 0 to 4 °C prior to processing (ANWAR, 2010).

For testing bacterial contamination, Lauryl Triptose broth was utilized as the medium in the presumptive coliform test. Three sets of tubes were inoculated with 10 mL, 1 mL, and 0.1 mL of each water sample. The tubes were incubated at temperatures between 37 °C and 44 °C for 24 to 48 hours and were examined for acid and gas production. Following the presumptive coliform test, the total coliform confirmatory test was conducted using Brilliant Green Lactose Bile broth. The inoculated tubes for total coliform were incubated at 37 °C for 24 to 48 hours, while the tubes for fecal coliform were incubated at 44 °C and monitored for gas production. After confirming the presence of fecal coliform, Eosin Methylene Blue (EMB) agar plates were employed to detect E. coli. A loop dipped in the broth from each positive tube was used to streak the EMB plates, which were then examined for bacterial growth (ANWAR, 2010; ALI, 2011).

Various chemical tests were conducted to assess the levels of specific chemical ions in the sampled water, including chlorides (Cl), nitrates (NO2), nitrates (NO3), sulfates (SO4), and total soluble solids (TSS). These ions were analyzed according to standard procedures. For nitrates (NO2), nitrates (NO3), and sulfates (SO4), the Cadmium Reduction Method (Hach-8192) and SulfaVer4 (Hach-8051) were utilized, respectively, using a spectrophotometer for measurement. Chloride (Cl) levels were determined by an argentometric method that employed a potassium chromate indicator and a standard AgNO3 solution. For TSS determination, all water samples were filtered through Beckman filter paper and dried in an oven at a temperature of 103-105 °C (SOYLAK, 2002; FELDMAN, 2007; Khan N, 2012).

This study concludes that the water quality in the KPK province is neither chemically nor microbiologically suitable for drinking, particularly from unprotected sources such as wells and hotels that are prone to microbial contamination. It is essential for individuals to ensure the purity of their drinking water, as failure to do so could lead to serious health consequences. Microbial contamination can be mitigated by adopting specific precautionary measures. For households, particularly for families and children, it is advisable to use filtered or boiled water due to the potential risk of tap water contamination. When traveling, bottled water is a safer option. We recommend that ongoing water surveys be conducted to gather baseline data and assess levels of various ions and heavy metals. This information will be crucial for determining future needs and informing policy decisions (Awan, 2024).

Physiochemical And Microbial Evaluation: A Case Study of Kohat District, KPK, Pakistan

A total of 60 water samples were collected methodically from a range of drinking water sources in both urban and rural areas of the Kohat district. The sampling procedure included:

1. **Sample Composition:**
   - 54 samples were gathered from 15 designated population zones.
   - 6 bottled water samples were acquired from the open market.
2. **Collection Procedure:**
   - Clear, clean, and dry polyethylene bottles were employed for gathering samples.
   - Each bottle was rinsed with the water sample at the collection site to remove any possible contaminants.
   - The bottles were filled carefully to prevent the entrapment of air bubbles,

ensuring the integrity of the samples.

1. **Storage**:
    - Post-collection, the filled bottles were promptly placed in a refrigerator to preserve the samples until the analysis of various water quality parameters commenced.

This meticulous collection and storage method aimed to ensure the accuracy and reliability of the subsequent water quality analysis, adhering to the protocols outlined in Association (1998).

The following methods were employed to measure various water quality parameters:

1. **pH Measurement**:
    - The pH was determined using the electrometric method (4500-H+B) with a Mettler Delta 320 pH meter.
2. **Electrical Conductivity**:
    - Electrical conductivity was assessed through laboratory methods (2510 B) using a Jenway 4060 conductivity meter (APHA, 1998).
3. **Total Solids**:
    - Total solids were quantified by drying water samples in a Memmert B 54 oven at temperatures ranging from 103 to 105 °C (2540-B). The weight gained after drying was expressed as milligrams of total solids per liter of the sample.
4. **Total Dissolved Solids (TDS)**:
    - Total dissolved solids were assessed by filtering a thoroughly mixed sample through Beckman filter paper and then drying the filtered residue in an oven, following method 2540-C.

5. **Total Suspended Solids (TSS)**:
    - The total suspended solids were determined by subtracting the total dissolved solids from the total solids, in accordance with method 2540-D (Association, 1998).

These methodologies ensured accurate assessment of the physical and chemical properties of the water samples collected from the Kohat district, providing a comprehensive overview of water quality.

1. **Alkalinity Measurement**:
    - Alkalinity in the water samples was evaluated using the titration method (2320 B), with methyl orange serving as the indicator and a standardized sulfuric acid solution (Association, 1998).
2. **Total Hardness**:
    - Total hardness was assessed in milligrams of $CaCO_3$ per liter by employing the EDTA titrimetric method (2340 C), using Eriochrome black-T as the indicator in conjunction with a standardized solution of ethylenediaminetetraacetic acid (EDTA).
3. **Calcium Hardness**:
    - Calcium hardness was assessed through the EDTA titrimetric method (3500-Ca B), utilizing a murexide indicator in conjunction with a standardized solution of EDTA.
4. **Magnesium Hardness**:
    - Magnesium hardness was determined by subtracting calcium hardness from total hardness (3500-Mg B).
5. **Chloride Levels**:
    - Chloride concentrations were assessed using the argentometric method (4500-

Cl- B), utilizing a potassium chromate indicator in conjunction with a standardized $AgNO_3$ solution (Association, 1998).

These methods provided a detailed analysis of the chemical composition of the water samples, crucial for assessing water quality and safety for human consumption.

- **Range of pH Levels**:
  - The pH readings for all water samples ranged from 6.39 to 7.85.
  - Lowest pH: The lowest pH was recorded at the Shaikhan hand pump (6.39).
  - Highest pH: The highest pH was observed at the Hasan Abad tube well (7.85).
- **Specific Sources**:
  - Hand Pumps: pH values ranged from 6.39 to 7.60.
  - Streams: pH values ranged from 6.76 to 7.76.
  - Tanks: pH values ranged from 6.78 to 7.70.
  - Tube Wells: pH values ranged from 6.80 to 7.85.
  - Wells: pH values ranged from 6.86 to 7.80.
  - For bottled water, the pH values varied between 6.97 and 7.80.
- **Standards Compliance**:
  - All samples, except for the Shaikhan hand pump (6.39), complied with the World Health Organization (WHO) and Pakistani standards, which specify a range of 6.50 to 9.20 (Association, 1998; WHO, 1996; WHO, 2006; PCRWR, 2005).
- **Health Implications**:
  - The low pH level of the Shaikhan hand pump suggests that it is not safe for human consumption.
  - Low pH levels can cause redness and irritation of the eyes.

- pH also affects the corrosion of metals and the effectiveness of disinfection in water distribution systems, thus indirectly impacting health (WHO, 1986).

This analysis emphasizes the importance of monitoring pH levels in drinking water sources to ensure safety and compliance with health standards.

- **Overall Range**:
    - The total alkalinity for all water samples was observed to range between 116 and 736 mg/L.
    - Lowest Alkalinity: The lowest level was found in Aqua bottled water (116 mg/L).
    - Highest Alkalinity: The highest level was recorded in the Shakardara hand pump (736 mg/L).
- **Alkalinity by Water Source**:
    - Hand Pumps: Ranged from 336 to 736 mg/L.
    - Streams: Ranged from 288 to 452 mg/L.
    - Tanks: Ranged from 212 to 504 mg/L.
    - Tube Wells: Ranged from 276 to 560 mg/L.
    - Wells: Ranged from 260 to 530 mg/L.

The analysis indicates significant variability in total alkalinity among different water sources, with hand pumps showing the highest levels. The findings highlight the need for monitoring alkalinity levels, as they can influence water quality and suitability for consumption.

- **Bottled Water Alkalinity**:

    - The total alkalinity values in bottled water ranged from 116 to 243 mg/L.

- **Compliance with Standards**:
    - Except for four samples, all water sources were within the limits set by:
        - WHO: 500 (mg/L)
        - Pakistani Standards: 400 to 500 (mg/L)
- **Samples Exceeding Standards**:
    - Lachi Hand-Pump: 556 (mg/L)
    - Lachi Tube-Well: 560 (mg/L)
    - Shakardara Hand-Pump: 736 (mg/L)
    - Shakardara Tank: 504 (mg/L)

Implications of High Alkalinity

- **Associated Conditions**:
- Elevated alkalinity levels (generally exceeding 500 (mg/L)) are frequently associated with:
    - Elevated pH
    - Increased hardness
    - Higher total dissolved solids (TDS)
- **Impact on Infrastructure**:
- These conditions can adversely affect systems like:
    - Hot water heaters
    - Boilers
    - Heat exchangers

Excessive scaling from high alkalinity reduces heat transfer efficiency, which can lead to:

- Higher energy consumption

- Decreased productivity

Monitoring alkalinity levels is crucial for ensuring the safety and efficiency of water use in various applications. Addressing high alkalinity in specific sources will be essential to mitigate potential operational issues and health risks.

