EFFECT OF LAND-USE PATTERNS ON WATER QUALITY CHARACTERISTICS OF SPRINGS AND RELATED HEALTH ISSUES IN CITY MUZAFFARABAD AZAD KASHMIR, PAKISTAN.

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ABSTRACT

Assessing the association between land use land cover (LULC) and water quality helps protect freshwater supplies and meet the growing demand for water in industry, agriculture, communities, and drinking water supply. Spring water quality assessment of different areas in Muzaffarabad District was carried out by taking selected significant parameters, physical, chemical, biological, and heavy metals. Heavy metals including Pb, Cr, Cd, Fe, and Mn were also analyzed. Bacterial study of 12 Muzaffarabad District spring water samples showed alarming results. Springs 1, 2, 3, 4, 5, and 6 have total bacterial growth above 500 CFU/ml, suggesting poor water quality. Springs 1–12 had coliforms, with Springs 3 and 6 having the most. Some water sample sites have coliform and bacterium contamination, may cause diarrhea, dysentery, typhoid, and other water-related disorders. In heavy metal examination, most samples had acceptable Fe, Pb, Cr, and Cd levels, but some exceeded Mn limits. Springs 5 and 9 typically have greater Mn levels, while others stayed within guidelines. Spring 12's Crand Mn levels were high. These findings emphasize the necessity for continual monitoring and management to meet district spring water quality criteria. The result of the physical and chemical parameters of water samples showed several significant findings. Most notably, the levels of salts and pH exceeded the recommended limits set by Pak EPA across the majority of the springs. This suggests potential contamination sources or geological factors contributing to elevated levels, with salts potentially accumulating from agricultural runoff or natural mineral deposits, and pH levels influenced by various factors such as soil composition, industrial discharges, or acid rain. However, other physical parameters including temperature, TDS, (EC), and Turbidity were all within permissible limits, reflecting natural variations in water quality influenced by seasonal changes and local environmental conditions. Additionally, chemical parameters such as Cl, Na, carbonates, NaCl, hardness, and alkalinity were all within acceptable ranges, suggesting minimal anthropogenic contamination and favorable geological characteristics of the area. A study conducted 60 random surveys in nearby areas to assess waterborne illness effects. While most people considered the spring water visually and otherwise good, some reported waterborne diseases even after boiling. The incident affected many people but was not fatal to anyone. Sanitation and contamination awareness are widely available. The study also noted that urbanization, agricultural, and industrial

expansion can introduce pesticides, sewage, and solid waste runoff into springs, threatening water quality and human health. Due to fuel leaks and spills, petrol pumps can contaminate surrounding springs, requiring maintenance, pollution control, and regular testing to assure water safety. Waste dumping near heavy traffic can pollute springs. For spring water integrity, waste treatment, monitoring, and community education are essential. Animal and human waste dumping near springs also poses contamination problems.

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TABLE OF CONTENTS

CHAPTER 3

RESULTS AND DISCUSSION

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ASS	Atomic Absorption Spectroscopy
AJK	Azad Jammu and Kashmir
CDA	Capital Development Authority
DWQI	Drinking Water Quality Index
CDI	Chronic Daily Intake
EBT	Eriochrome black T
EC	Electrical Conductivity
E-coli	Escherichia coli
GWSSA	The Global Water Supply and Sanitation Assessment
HM	Heavy Metals
ICT	Islamabad Capital Territory
IWM	Integrated Water Management
MAC	MacConkey
MGD	Million Gallons Per Day
NA	Nutrient agar
NEQs	National environmental quality standard
NCS	National Conservation Strategy
PAK EPA	Pakistan Environmental Protection Agency
PCRWR	Pakistan Council of Research in Water Resource
PSQCA	Pakistan Standards and Quality Control Authority
PTE	Potentially hazardous element
PHWDs	Potential Hazardous Waterborne Diseases
GW	Groundwater
TDS	Total Dissolved Solids
UV	Ultraviolet
WHO	World Health Organization
LCLU	Land Cover And Land Use