The total dissolved solids (TDS) concentrations across all water samples ranged from 188 to 4428 (mg/L), with the lowest level detected in Mitchell's bottled water and the highest in the Lachi tube well. The TDS values for various water sources were as follows:

- Hand pumps: 514 to 3984 (mg/L)
- Streams: 346 to 643 (mg/L)
- Tanks: 324 to 857 (mg/L)
- Tube wells: 430 to 4428 (mg/L)
- Wells: 408 to 1690 (mg/L)
- Bottled waters: 188 to 322 (mg/L)

Notably, with the exception of five samples, the TDS values of the remaining 55 samples complied with the WHO standard limit of 995 mg/L for drinking water. However, three samples surpassed Pakistan's standard of 1500 mg/L. The samples with elevated TDS levels included:

- Lachi hand-pump: 3984 (mg/L)
- Lachi tube-well: 4428 (mg/L)
- Ara Khail well: 1690 (mg/L)
- Shakardara hand-pump: 1088 (mg/L)
- Uster Zai hand-pump: 1266 (mg/L)

These findings highlight potential concerns regarding water quality, particularly from certain sources that significantly exceed the recommended standards for TDS.

The total suspended solids (TSS) levels in all water samples varied from 1 to 88 (mg/L), with the lowest TSS value observed in Mitchell's bottled water and the highest recorded in the Lachi tube well. The TSS values from different sources were as follows:

- Hand pumps: 2 to 70 (mg/L)
- Streams: 4 to 9 (mg/L)
- Tanks: 2 to 26 (mg/L)
- Tube wells: 2 to 88 (mg/L)
- Wells: 3 to 18 (mg/L)
- Bottled waters: 1 to 4 (mg/L)

More than 50% of the samples (34 out of 60) exceeded the WHO and Pakistan standard limit of 5 mg/L for drinking water. Among these 34 samples, only four had TSS values exceeding 20 mg/L, indicating significant pollution levels. The highly polluted samples were:

- Jungle Khail tank: 26 (mg/L)
- Lachi hand-pump: 70 (mg/L)
- Lachi tube-well: 88 (mg/L)
- Shakadara hand-pump: 55 (mg/L)

These findings highlight serious concerns regarding water quality in several sources, with TSS levels exceeding acceptable limits for safe drinking water.

The total solids (TS) concentrations in all water samples varied considerably, spanning from 190 to 4,516 mg/L. The lowest TS value was recorded in Mitchell's bottled water, while the highest was noted in the Lachi tube well. Below is a breakdown of TS values from various water sources:

- Hand pumps: 524 to 4,054 (mg/L)
- Streams: 350 to 650 (mg/L)
- Tanks: 350 to 872 (mg/L)
- Tube-wells: 432 to 4,516 (mg/L)
- Wells: 413 to 1,708 (mg/L)
- Bottled waters: 190 to 326 (mg/L)

Out of all the samples analyzed, five were found to exceed the WHO standard of 1,000 mg/L for drinking water. Additionally, three samples surpassed Pakistan's standard of 1,500 mg/L. The most concerning samples included:

- Lachi hand-pump: 4,054 (mg/L)
- Lachi tube-well: 4,516 (mg/L)
- Shakadara hand-pump: 55 (mg/L)

The detection of high levels of total dissolved solids (TDS), total suspended solids (TSS), and total solids (TS) in drinking water is concerning. Elevated TS levels can adversely affect taste and contribute to excessive scaling in water distribution systems. On the other hand, excessively low solid concentrations can also be unappealing to consumers due to a bland taste and may lead to corrosion in water supply systems. This underscores the urgent need for effective water quality management and treatment to ensure compliance with safe drinking water standards.

The total hardness levels of the water samples analyzed in the study showed considerable variation, with values ranging from 64 to 884 mg/L. Below is a detailed breakdown of the total hardness measured in various water sources:

- Bottled Water: 64 to 260 mg/L
- Streams: 176 to 852 mg/L
- Tanks: 188 to 512 mg/L
- Tube-Wells: 178 to 500 mg/L
- Wells: 224 to 884 mg/L
- Lachi Hand-Pump: Highest recorded value of 884 mg/L

Out of all the samples analyzed, five were found to exceed the World Health Organization (WHO) standard of 500 (mg/L) and Pakistani standard for total hardness in drinking water between 400 and 500 (mg/L).

The implications of high total hardness levels can affect both health and water quality, including:

- **Taste**: High hardness can result in an unpleasant taste.
- **Scaling**: Excessive hardness can lead to scaling in pipes and appliances, impacting their efficiency and lifespan.
- **Health Concerns**: While hardness itself is not typically harmful to health, it can be an indicator of other water quality issues.

Given these findings, it is crucial to monitor and treat water sources with elevated hardness levels to ensure they meet the required drinking water standards.

The analysis of total hardness in the water samples revealed several sources with elevated levels, specifically:

- Lachi Hand-Pump: 852 (mg/L)
- Lachi Tube-Well: 884 (mg/L)
- Muhammad Zai Stream: 512 (mg/L)
- Shaikhan Tube-Well: 560 (mg/L)
- Uster Zai Hand-Pump: 784 (mg/L)

Scale Deposition:

- Water hardness levels exceeding 200 mg/L can result in scale accumulation in pipes and water distribution systems, potentially obstructing water flow and raising maintenance expenses.
- High hardness levels also necessitate increased soap consumption for effective cleaning, as hard water diminishes the efficacy of soaps and detergents.

Corrosion Risk:

- Soft water (hardness < 100 mg/L) poses a risk of corrosion in plumbing systems. This corrosion can result in the leaching of heavy metals like cadmium, copper, lead, and zinc into drinking water.
- The extent of corrosion and the solubilization of these metals is influenced by various factors, including:
  - **pH Levels**: Lower pH values can increase the aggressiveness of water, leading to more corrosion.
  - **Alkalinity**: Higher alkalinity may help buffer against changes in pH but can also influence the solubility of metals.
  - **Dissolved Oxygen Concentration**: Elevated levels of dissolved oxygen can enhance the corrosion process.

Given these interactions, it's crucial to monitor and manage the hardness levels of drinking water, along with pH and alkalinity, to mitigate potential health risks and maintain water quality. Regular testing and appropriate treatment methods can help ensure safe drinking water and protect plumbing infrastructure.

For Microbial Contamination Testing in Kohat District Sample Collection

- **Total Samples**: 60 water samples
- **Sources**:
  - 54 samples were gathered from a variety of drinking water sources located in the urban and rural areas of Kohat.
  - 6 bottles of water from the local marketplace.
- **Collection Method**:
  - Samples were collected using clear, clean, and dry polyethylene bottles.
  - Each bottle was rinsed with the sample water at the collection site to minimize contamination.
  - Samples were filled carefully to ensure no air bubbles remained.
  - Bottles were then stored in a refrigerator to preserve sample integrity before analysis.

Microbial contamination testing is crucial for assessing water quality, as it can pose significant health risks to consumers. The methodologies used in this analysis help identify the presence of harmful bacteria and other pathogens in drinking water sources.

The water samples were analyzed for various microbial quality parameters, ensuring compliance with health standards. Regular monitoring and testing are essential for ensuring safe drinking water and protecting public health in Kohat. This comprehensive approach not only assesses the current state of water quality but also provides baseline data for future water management and policy-making efforts in the region.

For Analysis of E. coli Contamination in Water Samples

- **Technique Used**: Multiple tube fermentation technique

- **Medium**: MacConkey Broth (Oxoid Ltd, Basing Stoke, Hampshire, England)

- **Procedure**:
    - MacConkey Broth was prepared by dissolving it in distilled water and autoclaving for 15 minutes at 121°C to ensure sterility.
    - Water samples were mixed with the broth and incubated at 44°C for 24 hours.
    - The presence of E. coli was indicated by a color change from bluish to white.

- **Contamination Findings**:
    - Out of 60 water samples analyzed, **38 samples** were found contaminated with E. coli.
- **Health Implications**:
    - E. coli and other coliform bacteria are known to be hazardous, posing significant health risks and leading to various serious infections in humans.

- **Overall Water Quality**: The findings suggest that the drinking water sources in Kohat are primarily polluted, with implications for public health.

- **Source Safety**: Among the various water sources, tube wells were identified as relatively safer for human consumption compared to others.

- **Critical Areas**: Lachi, Shakardara, and Ara Khail have been identified as heavily polluted regions where drinking water must undergo treatment before it can be considered safe for consumption.

- **Water Treatment**: It is crucial to treat water from contaminated sources to mitigate health risks.

- **Continued Monitoring**: Regular monitoring and analysis of water quality in these areas are essential for ensuring public health safety.

CHAPTER 3 - METHODOLOGY

This study seeks to examine the public perception of water quality in Kohat city. The research uses a hybrid research methodology, as this seems to be the ideal way to conduct this research, consequently, both qualitative as well as quantitative data are collected for this research. This study is conducted in two phases, in the first phase, water samples are collected and tested in the lab to evaluate the physiochemical and microbial properties of drinking water, and in the second phase, A field survey is performed on the people of Kohat city to investigate their perception about the quality of drinking water.

Study Area

Kohat City is the capital of the Kohat district and is located in the KPK province of Pakistan. Kohat is located south of the provincial capital of Peshawar. Kohat district has a total population of 950,000. For this research, Kohat City has been divided into 7 areas namely Kohat Development Authority (KDA), Hasan Abad Shahpur, Jungle Khail, Uster Zai, Muhammad Zai, College Town, and Behzadi Checkerkot. Following is a map highlighting the boundary of Kohat City.

Figure 4: Kohat City boundary highlighted

Area 1: Kohat Development Authority (KDA)

KDA was established in 1979 and is located in the northern part of the city, located just north of the Kohat cantonment. Also, located in the KDA area is the Kohat Medical University (KMU). The KDA has two phases of township which are fully developed. There is also an oil and gas extraction project in the east of the KDA area which is being worked on by Oil and Gas Development Company Limited (OGDCL). The main source of water in KDA is the local tubewell setup, there are also water tanks for containing water. However, the main source in the area is tube wells.

Area 2: Hasan Abad Shahpur

Hasan Abad Shahpur is located in the western parts of the Kohat city. It is located near the Tanda Dam reservoir. The main source of water in the region is Tubewell/ private bore, there used to be hand pumps and open wells in the area in the past however, they all have dried up and now, there is only one source of water which is to tubewell/bore.

Area 3: Jungle Khail

Jungle Khail is located in the north of Kohat city, it is also next to the Kohat cantonment. The region is located atop a hill, and the main source of water in this region is hand pump. There is also a local spring (called Chinnay or Chinnoe) which is also tested in this study, however, the spring is mostly used for bathing and washing cloths and not for drinking purposes.

Area 4: Muhammad Zai

Muhammad Zai is located west of Jungle Khail. Most of the population in the area lives along the main road (also called Hangu road) and other roads and does not extend too deeply, giving it a more densely packed feeling. The main source here is also tubewell/bore.

Area 5: Uster Zai

Uster Zai is located even further west of Muhammad Zai. It has a bit more rural environment with a high population. The main source of water is tubewell/ bore.

Area 6: Behzadi Checkerkot

Behzadi Checkerkot is located in the center of the city, just south of the Kohat cantonment and next to the ISSB. The area is densely packed and used to have guava orchards, however, most of the orchards have been cut down and replaced with houses. The main source of water in this area is tubewell/bores. There used to be open wells in the area but most have dried up.

Area 7: College Town

College town is also located in the central parts of the city along the Rawalpindi Road. The main source of water in the area is tubewell/ bore.

Data Collection

The initial phase of the research focuses on acquiring data on the existing physiochemical condition of the drinking water in the region; to do this, two forms of data were acquired:

- Secondary source of data
- Primary source of data

Both primary and secondary sources were accessed for data collection. The first step of the current research was to review some well-renowned literature related to the Physiological and microbial condition of Kohat City. The secondary data collection is a cheap and easy process to collect data when compared with the primary data and so, firstly the secondary data was collected. The secondary sources that were accessed for data collection consisted of the following:

- Articles
- Books
- Published reports

Peer-reviewed research papers, reports published nationally and internationally, and data provided by APHA, WHO, SDG, and PCRWR were studied to better understand the procedures and testing standards for a physiochemical and microbial evaluation. The review of the literature helped in understand the procedures of sample collection and allowed us to pick relevant locations for sampling based on historical data. It also highlighted the type of water resources historically used in the region to see how things have changed.

For the primary data source, Sample collection was done throughout Kohat city. The regions selected were based on historical data. The sample collection procedure was implemented according to the standards. Clean and clear polyethylene bottles were used for this process, the water was poured directly from the source to the bottle. Each sample bottle was filled to the top in such a way that no air bubbles would remain and then the bottle cap was sealed and placed in the refrigerator under a temperature between 0-4^{O}C. The samples were collected during the daytime at a temperature of 29-33^{O}C. The samples were checked on-site for odor, color, clarity, taste, and visibly suspended particles. A total of 10 samples were collected throughout the study area. The samples were tested in the Institute of Environmental Sciences & Engineering (IESE) lab at the National University of Science and Technology (NUST) H-12, Islamabad.

For the second phase, the Field survey and interview were conducted to acquire the data for analysis. The field survey was performed in 7 areas in Kohat City with individuals asked to provide suitable answers to the questionnaire. The questions asked were carefully chosen to collect data about the various aspects of the attendee such as socio-demographic standing, personal knowledge regarding the topic, accessibility to subject matter, and so on.

Sample size

The sample size is calculated using the Cochran formula:

$$n° = \frac{Z^2 * pq}{e^2}$$

where,

e is the margin of error

p is the proportion of the population with the required attribute

q is 1-p

If we assume that the average household has 5 members and 2 members are responsible for the provision of water in their household, to account for the variance, we can take p as 0.4. Also, Z can be acquired from the z-table which is 1.96 for 95% accuracy. This will give us the equation,

$$n° = \frac{(1.96)^2 * 0.4 * (1 - 0.4)}{0.05^2} = 369$$

We got 369 as the sample size for the survey with a margin of error of 5%.

Interviews

Interviews play a very important role in shaping the outcome of the entire research. To conduct the interview, random people were selected to keep the study unbiased, as there is no special qualification required for answering the survey. Individuals from various backgrounds participated in the interviews.

Work flow chart

The research methodology framework is structured as follows,

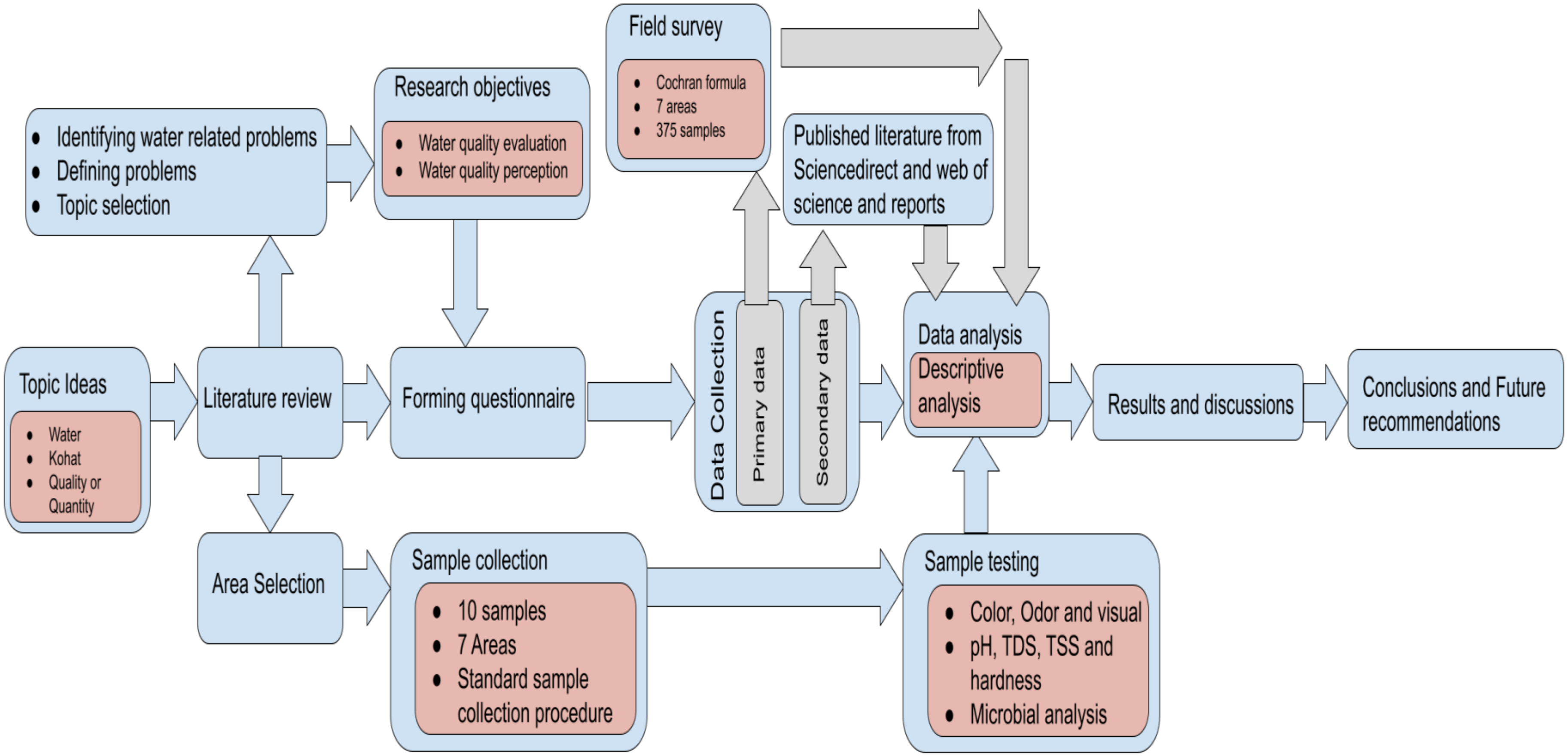

Figure 5: Research Methodology Framework

Data Analysis

This phase of the research focused on the systematic compilation and analysis of collected data using SPSS (Statistical Package for the Social Sciences). The data analysis process encompassed several key steps, including cleaning, inspection, modeling, and transformation.

Types of Data Collected

1. Quantitative Analysis
   - Descriptive Analysis:
     - Conducted on the results from the field survey, this analysis helped convert raw data into meaningful information.
     - Utilized SPSS to perform descriptive statistics, summarizing the data effectively.
     - The output provided insights into the current conditions and issues faced by residents in the study area.
2. Qualitative Analysis
   - While not detailed in the provided text, qualitative analysis typically involves assessing non-numeric data to understand underlying themes, perceptions, and experiences of the participants.

The quantitative analysis yielded descriptive statistics that offered a clear understanding of the living conditions and challenges faced by the residents in the study area. This information is critical for assessing the present situation and guiding future interventions.

The data analysis conducted through SPSS not only transformed raw data into actionable insights but also facilitated a comprehensive understanding of the socio-environmental conditions in the study area. The integration of quantitative and qualitative data is essential for a holistic analysis of the research problem.