CHAPTER 1

INTRODUCTION

The global water environment is facing significant jeopardy as a result of alterations in its biological, chemical, and physical characteristics (Mishra, et al., 2014). Water is a crucial and invaluable natural asset on our planet. It is vital for the survival of all living things, ecological systems, human well-being, food production, and economic progress. The depletion of water resources is the foremost environmental challenge encountered by many countries worldwide. The problem of drinking water quality is a constant fear in the global community (Salimullah & Fazlullah, 2001). The degradation of groundwater, the main drinking water source, is occurring as a result of escalating growth in population, urbanization, alterations in how land is used and covered, rising water demand, and changes in the climate. The cumulative impacts of these alterations and natural phenomena such as droughts and water supplies, namely freshwater, are increasingly insufficient and contaminated (Najmul, et al., 2010).

Water is a precious commodity on Earth and essential for all living organisms in its pure form, as it makes up the bulk of living tissues and is essential for sustaining life. It fulfills a crucial function in the global economy. The demand for clean water is steadily rising due to population growth and development. The worldwide problem of water pollution has raised concerns due to the lack of access to drinking water in numerous locations, even though 70% of the Earth's surface is covered by water (Yadav, et al., 2021). A multitude of inorganic and organic pollutants released from both human activities and natural origins have rapidly deteriorated the overall condition of water supplies. Understanding the correlation between land utilization and the quality of water from rivers aids in the identification of potential risks to water safety. Recognizing this correlation is crucial for efficient and enduring management of surface water quality, particularly in reducing the amount of pollutants in the water body (Ding, et al., 2015).

Water contamination is a significant global problem that affects both developed and developing countries. Rivers, in particular, are facing escalating risks of contamination, posing a significant threat to surface water supplies worldwide (Nabeela, et al., 2014). The quality of surface water is crucial for a multitude of functions, including home, industrial, and agricultural usage, as well as preventing illness. Natural and human activities can diminish the value of water resources, impacting their quality and making them less suitable for human consumption (Chaudhry & Malik, 2017). Research has demonstrated that both natural and human activities have caused alterations in the way land is used and covered (LULC), which in turn impacts the provision of services by the riverside ecosystem. Human activities, namely agriculture, deforestation, and urbanization, have been recognized as the primary factors responsible for altering LULC, consequently impacting the water bodies' quality. These activities, either individually or together, influence the overall state of water resources. The land use within a watershed significantly affects the water quality and quantity of rivers (Khan, et al., 2017).

1.1 Sources of Water Contamination

Household and municipal trash, waste from industries (organic, inorganic, trace elements, etc.), and mining activities (chemical, minor elements, intrusion, etc.) are a few examples of the sources of contamination. Installation, usage, and recycling of water supply sources can lead to deterioration due to infiltration, over-pumping, saltwater mixing, pollution of surface water, and rock-water interactions (Karunanidhi, et al., 2021). Numerous human activities that alter the physicochemical properties of water lead to the decline of groundwater quality and the subsequent contamination of water resources. The majority of pollution sources are water usage discharge of harmful substances. Additional causes of pollution for surface water include domestic waste such as drainage and wastewater. This is due to the natural filtration process that occurs. On the other hand, the condition of underground water varies gradually and remains free from bacteria since it is not immediately exposed to pollutant sources. Improper placement of wells and inadequate disposal of gutter discharge leads to the contamination of subsurface water. Agricultural runoff, which encompasses pesticides, herbicides, and hazardous materials from industry, can lead to surface water pollution (Luby, et al., 2000).

The majority of water contamination is human caused, meaning it originates from human activities. This category typically involves the disposal and discharge of effluent and solid waste, the disposal and discharge of industrial waste, the application of chemicals such as pesticides and insecticides, the disposal and execution of waste from mining operations, and the disposal and burial of nuclear energy waste. Human-caused sources can result from a variety of activities, including excessive withdrawal of groundwater, unrestricted application of fertilizers, mining operations, garbage disposal, extended urban development, improper use of chemicals, the burial of inorganic and organic substances, and sewage storage (infiltration), disruption of river networks, the extraction and processing of toxic minerals, and waste from graveyards, which may also seep into the deep undisturbed soil (Rail, 2000).