CHAPTER 4 – RESULTS AND DISCUSSIONS

The objective of this research was basically to investigate the perception amongst the general masses regarding the perception of drinking water quality in Kohat City. The previously collected data on the water quality situation was also analyzed along with the new data collected from the samples tested in this research. The two were analyzed to see the changes that have occurred in the region regarding the quality of drinking water over the years after which the perception survey was carried out to examine the perception regarding the drinking water quality in the region.

Physiochemical And Microbial Analysis

This study helps identify the existing situation of water quality and compares it to the previously available data. The following table 1 shows the results of the Physiochemical and microbial test performed in the IESE lab in NUST, Islamabad.

Table 1: Physiochemical and Microbial Test Results

S. #	Sample ID	pH	TDS (mg/L)	Turbidity (NTU)	Hardness (mg/L)	Microbial Analysis
	WHO Guidelines	6.5-8.5	< 500	< 5	< 500	
	NSDWQ	6.5-8.5	< 1000	< 5	< 500	
1	KDA Tube well	7.84	492	1.68	332	Contaminated
2	College Town Tube well	6.83	493	1.69	276	//
3	Uster Zai Tube well	7.55	482	0.92	291	//
4	Hassan Abad Shahpur Tube well	6.95	497	1.95	392	//
5	Belitang Open well	6.65	492	1.85	383	//
6	Jungle Khail hand pump	7.95	473	2.93	265	//
7	Behzadi checkerkot Tube well	7.84	492	2.68	332	//
8	Jungle Khail stream	6.83	493	1.69	276	//
9	Muhammad Zai Tube well	7.55	482	2.92	391	//
10	Ali Zai Tube well	7.23	485	1.23	310	//

The results show the different values of pH, Total Dissolved Solids (TDS), Turbidity (Total

Suspended Solids (TSS)), Hardness, and Microbial contamination along with the acceptable values of these parameters, as per the World Health Organization (WHO) and National Standards for Drinking Water Quality (NSDWQ) by Government of Pakistan. From Table 1, we see that the highest value for the pH is 7.95 found at Jungle Khail whereas the lowest is 6.65 found in the Belitang region, all values of pH are within the given WHO and NSDWQ standards limits of 6.5 to 8.5. This means that the region as a whole has no issue concerning the pH value of drinking water.

The highest value of total dissolved solids is 497 found at Hasan Abad Shahpur and the lowest value is 473 found at Jungle Khail. All the values in the test are found to be within the given limit of less than 500 for the WHO standard and less than 1000 for the NSDWQ standards, however, the values are barely under the WHO limits. There are currently no issues concerning the TDS value of drinking water in the region.

The highest value of total suspended solids or turbidity is 2.93 found at Jungle Khail and the lowest value is 0.92 found at Uster Zai. All values of turbidity are within the given WHO and NSDWQ standard limits of less than 5. This means that the region as a whole has no issue concerning the turbidity value of drinking water.

The highest value for hardness is 392 found at Hasan Abad Shahpur whereas the lowest is 265 found in the Jungle Khail region, all values of hardness are within the given WHO and NSDWQ standard limits of less than 500. This means that the region as a whole has no issue about the hardness value of drinking water.

All of the water samples obtained have been found contaminated with microbes. Microbial Analysis reveals that the water samples were contaminated with the presence of coliform

(E. coli) and fecal coliform (F. coli) counts. Therefore, microbiologically unfit for drinking purposes. Particularly alarming is the presence of F. coli as they are known to cause diseases such as diarrhea in children and foreigners. The coliforms can be removed from the water by disinfection, filtration, and chlorination, there are other more advanced methods for the removal of coliforms as well such as Ultraviolet disinfection and membrane filtration.

Analysis of Regions with respect to The Previous Data

For this part of the analysis, the previous data collected on Kohat City is compared to the current report to see how things have changed over the years, the data is arranged by year and by region.

Table 2: Physiochemical and Microbial test Results for KDA

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	7.05	7.84
Total Dissolved Solids (TDS)	mg/l	<500	544	492
Turbidity (TSS)	NTU	<5	9	1.68
Hardness	mg/l	<500	388	332
Microbial contamination	---	---	Contaminated	Contaminated

The above table 2 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for KDA. From the table, the pH value has increased from 7.05 in 2012 to 7.84 in 2022, while the increase in the pH shows that the water has moved towards alkaline (base), the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012.

The TDS value has decreased from 544 in 2012 to 492 in 2022. The decrease in the TDS value has brought it under the WHO limit of 500, it should be noted that the TDS value in 2012 was still within the NSDWQ limits and only slightly above the WHO limit. The TDS was a slight problem in the past but has now been solved, although the TDS value is still quite close to the WHO limit. The turbidity value has decreased from 9 in 2012 to 1.68 in 2022. This is a great improvement in the turbidity of the region, the decrease in the turbidity has brought the value under the WHO and NSDWQ limit of less than 5. The turbidity was a major problem in the past; however, it has been solved and is within safe limits. The hardness value has decreased from 388 in 2012 to 332 in 2022.

The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 3: Physiochemical and Microbial test Results for College Town

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	6.8	6.83
Total Dissolved Solids (TDS)	mg/l	<500	476	493
Turbidity	NTU	<5	6	1.69
Hardness	mg/l	<500	486	276
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 3 shows the results of the physiochemical and microbial analysis done by the

IESE lab compared to the past data for College Town. From the table, the pH value has increased from 6.8 in 2012 to 6.83 in 2022, while the increase in the pH shows that the water has moved towards alkaline (base), the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012. The TDS value has increased from 476 in 2012 to 493 in 2022. Despite the increase, the TDS value has remained under the WHO limit of 500, it should be noted that the TDS value in 2022 has gotten closer to the WHO limit, however, it remains within the WHO limits. The TDS was not a problem in the past, although the TDS value is still quite close to the WHO limit, it is still not a problem in the region. The turbidity value has decreased from 6 in 2012 to 1.69 in 2022. This is a great improvement in the turbidity of the region, the decrease in the turbidity has brought the value under the WHO and NSDWQ limit of less than 5.

The turbidity was a major problem in the past; however, it has been solved and is within safe limits. The hardness value has decreased from 486 in 2012 to 276 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness is not a problem in the region and is still not an issue today. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 4: Physiochemical and Microbial test Results for Uster Zai

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	7.08	7.55
Total Dissolved Solids (TDS)	mg/l	<500	461	482
Turbidity	NTU	<5	7	0.92
Hardness	mg/l	<500	332	291
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 4 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Uster Zai. From the table, the pH value has increased from 7.08 in 2012 to 7.55 in 2022, while the increase in the pH shows that the water has moved towards alkaline (base), the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012. The TDS value has increased from 461 in 2012 to 482 in 2022. Despite the increase, the TDS value has remained under the WHO limit of 500, it should be noted that the TDS value in 2022 has gotten closer to the WHO limit, however, it remains within the WHO limits. The TDS was not a problem in the past, although the TDS value is still quite close to the WHO limit, it is still not a problem in the region.

The turbidity value has decreased from 7 in 2012 to 0.92 in 2022. This is a great improvement in the turbidity of the region, the decrease in the turbidity has brought the value under the WHO and NSDWQ limit of less than 5. The turbidity was a major problem in the past; however, it has been solved and is within safe limits. The hardness value has decreased from 332 in 2012 to 291 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 5: Physiochemical and Microbial test Results for Hasan Abad Shahpur

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	7.85	6.95
Total Dissolved Solids (TDS)	mg/l	<500	430	497
Turbidity	NTU	<5	2	1.95
Hardness	mg/l	<500	324	392
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 5 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Hasan Abad Shahpur. From the table, the pH value has decreased from 7.85 in 2012 to 6.95 in 2022, while a decrease in the pH shows that the water has moved towards acidic, the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012.

The TDS value has decreased from 430 in 2012 to 497 in 2022. Despite the increase, the TDS value has remained under the WHO limit of 500, it should be noted that the TDS value in 2022 has gotten closer to the WHO limit, however, it remains within the WHO limits. The TDS was not a problem in the past, although the TDS value is still quite close to the WHO limit, it is still not a problem in the region. The turbidity value has decreased from 2 in 2012 to 1.95 in 2022. This is a slight improvement in the turbidity of the region, the turbidity values in 2012 and 2022 were under the WHO and NSDWQ limit of less than 5.

The turbidity was not a problem in the past and is still not a problem as it is within the safe limits. The hardness value has increased from 324 in 2012 to 392 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 6: Physiochemical and Microbial test Results for Belitang

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	7.8	6.65
Total Dissolved Solids (TDS)	mg/l	<500	867	492
Turbidity	NTU	<5	13	1.85
Hardness	mg/l	<500	480	383
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 6 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Belitang. From the table, the pH value has decreased from 7.8 in 2012 to 6.65 in 2022, while a decrease in the pH shows that the water has moved towards acidic, the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012. The TDS value has decreased from 867 in 2012 to 492 in 2022. The decrease in the TDS value has brought it under the WHO limit of 500, it should be noted that the TDS value in 2012 was still within the NSDWQ limits and was above the WHO limit. The TDS was a problem in the past but has now been solved, although the TDS value is still quite close to the WHO limit.

The turbidity value has decreased from 13 in 2012 to 1.85 in 2022. This is a great improvement in the turbidity of the region, the decrease in the turbidity has brought the value under the WHO and NSDWQ limit of less than 5. The turbidity was a major problem in the past; however, it has been solved and is within safe limits. The hardness value has decreased from 480 in 2012 to 383 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 7: Physiochemical and Microbial test Results for Jungle Khail (hand pump)

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	6.89	7.95
Total Dissolved Solids (TDS)	mg/l	<500	548	473
Turbidity	NTU	<5	14	2.93
Hardness	mg/l	<500	440	265
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 7 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Jungle Khail (hand pump). From the table, the pH value has increased from 6.89 in 2012 to 7.95 in 2022, while the increase in the pH shows that the water has moved towards alkaline (base), the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012. The TDS value has decreased from 548 in 2012 to 473 in 2022. The decrease in the TDS value has brought it under the WHO limit of 500, it should be noted that the TDS value in 2012 was still within the NSDWQ limits and only slightly above the WHO limit. The TDS was a slight problem in the past but has now been solved, although the TDS value is still quite close to the WHO limit. The turbidity value has decreased from 14 in 2012 to 2.93 in 2022. This is a great improvement in the turbidity of the region, the decrease in the turbidity has brought the value under the WHO and NSDWQ limit of less than 5.

The turbidity was a major problem in the past; however, it has been solved and is within safe limits. The hardness value has decreased from 440 in 2012 to 265 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 8: Physiochemical and Microbial test Results for Jungle Khail (stream)

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	6.87	6.83
Total Dissolved Solids (TDS)	mg/l	<500	529	493
Turbidity	NTU	<5	4	1.69
Hardness	mg/l	<500	372	276
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 8 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Jungle Khail (stream). From the table, the pH value has decreased from 6.87 in 2012 to 6.83 in 2022, while a decrease in the pH shows that the water has moved towards acidic, the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012.

The TDS value has decreased from 529 in 2012 to 493 in 2022. The decrease in the TDS value has brought it under the WHO limit of 500, it should be noted that the TDS value in 2012 was still within the NSDWQ limits and only slightly above the WHO limit. The TDS was a slight problem in the past but has now been solved, although the TDS value is still quite close to the WHO limit. The turbidity value has decreased from 4 in 2012 to 1.69 in 2022. This is a slight improvement in the turbidity of the region, the turbidity values in 2012 and 2022 were under the WHO and NSDWQ limit of less than 5.

The turbidity was not a problem in the past and is still not a problem as it is within the safe limits. The hardness value has decreased from 372 in 2012 to 276 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 9: Physiochemical and Microbial test Results for Muhammad Zai

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	6.84	7.55
Total Dissolved Solids (TDS)	mg/l	<500	676	482
Turbidity	NTU	<5	4	2.92
Hardness	mg/l	<500	444	391
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 9 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Muhammad Zai. From the table, the pH value has increased from 6.84 in 2012 to 7.55 in 2022, while the increase in the pH shows that the water has moved towards alkaline (base), the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012.

The TDS value has decreased from 676 in 2012 to 482 in 2022. The decrease in the TDS value has brought it under the WHO limit of 500, it should be noted that the TDS value in 2012 was still within the NSDWQ limits and only slightly above the WHO limit. The TDS was a slight problem in the past but has now been solved, although the TDS value is still quite close to the WHO limit. The turbidity value has decreased from 4 in 2012 to 2.92 in 2022. This is a slight improvement in the turbidity of the region, the turbidity values in 2012 and 2022 were under the WHO and NSDWQ limit of less than 5.

The turbidity was not a problem in the past and is still not a problem as it is within the safe limits. The hardness value has decreased from 444 in 2012 to 391 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 10: Physiochemical and Microbial test Results for Ali Zai

Parameters	Units	WHO guideline	Yearly data	
			2012	2022
pH	---	6.5-8.5	7.4	7.23
Total Dissolved Solids (TDS)	mg/l	<500	561	485
Turbidity	NTU	<5	5	1.23
Hardness	mg/l	<500	350	310
Microbial contamination	---	---	Contaminated	Contaminated

The above Table 10 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Ali Zai. From the table, the pH value has decreased from 7.4 in 2012 to 7.23 in 2022, while a decrease in the pH shows that the water has moved towards acidic, the value is still within the allowed WHO limits. It should be noted that pH was not a problem in the region even in 2012.

The TDS value has decreased from 561 in 2012 to 485 in 2022. The decrease in the TDS value has brought it under the WHO limit of 500, it should be noted that the TDS value in 2012 was still within the NSDWQ limits and only slightly above the WHO limit. The TDS was a slight problem in the past but has now been solved, although the TDS value is still quite close to the WHO limit. The turbidity value has decreased from 5 in 2012 to 1.23 in 2022. This is a slight improvement in the turbidity of the region, the turbidity values in 2012 and 2022 were under the WHO and NSDWQ limit of less than 5.

The turbidity was not a problem in the past and is still not a problem as it is within the safe limits. The hardness value has decreased from 350 in 2012 to 310 in 2022. The hardness value is within the allowed WHO limits, it should be noted that the hardness value was within the WHO limits in 2012, thus water hardness was not a problem in the region and is still not a problem. The samples were found to be contaminated both in 2012 and in 2022. The contamination found was of E. coli and F. coli in both tests. The region has been unable to deal with the coliforms in the past decade. The microbial contamination was and still is one of the major problems of the regional water supply.

Table 11: Physiochemical and Microbial test Results for Behzadi Checkerkot

Parameters	Units	WHO guideline	Yearly data
			2022
pH	---	6.5-8.5	7.84
Total Dissolved Solids (TDS)	mg/l	<500	492
Turbidity	NTU	<5	2.68
Hardness	mg/l	<500	332
Microbial contamination	---	---	Contaminated

The above Table 11 shows the results of the physiochemical and microbial analysis done by the IESE lab compared to the past data for Behzadi Checkerkot. In the case of Behzadi Checkerkot, there is no previous data to rely on. The current data indicates that there is only one particular issue in the region which is microbial contamination, it is a problem that has persisted throughout Kohat city. Another notable statistic is the TDS value being very close to the WHO limits; however, it is still within the given limits.

Field Survey Analysis

This study helps identify the perception of the people of Kohat City regarding the quality of drinking water in the region. The survey was performed in the form of a face-to-face interview of the survey questions. The candidates were chosen randomly as the targeted demographic was the entire population of Kohat City.

Socio-demographic Analysis Concerning Residential Area

The following Table 12(a and b) shows the socio-demographic statistics of Kohat city.

Table 12a: Socio-Demographic Statistics of Kohat City

Parameters		Residential location							
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)	Total (%)
Age	Below 20	3.46	1.33	6.67	1.33	1.33	1.07	1.87	17.07
	20-30	4.26	2.66	2.93	2.93	3.73	5.33	6.93	28.80
	30-40	3.20	0	3.20	3.20	3.47	6.13	5.07	24.27
	40-50	4	2.66	2.40	1.33	1.07	3.47	3.20	18.13
	50+	2.13	1.33	1.33	2.67	1.07	1.87	1.33	11.73
Marital	Married	11.20	5.33	8.27	8.27	8.53	14.40	9.87	65.87
	Single	5.86	2.66	8.27	3.20	2.13	3.47	8.53	34.13
Education	No Education	3.20	2.13	0.27	2.67	2.13	4.27	0.53	15.20
	10 years	5.06	2.13	2.40	4.53	2.93	4.00	1.07	22.13
	12 years	6.40	3.46	11.73	2.67	5.60	4.80	9.33	44.00
	14 years	0.80	0	1.33	1.07	0.00	3.20	2.67	9.07
	16 years or more	1.60	0.26	0.80	0.53	0.00	1.60	4.80	9.60
Gender	Male	17.06	8	16.53	11.47	10.67	17.87	16.53	98.13
	Female	0	0	0.00	0.00	0.00	0.00	1.87	1.87
	Others	0	0	0.00	0.00	0.00	0.00	0.00	0.00

Table 13b: Socio-Demographic Statistics of Kohat City

Parameters		Residential location							
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)	Total (%)
How long have you been living in Kohat? (YEARS)	Less than 5 years	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	More than 5 years	17.06	8	16.53	11.47	10.67	17.87	18.40	100.00
How many Household members?	1 to 3	5.60	0.80	5.07	1.07	2.13	5.07	5.07	24.80
	4 to 6	8.26	4	8.5	6.40%	5.60	8.80	12.53	54.13
	7 to 9	1.60	2.66	2.67	3.73	2.67	3.20	0.53	17.07
	10 or more	1.60	0.53	0.27	0.27	0.27	0.80	0.27	4.00

The data collected shows the percentage in each category out of a total sample size of 375. Concerning age, 17.07% of the total sample were below 20 years, 28.8% were between the ages of 20 and 30, 24.27% were between the ages of 30 and 40, 18.13% were between the ages of 40 and 50 whereas 11.73% were above the age of 50. We have a fairly even spread of ages and taking into account the perspectives of the different generations. As for marital status, 65.87% of the participants were married and 34.13% were single, the marital status distribution is a bit lopsided, but there is still considerable participation from single-status individuals to consider their perspectives.