Trace elements and other chemicals, including those derived from mineral extraction, urban and agricultural wastewater, nutrients, energy sources, and other human activities, can be present in waste matter and water. These substances can provide a significant risk to individuals who consume such water, potentially leading to harm or even death. Furthermore, the presence of fertilizers, farm animals, agricultural operations, and sewage releases has been linked to higher levels of critical nutrients, such as nitrogen and phosphorus ions or organic substances, which can lead to pollution. Petroleum hydrocarbons and biological waste (bacteria, viruses, and parasites) are other pollutants that have been found in water and are linked to human activity. The contamination of various inorganic substances, which can be harmful and are linked to the salt content of water resources due to elevated levels of Ca, Mg, Na, Cl, and F, is caused by the penetration of disposals, extraction operations, and wastewater leaks (Kuroda & Fukushi, 2008).

Moreover, water sources might be contaminated as a result of weathering, erosion processes, or other natural phenomena. This group involves the following kinds of sources, easily dissolved rocks (such as gypsum and mineral salt), disintegration of rocks can also contaminate the water aquifers underground, natural spring water, and surface water bodies, strong evaporation, particularly in shallow waterways that elevates groundwater and leads to salt accumulation in water channels, deterioration of water sources in locations near hot geothermal and volcanic fields which may also alter the chemical properties of water, rock oxidation, contamination by seawater, decay of radioactive substances from uranium-rich rock foundations, and the chemical breakdown involving substances in the air or the water. This process can occur naturally and due to the impact of human activities (Machiwal & Jha, 2015).

1.2 Impacts of Drinking Contaminated Water

The escalating presence of hazardous compounds in the environment is causing significant alarm among residents. An extensive array of pollutants is consistently released into waterways primarily as a result of industrialization, advances in technology, expanding population growth, and the utilization of natural resources, as well as the discharge of agricultural and household waste. Heavy metals are a particularly hazardous group of contaminants due to their enduring nature, toxic effects, ability to build up in organisms, and potential to go through food chain intensification. Furthermore, they are non-degradable. The presence of heavy metals such as lead, mercury, cadmium, and arsenic in the natural environment is a cause for concern due to their long-lasting nature and well-documented ability to cause severe health problems in humans (Bagul, et al., 2015).

Acute waterborne heavy metal intoxications can harm different parts of the body, including the nervous system, the heart, the digestive system, the lungs, kidneys, liver, endocrine glands, and bones. Complete avoidance of exposure to hazardous metals is unattainable. Individuals may experience kidney problems as a result of using drinking water that is contaminated primarily with lead and cadmium. This damage frequently leads to behavioral and cognitive impairments (such as excessive movement), memory and attention deficits, hypertension, auditory impairments, headaches, stunted growth, fertility issues in both genders, gastrointestinal disorders, and musculoskeletal pain. There is a considerable amount of research on lead due to its detrimental consequences. Lead is widely recognized as the primary health hazard for children, and the consequences of lead poisoning can have long-lasting impacts. Lead poisoning not only hampers a child's physical growth but also harms the brain and nervous system and leads to mental retardation. Individuals get hair loss as a result of drinking water contaminated with nickel and chromium. Prolonged exposure can result in renal and hepatic impairment, as well as harm to cardiovascular and neural function (Sankhla, et al., 2016).

The majority of research studies conducted in Pakistan demonstrate the existence of fecal pollution in drinking water by detecting the presence of fecal coliforms. However, these studies do not provide any information regarding the level of chlorine in the water distribution system. Diarrheal illnesses, which are caused by waterborne pathogens such as bacteria and protozoa, result in around 2.5 million fatalities annually (Khan, et al., 2000). Approximately 40 percent of illnesses can be attributed to water, as reported by the Pakistan Council of Research and Water Resources. People acquire their potable water from groundwater and surface sources, such as natural springs. Nevertheless, both surface and groundwater sources have the potential to be contaminated by microbiological and chemical pollutants originating from both specific and diffuse sources. Surface water sources include lakes, rivers, and streams. The characteristics of surface water undergo rapid changes in reaction to modifications in the environment that surrounds it (Mahboob, 2016).