With regards to education, 15.2% of the participants had no education, 22.13% had 10 years of education, 44% had 12 years of education, 9.07% had 14 years of education and 9.6% had 16 years or above education, this shows that the perspectives of people from all education levels were included, though data is lopsided towards the 12 years education participants. With regards to gender, 98.13% of the participants were male, 1.87% of the participants were female and no individual identifying as “Others” participated in the random survey, the disparity in male-to-female participation is due to cultural reasons. All of the participants had been living in Kohat for over 5 years. With regards to household members, 24.8% answered 1 to 3, 54.13% answered 4-6, 17.07% answered 7-9 and 4% answered 10 or more. Households of different sizes are considered in this study.

Water Availability with respect to Residential Area

The following Table 13(a and b) shows the availability of water in the residential location.

Table 14a: Availability of Water with respect to Residential Location

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Is the water available from your main source throughout the year?	no	98.40	3.30	59.70	0.00	0.00	0.00	0.00
	yes	1.60	96.70	40.30	100.00	100.00	100.00	100.00
Jan	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	no	100.00	96.70	100.00	100.00	100.00	100.00	100.00
	yes	0.00	3.30	0.00	0.00	0.00	0.00	0.00
Apr	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	no	76.60	100.00	100.00	100.00	100.00	100.00	100.00
	yes	23.40	0.00	0.00	0.00	0.00	0.00	0.00
Jun	no	7.80	100.00	79.00	100.00	100.00	100.00	100.00
	yes	92.20	0.00	21.00	0.00	0.00	0.00	0.00
Jul	no	1.60	100.00	79.00	100.00	100.00	100.00	100.00
	yes	98.40	0.00	21.00	0.00	0.00	0.00	0.00

Table 15b: Availability of Water with respect to Residential Location

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Aug	no	51.60	100.00	100.00	100.00	100.00	100.00	100.00
	yes	48.40	0.00	0.00	0.00	0.00	0.00	0.00
Sep	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	no	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Is the water available throughout the day?	3hrs	0.00	0.00	41.90	0.00	0.00	0.00	0.00
	4hrs	0.00	0.00	0.00	69.80	77.50	71.60	43.50
	6hrs	0.00	0.00	1.60	0.00	0.00	0.00	0.00

The notable areas are Jungle Khail, Hasan Abad Shahpur, and KDA where water is not available throughout the year, the remaining areas have water supply throughout the year and are not facing any difficulty concerning the availability of water. On the other hand, Jungle Khail seems to be the area that has the most availability problems, 98.4% of the participants from Jungle Khail say that water is not available throughout the year and 1.6% have water available to them.

The water shortage occurs from May to August, with June and July being particularly worse off, as 92.2% and 94.4% of participants suffer from water shortages during June and July, respectively. 59.7% of participants from KDA also suffer from water shortage, 79% in June and 79% in July. There seem to be some individuals suffering from water shortage in Hasan Abad Shahpur but due to 3.3% being such a small percentage, this may be an individual's problem and not a regional issue. Throughout the day water seems to be available for 3-4 hours.

Water Expenditure to Satisfaction

The following Table 14 shows the satisfaction with cost.

Table 16: Satisfaction with respect to Cost

Parameters		Are you satisfied with the drinking water service in your area?		
		No (%)	yes (%)	I have a private setup (%)
How much money do you spend on drinking water per month? (pkr)	0-1000	8	66.4	21.33
	1001-2000	0.26	0.26	1.86
	2001-3000	0	0	0.26
	4000+	0.26	0	1.33
Total		8.52	66.66	24.78

The data shows that 66.66% of the people are satisfied with their water service and 66.4% of the satisfied individuals pay between 0-1000 rupees for their water service, 8.52% of people are dissatisfied with the water provision services. The stats indicate that the dissatisfaction of 8.52% of people is not due to financial reasons, with 66.4% of people being satisfied, that the water services are reasonably priced. It should also be noted that nearly a quarter of the participants have their private setup for water provision. 21.33% of private setup users paying between 0-1000 rupee, it can be concluded that private setup can also be financially feasible in the region.

Water Sources to Residential Area

The following Table 15 (a and b) shows the residential locations of the available water sources.

Table 17a: Residential Locations with respect to Water Sources

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Is there any filtration plant located in your area?	Yes	0.00	0.00	96.80	74.40	0.00	76.10	97.10
	no	100.00	100.00	3.20	25.60	100.00	23.90	2.90
	maybe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Which of the following sources of water does your household use?	Tube well/ bore	1.60	100.00	100.00	100.00	100.00	88.10	100.0 0
	Hand pump	98.40	0.00	0.00	0.00	0.00	0.00	0.00
	Communal well	0.00	0.00	0.00	0.00	0.00	11.90	0.00
	public tap	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 18b: Residential Locations with respect to Water Sources

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Which would you consider your main source of water?	Tube well/ bore	1.60	100.00	100.00	100.00	100.00	88.10	100.00
	Hand pump	98.40	0.00	0.00	0.00	0.00	0.00	0.00
	Communal well	0.00	0.00	0.00	0.00	0.00	11.90	0.00
	public tap	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The data shows a clear lack of filtration plants in the Jungle Khail, Hasan Abad Shahpur, and Muhammad Zai areas, the slightly mixed responses given by Uster Zai and College Town may indicate that there are filtration plants in the region, however, the participant may feel that they are too far from their residence, a similar case may be true for Behzadi Checkerkot and KDA. The main water sources used throughout Kohat City seem to be Tube wells/bore, with the only exception being Jungle Khail with its hand pump and communal well in College Town.

Water Testing/Awareness in Residential Area

The following Table 16(a and b) shows the residential location of the water provision and testing.

Table 19a: Residential Location to Water Provision/Testing

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Are you satisfied with the drinking water service in your area?	No	42.20	3.30	0.00	0.00	0.00	0.00	5.80
	yes	56.30	0.00	98.40	76.70	80.00	92.50	37.70
	I have a private setup	1.60	96.70	1.60	23.30	20.00	7.50	56.50
Do you test your water? (If yes describe)	no	95.30	100.00	91.90	93.00	90.00	95.50	88.40
	yes, visual	3.10	0.00	8.10	7.00	10.00	4.50	2.90
	yes, visual and odor	1.60	0.00	0.00	0.00	0.00	0.00	8.70
Would you consider yourself to be a vigilant and perceptive person?	No	0.00	6.70	4.80	2.30	0.00	3.00	1.40
	yes	92.20	86.70	85.50	95.30	85.00	85.10	85.50
	maybe	7.80	6.70	9.70	2.30	15.00	11.90	13.00
Would you consider yourself to be cautious about water used at home?	No	0.00	6.70	17.70	14.00	0.00	6.00	4.30
	yes	81.30	86.70	33.90	55.80	62.50	58.20	75.40
	Sometimes	18.80	6.70	48.40	30.20	37.50	35.80	20.30

Table 20b: Residential Location to Water Provision/Testing

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Who is responsible for the provision of drinking water?	Me	84.40	70.00	24.20	60.50	82.50	52.20	55.10
	my mother	4.70	0.00	45.20	11.60	0.00	1.50	17.40
	my wife	6.30	0.00	19.40	2.30	2.50	37.30	24.60
	my father	0.00	0.00	0.00	2.30	0.00	0.00	0.00
	my brother	1.60	10.00	3.20	7.00	0.00	0.00	0.00
	my son	3.10	20.00	8.10	16.30	15.00	9.00	2.90

The data shows that most regions are satisfied with their water provision except for Jungle Khail. Most participants do not test their drinking water in any way and the few who test their water only do so with visual and odor. Despite this lack of testing, the vast majority of the participants consider themselves to be vigilant and perceptive individuals. A distinct lack of caution towards water is noted despite the participants believing themselves to be cautious individuals concerning water usage. A diverse array of household individuals claims the water provision responsibility, usually following on the lady of the house, this makes the lack of female participants more impactful.

Water Effects/Properties to Residential Area

The following Table 17 (a and b) shows the residential location to the physical properties of water.

Table 21a: Residential Location with respect to Physical Properties of Water

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Do you think water in the area is causing health issues?	Strongly disagree	20.30	40.00	9.70	44.20	7.50	4.50	0.00
	disagree	45.30	43.30	19.40	46.50	87.50	68.70	17.40
	neutral	4.70	3.30	17.70	9.30	2.50	13.40	23.20
	agree	29.70	6.70	50.00	0.00	2.50	13.40	59.40
	strongly agree	0.00	6.70	3.20	0.00	0.00	0.00	0.00
Do you think that there is any bad taste in the water? (if yes then describe its intensity)	no	68.80	90.00	21.00	97.70	70.00	83.60	43.50
	very weak	29.70	10.00	75.80	2.30	30.00	14.90	24.60
	weak	1.60	0.00	3.20	0.00	0.00	1.50	1.40
	mild	0.00	0.00	0.00	0.00	0.00	0.00	5.80
	strong	0.00	0.00	0.00	0.00	0.00	0.00	23.20
	very strong	0.00	0.00	0.00	0.00	0.00	0.00	1.40
Do you think that there is any bad smell in the water? (if yes then describe its intensity)	no	100.00	96.70	100.00	100.00	100.00	100.00	7.20
	very weak	0.00	3.30	0.00	0.00	0.00	0.00	15.90
	weak	0.00	0.00	0.00	0.00	0.00	0.00	13.00
	mild	0.00	0.00	0.00	0.00	0.00	0.00	29.00
	strong	0.00	0.00	0.00	0.00	0.00	0.00	18.80
	very strong	0.00	0.00	0.00	0.00	0.00	0.00	15.90

Table 22b: Residential Location with respect to Physical Properties of Water

Does the water have any color? (If yes then describe its intensity)	no	90.60	96.70	91.90	97.70	92.50	98.50	82.60
	very weak	7.80	3.30	3.20	2.30	7.50	1.50	15.90
	weak	1.60	0.00	4.80	0.00	0.00	0.00	1.40
	mild	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	strong	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	very strong	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Does the water have any color? (particles)	no	87.50	90.00	93.50	69.80	62.50	71.60	88.40
	yes	12.50	0.00	3.20	4.70	2.50	20.90	7.20
	maybe	0.00	10.00	3.20	25.60	35.00	7.50	4.30

The data shows that in the case of Jungle Khail, 20.3% of participants strongly disagree with water causing health issues, 45.3% disagree, 4.7% are neutral and 29.7% agree, the majority of participants do not think that water in their area is causing health problems. For taste, 68.8% think there is no bad taste in water, 29.7% think that there is a very weak taste, and 1.6% think that there is a weak taste, in case of taste, the Jungle Khail water may have a very weak taste but not enough to be a problem. For color, 90.6% of the participants think there is no color in the water, 7.8% think there is very weak color and 1.6% think there is weak color, overall color is not a problem. For suspended particles, 87.5% say no, and 12.5% say yes. From the tests, we know that turbidity is not a problem in the region.

In the case of Hasan Abad Shahpur, 40% of participants strongly disagree with water causing health issues, 43.3% disagree, 3.3% are neutral 6.7% agree and 6.7% strongly agree, the majority of participants do not think that water in their area is causing health problems. For taste, 90% think there is no bad taste in water, and 10% think that there is a very weak taste, in the case of taste, the

Hasan Abad Shahpur water may have a very weak taste but not enough to be a problem. For color, 96.7% of the participants think there is no color in the water, 3.3% think there is a very weak color, and overall color is not a problem. For suspended particles, 90% say no, and 0% say yes. From the tests, we know that turbidity is not a problem in the region.

In the case of KDA, 9.7% of participants strongly disagree with water causing health issues, 19.4% disagree, 17.7% are neutral 50% agree and 3.2% strongly agree, the majority of participants think that water in their area is causing health problems. For taste, 21% think there is no bad taste in water, 75.8% think that there is a very weak taste, and 3.2% think that there is a weak taste, in case of taste, the KDA water may have a very weak taste but not enough to be a problem. For color, 91.2% of the participants think there is no color in the water, 3.2% think there is very weak color and 4.8% think there is weak color, overall color is not a problem. For suspended particles, 93.5% say no and 3.2% say yes. From the tests, we know that turbidity is not a problem in the region.

In the case of Uster Zai, 44.2% of participants strongly disagree with water causing health issues, 46.5% disagree, 9.3% are neutral, and the majority of participants do not think that water in their area is causing health problems. For taste, 97.7% think there is no bad taste in water, and 2.3% think that there is a very weak taste, in case of taste, the Uster Zai water may have a very weak taste but not enough to be a problem. For color, 97.7% of the participants think there is no color in the water, 2.3% think there is a very weak color, and overall color is not a problem. For suspended particles, 69.8% say no and 4.7% say yes. From the tests, we know that turbidity is not a problem in the region.

In the case of Muhammad Zai, 7.5% of participants strongly disagree with water causing health issues, 87.5% disagree, 2.5% are neutral and 2.5% agree, the majority of participants do not think that water in their area is causing health problems. For taste, 70% think there is no bad taste in water, and 30% think that there is a very weak taste, in the case of taste, the Muhammad Zai water may have a very weak taste but not enough to be a problem. For color, 92.5% of the participants think there is no color in the water, 7.5% think there is a very weak color, and overall color is not a problem. For suspended particles, 62.5% say no, and 2.5% say yes. From the tests, we know that turbidity is not a problem in the region. In the case of College Town, 4.5% of participants strongly disagree with water causing health issues, 68.7% disagree, 13.4% are neutral and 13.4% agree, the majority of participants do not think that water in their area is causing health problems. For taste, 83.6% think there is no bad taste in water, 14.9% think that there is a very weak taste, and 1.5% think that there is a weak taste, in case of taste, the College town water may have a very weak taste but not enough to be a problem. For color, 98.5% of the participants think there is no color in the water, 1.5% think there is a very weak color, and overall color is not a problem. For suspended particles, 71.6% say no, and 20.9% say yes. From the tests, we know that turbidity is not a problem in the region.

In the case of Behzadi Checkerkot, 0% of participants strongly disagree with water causing health issues, 17.4% disagree, 23.2% are neutral and 59.4% agree, the majority of participants think that water in their area is causing health problems. For taste, 43.5% think there is no bad taste in water, 24.6% think that there is a very weak taste, 1.4% think that there is a weak taste, 5.8% think there is a mild taste, 23.2% think there is strong taste and 1.4% think there is a very strong taste, in case of taste, the Behzadi Checkerkot water may have a mild taste. For color, 82.6% of the participants think there is no color in the water, 15.9% think there is very weak color and 1.4% think there is weak color, overall color is not a problem. For suspended particles, 88.4% say no and 7.2% say yes. From the tests, we know that turbidity is not a problem in the region.

The following Table 18 (a and b) shows the Residential location concerning water treatment and waterborne illnesses.

Table 23a: Residential Location to Water Treatment and Water Borne Illnesses

Parameters		Residential location						
		Jungle Khail (%)	Hasan Abad Shahpur (%)	KDA (%)	Uster Zai (%)	Muhammad Zai (%)	College town (%)	Behzadi Checkerkot (%)
Do you treat your water yourself?	No/ others	53.10	100.00	98.40	88.40	90.00	88.10	79.70
	boiling	29.70	0.00	0.00	0.00	7.50	3.00	20.30
	passing through cloth	15.60	0.00	0.00	0.00	0.00	4.50	0.00
	solar disinfection	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	water filter	1.60	0.00	1.60	11.60	2.50	4.50	0.00
	chlorination	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Has any member of your family suffered from any waterborne disease?	No	84.40	76.70	83.90	97.70	100.00	85.10	56.50
	yes	1.60	6.70	9.70	2.30	0.00	6.00	36.20
	maybe	14.10	16.70	6.50	0.00	0.00	9.00	7.20
Do you think kidney stones are common in your area?	Strongly disagree	31.30	26.70	0.00	53.50	2.50	0.00	0.00
	disagree	7.80	30.00	6.50	32.60	20.00	22.40	0.00
	neutral	21.90	20.00	1.60	0.00	15.00	37.30	4.30
	agree	39.10	10.00	82.30	14.00	57.50	38.80	62.30
	strongly agree	0.00	13.30	9.70	0.00	5.00	1.50	33.30
Do you think Gastral infection is common in your area?	Strongly disagree	37.50	13.30	0.00	48.80	2.50	0.00	0.00
	disagree	21.90	26.70	64.50	30.20	27.50	55.20	24.60
	neutral	29.70	40.00	19.40	18.60	70.00	44.80	24.60
	agree	10.90	20.00	16.10	2.30	0.00	0.00	31.90
	strongly agree	0.00	0.00	0.00	0.00	0.00	0.00	18.80

Table 24b: Residential Location to Water Treatment and Water Borne Illnesses

Do you think Urinary tract infection is common in your area?	Strongly disagree	45.30	26.70	0.00	25.60	0.00	0.00	0.00
	disagree	34.40	36.70	50.00	32.60	12.50	23.90	29.00
	neutral	20.30	33.30	40.30	39.50	87.50	44.80	36.20
	agree	0.00	3.30	9.70	0.00	0.00	31.30	15.90
	strongly agree	0.00	0.00	0.00	2.30	0.00	0.00	18.80
Do you think diarrhea and constipation are common in your area?	Strongly disagree	21.90	13.30	0.00	30.20	2.50	0.00	0.00
	disagree	14.10	0.00	12.90	14.00	35.00	44.80	5.80
	neutral	25.00	36.70	19.40	37.20	15.00	14.90	23.20
	agree	39.10	33.30	67.70	18.60	47.50	38.80	63.80
	strongly agree	0.00	16.70	0.00	0.00	0.00	1.50	7.20
Do you think stomach illness in children is common in your area?	Strongly disagree	28.10	0.00	0.00	34.90	2.50	0.00	0.00
	disagree	7.80	26.70	35.50	53.50	40.00	31.30	10.10
	neutral	31.30	36.70	11.30	4.70	20.00	22.40	23.20
	agree	31.30	33.30	51.60	7.00	37.50	44.80	47.80
	strongly agree	1.60	3.30	1.60	0.00	0.00	1.50	18.80
Do you think illness caused by poor water quality is common in your area?	Strongly disagree	12.50	16.70	1.60	55.80	0.00	4.50	1.40
	disagree	39.10	33.30	25.80	34.90	80.00	50.70	20.30
	neutral	12.50	26.70	8.10	7.00	15.00	11.90	5.80
	agree	35.90	20.00	64.50	0.00	5.00	31.30	46.40
	strongly agree	0.00	3.30	0.00	2.30	0.00	1.50	26.10

The data shows that the most common water treatment method is boiling used mainly in Jungle Khail and Behzadi Checkerkot, most people do not treat their water before using it. Passing the water through a cloth is also done in Jungle Khail to remove any suspended solids, Water filter is used for the same purpose on Uster Zai. 36.2% of individuals in Behzadi Checkerkot have had a family member suffer from a waterborne disease. Kidney stone seems to be common throughout the city except for Uster Zai, the two places where it is most common are Behzadi Checkerkot and KDA.