In Pakistan, poor water quality is the main issue affecting both the environment and public health. Both groundwater and surface water including the spring water in the country have been polluted with many toxic substances and microbes that make them unfit for drinking. Drinkable water has become contaminated due to poor living circumstances and some lack of attention (Azizullah, et al., 2011). Based on the available hospital data, it is evident that a notable portion of the ailments treated are caused by waterborne microbes. This suggests that a substantial percentage of infections in Pakistan can be attributed to the use of polluted water. Infections of the digestive tract leading to diarrhea have a significant prevalence in both children and adults, constituting 25% of patients receiving medical care in hospitals and clinics. Each individual requires around 2 liters of potable water, resulting in a daily global need of around 12 million liters. The impoverished health conditions of the Pakistani population are seen in the elevated child mortality rate of 12.6% and the very low fertility rate of 7% (Aslam & Ahmed, 2001).

Only a few urban places have water purification facilities installed; however, some of them are ineffective and fail to detect microbial contamination. According to a government survey on clean and safe drinking water, just 56% of all residents in the country have access to it, while 44% of residents living in rural regions lack access to clean water (Rasheed, et al., 2009). According to multiple studies, 70% of people lack the availability of safe drinking water. The contaminated water situations in Pakistan have resulted in a significant increase in the number of individuals suffering from conditions such as typhoid, hepatitis, dysentery, cholera, and diarrhea. A significant portion of hospital beds are taken up by patients suffering from diseases linked to water. Furthermore, waterborne diseases are responsible for a massive portion of fatalities in the nation, accounting for 33% of all deaths (Amin, et al., 2012). More than 60% of people in Pakistan drink water from underground sources. The majority of rural inhabitants in Pakistan lack access to clean water for drinking. About 68% of them have poor-quality water. According to a report from The Global Water Supply and Sanitation Assessment (GWSSAR) in 2000, over 3 million people in Pakistan are sick because of the polluted water, and 0.1 million of them die every year. In Pakistan, hospitals see one hundred million cases of diarrhea every year, and 0.25 million children lose their lives as a result of drinking impure water. Poor sanitation, unclean water, and lack of hand hygiene can result in diarrhea. Annually, this leads to the death of 0.25 million children under five (Bhatti, et al., 2018).

1.3 Impacts of Land Use Trends on Water Quality

Rural-urban migration is a significant occurrence in today's world, mostly driven by economic and industrial advancements, along with related causes. The rapid urban expansion is intricate since it diminishes the amount of greenery within and in the vicinity of cities. As a result of rapid population growth, green fields are being transformed into urbanized regions. Given the negative impact of human activities on the environment in urban areas, legislators, geography researchers, administrators, and planners in cities are today confronted with the task of closely observing changes in land cover and urban land utilization. LULC, which refers to changes in land use and land cover, plays a crucial role in the natural world since it provides a close connection between humans and the environment (Tao, et al., 2016).

Gaining a comprehensive understanding of LCLU is essential to grasp the wide-ranging impacts of human actions on the ecosystems, water supplies, and surroundings of cities. The pace of LULC is much more pronounced in developing countries compared to industrialized ones. By 2020, a significant number of large cities are expected to be situated in developing nations. The considerable urban population in developing countries has a notable impact on LULC, environmental degradation, the health of ecosystems, and the abundance of natural assets. The environment and ecosystem in the world suffered greatly due to the fast urbanization that occurred in the early 2000s (Lambin, et al., 2003).

The population expansion rate plays a crucial role, given the continuous increase in the world's urban population annually. Urban expansion leads to the substitution of natural land covers with impermeable urban materials, resulting in changes to the physical surroundings. These changes have a negative influence on land surface features and disrupt land surface energy processes. Moreover, as a result of swift urbanization, there is a growing trend of converting agricultural land into urban areas. These changes have resulted in a decline in vegetation and have also affected the potential for food production and the quality of water. Human-induced actions are responsible for the changes in LULC, which have significant impacts on the regional environment of certain locations. The composition of land cover is constantly changing and varies across different sizes and periods (Wang, et al., 2016).

Hence, alterations in land cover caused by either human or natural factors can significantly impact climate, biogeochemical and water cycle, plant and animal life, human health, and the condition of the soil. This emphasizes the significance of studying changes in land use and land cover about environmental fluctuations and the promotion of sustainable development. Islamabad, the capital city of Pakistan, draws in individuals from various regions of the country due to a multitude of factors. The influx of people from other cities to Islamabad has resulted in a notable decline in the city's climate and urban conditions. The land cover in the study region has been undergoing rapid changes due to this trend. This significant rate of urbanization has distinct effects on climate change and water. Urbanization exerts a significant influence on both the economy and social progress of a country. However, in emerging nations, rapid and unregulated urbanization gives rise to other issues, including traffic congestion, air pollution, and strain on water supplies (Appiah, et al., 2015).

Various construction projects have been done in the Muzaffarabad district and some surrounding areas. The exponential expansion of Pakistan and the major cities has placed escalating pressure on natural resources and resulted in detrimental impacts on the environment including the compromised quality of water resources be it surface or groundwater resources. To ensure the high standard of the cities, local authorities require information regarding the physical surroundings to effectively strategize for the country's future growth. For over two decades, multiple research projects have focused on analyzing and describing the land cover and its changes in Pakistan. The primary aims were to examine the predominant land cover categories in the years 1993, 1997, 2002, 2007, 2013, and 2017, assess the extent and characteristics of land cover modifications that occurred during these periods, investigate the patterns of urban growth in major cities, northern areas and evaluating the effects of urbanization on the underground water supplies of these regions (Oyinloye & Kufoniyi, 2016).

Assessing the correlation between LULC and water quality is important as it provides insights into safeguarding freshwater resources, thereby addressing the increasing need for water in different sectors such as industry, agriculture, municipalities, drinking water supply, and recreational activities. The association between LULC and water quality can be applied in unrestricted watersheds due to the tedious and expensive nature of surveillance. This will assist policymakers and watershed managers in implementing preemptive measures for future land use growth. Human actions have modified ecological, geochemical, and hydrological events across several scales, encompassing local, regional, and global levels. The unique features of a catchment, such as LULC, texture of soil, geomorphology, elevation, and socioeconomic situations, influence how water quality metrics respond to climatic factors (Ullah, et al., 2018).

1.4 Water quality of Muzaffarabad, Azad Jammu and Kashmir, Pakistan

An essential requirement for the sustenance of human, animal, and plant life is a secure and sufficient water supply. The water we consume must be devoid of pathogenic microorganisms, toxic compounds, high mineral content, and organic material. Additionally, it should be clear, tasteless, and odorless. According to a report by the World Health Organization (WHO) in 2000, around 40 percent of the population in developing nations lacks accessibility to clean water or sanitation due to a scarcity of water (Igbinosa & Okoh, 2009). Regrettably, water can become contaminated due to pervasive environmental conditions exacerbated by human actions, rendering water from most sources unfit for ingestion without appropriate treatment. In Pakistan, water used for drinking from its source to distribution is heavily polluted with coliforms and fecal coliforms. Furthermore, multiple studies have identified water quality and waterborne infections as significant issues in Azad Jammu and Kashmir (AJK) (Baig, et al., 2012). The drinking water in the Bagh district (AJK) is predominantly polluted with fecal coliform bacteria, significantly elevating the likelihood of waterborne infections. Water supplies are susceptible to pollution by fecal bacteria and intestinal pathogens, which present significant public health hazards. The government's Environmental Protection Agency in AJK has reported that 24 percent of the water used for drinking in AJK has been polluted with E.coli, which poses a high risk. In addition, a notable percentage of the streams in the area are considered to have an elevated degree of risk, as their contaminant amounts surpass the recommended limit of 101 E. coli per 100ml. It is worth mentioning that the level of fecal pollution may be greater during the summer months (Akbar, et al., 2013). In 2015-16, a research study was carried out by Shafi, et al., (2018) to assess the quality of potable water in the small town of Khillah, Muzaffarabad, (AJK). The microbe assessment along with the estimation of various physio-chemical variables, was conducted over eight months using well-established techniques. All the physio-chemical characteristics of the water are within the limits set by the WHO. Conversely, the drinking water sources in Khillah village were severely polluted by Coliforms, with contaminants being particularly high during the monsoon season (Shafi, et al., Drinking water quality and possibility of water borne diseases in village Khillah, Muzaffarabad, Azad Jammu And Kashmir, Pakistan., 2018).

Azad Jammu & Kashmir, along with other neighboring territories, are dealing with the issue of poor drinking water. A study was conducted by Ali, et al., (2019) to assess the levels of heavy metals in the water for drinking in Muzaffarabad and its surrounding areas. Fifty-three tap and spring water samples were carefully collected from the study location. These samples were tested for Copper, Chromium, Manganese, Lead, and Zinc. Cu, Fe, Mn, and Zn levels were below WHO and the Government of Pakistan (GOP) guidelines. 21% (n=11) of the samples exceeded WHO and GOP chromium and lead standards. In total, 66% of the water samples were determined to be safe for drinking, whereas in 33% of the samples, the concentration of heavy metals exceeded the allowable level. The study indicates a satisfactory condition in terms of the quality of heavy metals in drinking water

(Ali, et al., Assessment of heavy metal contamination in the drinking water of muzaffarabad, Azad Jammu and Kashmir, Pakistan. , 2019).

A study by Zahoor, et al., (2022) provided a concise overview of the main discoveries regarding important physicochemical characteristics of drinking water, with a specific focus on the detection of heavy metals and harmful microbes in Jagheer Katkair, Muzaffarabad Azad Kashmir. The assessment of drinking water quality is conducted through the utilization of the drinking water quality index (DWQI), which considers parameters such as turbidity, electrical conductivity (EC), calcium ions (Ca^{+2}), and magnesium ions (Mg^{+2}). In Jagheer Katkair, Muzaffarabad Azad Kashmir, the provision of safe drinking water is constantly affected by the growing population and inadequate sewage disposal. Around 8% of the population in Jagheer Katkair, Muzaffarabad Azad Kashmir has access to safe and protected drinking water. Consequently, a significant portion of the population, approximately 92%, is compelled to rely on water that is contaminated due to insufficient supplies of clean and sustaining drinking water. The main contributors to water pollution are microbial pollution, turbidity, electrical conductivity, and hardness, as they are often released into the water supply. A significant majority of cancer cases are attributed to bone disorders that are influenced by human activities. The main focus of this study was to analyze the drinking water quality, identify possible sources of pollution, and evaluate the steps that were implemented to ensure water quality in Jagheer Katkair, Muzaffarabad Azad Kashmir. In response to the distressing water pollution statistics in Jagheer Katkair, Muzaffarabad Azad Kashmir, there is an urgent determination to promptly enforce preventive steps and wastewater treatment technologies (Zahoor, et al., 2022).

In a study conducted by Sarwar, et al., (2007), the physiochemical properties of Jhelum river water in Region Muzaffarabad during 2001-02 were assessed. The pH, electrical conductivity (EC), total dissolved solids (TDS), and suspended solids (SS) of thirty water samples were examined at both high and low flow rates. The flow was high in July and August and low in December and January. Maximum flow conditions had a mean pH of 7.18, lower than low flow conditions, which had 7.79. At low flow, the average EC value was 0.24 dSm-1, slightly higher than at high flow, 0.19. At high flow, TDS levels ranged from 90 to 800 mg/L, averaging 273.6 mg/L. TDS levels ranged from 30-430 mg/L under low flow conditions, with a mean of 145.67 mg/L. At the maximum flow rate, the hardness ranged from 40 mg/L to 160 mg/L, with 95.13 mg/L as average. The mean number for the whole range was 114.4 mg/L. When the flow rate is elevated, the SS number is between 200 mg and 1200 mg. When the flow rate is low, it is between 30 mg and 600 mg. The health and environmental standards set by the US Environmental Protection Agency (USEPA) and the WHO for the Jhelum River water have been studied and found to be met for both drinking and irrigation (Sarwar, et al., 2007).

1.5 Literature Review

Effective land use management involves understanding how changes in land use and land cover can impact the hydrological dynamics of a sub-watershed. The Alto Paraguaçu Watershed is one of the most important fruit and vegetable growing regions in Brazil, and it is located in the country's northeast and north. In addition, it currently has the distinction of being this region's main English potato producer. Water availability limits the region's ability to expand its agricultural frontiers. Calijuri, et al., (2015) conducted three sample campaigns and assessed the effects of land cover and use on the quantity and quality of water resources in the sub-watershed (Deng, et al., 2015). In total, ten locations throughout the watershed saw these campaigns, two of which took place during the rainy season and one during the dry. Additionally, hydrological analysis and assessment of land use and land cover changes were carried out for both seasons. The primary goal of this investigation was to establish a relationship between land use/land cover indicators and hydrological indicators, with the ultimate aim of developing a model capable of predicting water changes in the specific sub-watershed under scrutiny. The study demonstrates that alterations in land use and land cover, predominantly caused by agricultural expansion, have had a substantial impact on the hydrological behavior of the Alto Paraguaçu watershed. The modification process directly affects both the quality and quantity of water. This research highlights the significance of implementing effective land use and land cover strategies to ensure the preservation of water resources (Calijuri, et al., 2015).

There is a greater understanding of freshwater resource contamination worldwide as a result of rising levels of freshwater crisis and depletion. Tahiru et al. (2020) sought to assess land use and land cover changes (LULCC) in the White Volta Basin's Nawuni

Catchment and the ensuing effects on the region's water quality. To accomplish the objective, the study focused on the Nawuni Catchment in the White Volta Basin, utilizing satellite images from the Landsat Thematic Mapper and Landsat 8 Operational land imager. Evaluating the period from 2007 to 2017, this study examined how alterations in land use and land cover influenced water quality measures such as turbidity, ammonia, and total coliform counts. It was found that during this time, there were substantial shifts in the land cover. There was an increase of 4.1% in farmland, 0.1% in development, 9.4% in barren land, and 1.2% in closed grassland. On the other hand, open pasture had a 14.7% reduction, and water bodies saw a 0.1% decrease. Between 2007 and 2017, there was a decline in total coliforms but an increase in turbidity and ammonia levels, according to the research. Furthermore, the investigation demonstrated a statistically significant correlation between LULC classifications and water quality measures, suggesting that modifications to LULCC may be a factor in regional variations in water quality. As a result, to reduce contamination in the river basin, the study suggests that regular water quality monitoring be implemented together with efficient LULC planning and management (Tahiru, et al., 2020).

How land is exploited and regulated has a significant impact on water resources. Urbanization, the discharge of domestic wastewater, and the reduction of open spaces are major factors that affect both the quantity and quality of groundwater. A study by Ahmad, et al., (2021) examined how groundwater quality has changed over time, particularly between 2012 and 2019, and how it relates to land use and land cover in Peshawar, Pakistan. The study determined how these changes will affect Peshawar's citizens. A thorough sampling of groundwater was carried out from tube wells in the years 2012 and 2019, totaling 105 and 112 samples, respectively. Following that, the samples were examined, giving importance to seven vital water quality parameters: pH, turbidity, EC, calcium, magnesium, chloride, and nitrate. Furthermore, data on waterborne diseases in patients from 2012 and 2019 were collected to understand the correlation between groundwater quality and its impact on human health (Ahmad, et al., 2021)

Between 2012 and 2019, changes in land use and land cover about groundwater quality were examined using Landsat satellite imagery. The results showed that groundwater quality had decreased in 2019 as compared to 2012, with the effects being more noticeable in areas with high population densities. Significantly, it was discovered that the nitrate concentration was higher in the vicinity of agricultural activities, which was ascribed to the overuse of pesticides and fertilizers with a nitrogen base. As a result, the percentage of people with methemoglobinemia rose by 14% between 2012 and 2019, to 48% and 62%, respectively. The area's elevated calcium and magnesium levels have contributed to a higher occurrence of urinary tract infections, peptic ulcers, and dental caries. The overall conclusion is that human activities played a major role in the temporal and spatial variability of groundwater quality in the study region. This information can help local health authorities understand groundwater quality