Gastral infection is relatively uncommon and is mostly an issue in Behzadi Checkerkot. Urinary tract infection is also a problem in Behzadi Checkerkot and College Town. Diarrhea and constipation are also present throughout the city except for Uster Zai. Stomach illness in general is common in the city except in Uster Zai. KDA and Behzadi Checkerkot agreed that waterborne illnesses are common throughout their respective areas, but the remaining area disagrees.

Satisfaction to Residential Area

The following Table 19 shows the residential location to satisfaction.

Table 25: Residential Location with respect to Satisfaction

Parameters		Are you satisfied with the drinking water service in your area?		
		No (%)	Yes (%)	I have a private setup (%)
Residential locations	Jungle Khail	7.2	9.6	0.26
	Hasan Abad Shahpur	0.26	0	7.73
	KDA	0	16.26	0.26
	Uster Zai	0	8.8	26.66
	Muhammad Zai	0	8.53	2.13
	College town	0	16.53	1.33
	Behzadi Checkerkot	1.06	6.93	10.4
Total		8.53	66.67	24.8

The data shows that 7.2% of the total participants were dissatisfied with Jungle Khail, from the previous data we see that this is due to the water availability issues in the region from May to August. In Hasan Abad Shahpur, the dissatisfaction may be due to individuals having problems and not a regional issue, it should be noted that most of the Hasan Abad Shahpur participants use their private setups. The dissatisfaction in the Behzadi Checkerkot seems to be from the water quality and waterborne diseases.

CHAPTER 5 – CONCLUSIONS AND LIMITATIONS

The main purpose of our research was to investigate the perception of the people of Kohat City regarding the quality of drinking water in their city. To that end, we conducted a physiochemical evaluation of the city by collecting samples and testing them in the lab to determine the existing water quality situation in the city. We compared the results with the previously conducted studies to determine the changes that have occurred. A survey was conducted to find out the perception of drinking water quality in the city.

The physiochemical evaluation of the water quality shows that the city's water quality has improved from the previous data, The most notable improvements were in the turbidity and total dissolved solids values, however, the microbial contamination remained a constant problem, the samples were contaminated with both E. coli and F. coli, this is the one parameter that has not improved at all. To improve the water quality and deal with microbial contamination, we recommend using some form of disinfecting process on the water before use, such as Ultraviolet disinfection and chlorination, etc.

The survey was conducted on the people of Kohat City and it showed promising results, most of the people's perception about their drinking water quality is accurate barring a few exceptions. The biggest concern is the lack of measures taken against microbial contamination, the people do not treat their water before use, which may be a major cause of the spread of illnesses in the city. The data also shows the dissatisfaction of the people about availability and water quality, particularly noteworthy are the areas of Jungle Khail and Behzadi Checkerkot which are facing water shortage and water quality issues, respectively. The improvements in water quality in the city have largely gone unnoticed.

A distinct shift in water sources has occurred in the past decade mainly towards tube wells/bores. On a household level, there are no issues concerning the financial aspect of water provision, from the data, we see that the residents of the city are quite satisfied with the price of the water services.

One of the biggest limitations in this study was the lack of female participants, this was due to cultural reasons. For future studies, we recommend methods to include the female participants, especially since, in most households the lady of the house is responsible for the provision of water.

Recommendations

A recommendation for future studies is to find the exact source of the microbial contamination and how it is infecting the water sources. The E. coli primarily exists in the intestines of the cattle where it is excreted and enters the environment and finds its way to water sources. In case of Kohat, How the E. coli is able to find its way to the water source including the sub surface sources.

The regional reservoir, Tanda dam, is undergoing an expansion project. The tributary of the reservoir is being expanded. This expansion is expected to raise the water capacity of the reservoir. For future studies, it may be beneficial to study the changes that will occur after the completion of the project, how the water shortage situation in the region changes and how the perception of the population changes as well.

It may also be beneficial to study the changes in the physiochemical properties after the expansion in order to observe the effects of the expansion on the water quality. This research was performed on major areas of the Kohat city. A more depth research may also provide a deeper understanding of the regional water situation.

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1. Name of Client — Muhammad Hamza
2. No. of Samples — 10
3. Date of Receiving Samples — 28 June 2022
4. Date of Reporting Results — 05 July 2022

Physio-Chemical Analysis

S. #	Sample ID	pH	TDS (mg/L)	Turbidity (NTU)	Hardness (mg/L)	Microbial Analysis
	WHO Guidelines	**6.5-8.5**	**< 500**	**< 5**	**< 500**	
	NSDWQ	**6.5-8.5**	**< 1000**	**< 5**	**< 500**	
1	KDA Tube well	7.84	492	1.68	332	Contaminated
2	College Town Tube well	6.83	493	1.69	276	//
3	Uster Zai Tube well	7.55	482	0.92	291	//
4	Hassan Abad Shahpur Tube well	6.95	497	1.95	392	//
5	Belitang Open well	6.65	492	1.85	383	//
6	Jungle khail hand pump	7.95	473	2.93	265	//
7	Behzadi checkerkot Tube well	7.84	492	2.68	332	//
8	Jungle khail stream	6.83	493	1.69	276	//
9	Muhammad Zai Tube well	7.55	482	2.92	391	//
10	Ali Zai Tube well	7.23	485	1.23	310	//

Comments

- The samples brought by the client were analyzed using standard analytical instruments and procedures.
- As per above mentioned physic-chemical parameters for drinking water, all the values lie within permissible limits for safe drinking water.
- However, Microbial Analysis reveals that the water samples were contaminated with the presence of coliform and fecal coliform counts. Therefore, microbiologically unfit for drinking purposes

References

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Prepare
d By Engr.
M. Waqas

National Institute of Transportation (NIT)

To Study the Perception of Drinking Water Quality in Kohat City

General Questionnaire

Q1. Please select your residential location from the given areas, (if your exact area is not on the list then choose the closest location)

- KDA
- Hasan Abad Shahpur
- Jungle Khail
- Behzadi Checkerkot
- Uster Zai
- Muhammad Zai
- College town

Q2. Please select your age from the given ranges.

- Below 20
- 20-30
- 30-40
- 40-50
- 50+

Q3. Please select your marital status.

- Married
- Single

Q4. Please select your education.

- No education
- 10 years
- 12 years
- 14 years
- 16 or more years

Q5. Please select your gender.

- Male

- Female
- Others_______

Q6. How long have you been living in Kohat?

- 1
- 2
- 3
- 4
- 5+

Q7. Is there a filtration plant near your residence?

- Yes
- No
- Maybe

Q8. How many household members are in your family?

- 1-3
- 4-6
- 7-9
- 10 or more

Q9. How much money do you spend on drinking water? (Pkr)

- 0-1000
- 1000-2000
- 2000-3000
- 3000-4000
- 4000+

Q10. Which sources of water are available to you?

- Tube well/bore
- Hand pump
- Communal well
- Public tap
- Others______

Q11. Which would you consider your main source of water?

- Tube well/bore
- Hand pump
- Communal well

- Public tap
- Others______

Q12. Is the water available to you throughout the year from your main source? (if No then select the period for which it is unavailable)

- Yes
- No
    - Jan
    - Feb
    - Mar
    - Apr
    - May
    - Jun
    - Jul
    - Aug
    - Sep
    - Oct
    - Nov
    - Dec

Q13. Is the water available to you throughout the day? (if not then please select the number of hours it is available)

- Yes
- No
    - 3hrs
    - 4hrs
    - 5hrs
    - 6hrs
    - More than 6 hrs

Q14. Are you satisfied with your drinking water provision service?

- Yes
- No
- I have a private setup

Q15. Do you test your water in any way? (if yes then please describe it)

- No
- Yes______

Q16. Would you consider yourself a vigilant and perceptive person?

- Yes
- No
- Maybe

Q17. Would you consider yourself to be cautious about water used in your home?

- Yes
- No
- Sometimes

Q18. Who is responsible for the provision of drinking water in your household?

- _______________

Q19. Do you agree with the statement "Water in your area is causing health issues in your area"?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Q20. Do you think the water in your area has any taste? (if yes then describe its intensity)

- No
- Yes
    - Very weak
    - Weak
    - Mild
    - Strong
    - Very Strong

Q21. Do you think the water in your area has any smell? (if yes then describe its intensity)

- No
- Yes
    - Very weak
    - Weak
    - Mild
    - Strong
    - Very Strong

Q22. Do you think the water in your area has any color? (if yes then describe its intensity)

- No
- Yes
    - Very weak
    - Weak
    - Mild
    - Strong
    - Very Strong

Q23. Do you think water in your area has any particles in it?

- Yes
- No
- Maybe

Q24. Do you use any method to treat your water before use?

- Boiling
- Solar disinfection
- Chlorination
- Passing through cloth
- Filtration
- No/others_______

Q25. Do you think waterborne diseases are common in your area?

- Yes
- No
- Maybe

Q26. Would you agree with the statement "Kidney stones are common in your area"?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Q27. Would you agree to the statement "Gastral infection is common in your area"?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Q28. Would you agree with the statement "Urinary infection is common in your area"?

- Strongly disagree

- Disagree
- Neutral
- Agree
- Strongly agree

Q29. Would you agree to the statement “Diarrhea and constipation are common in your area”?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Q30. Would you agree with the statement “Stomach illness in children is common in your area”?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Q31. Would you agree with the statement “Illness caused by poor water quality is common in your area”?

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree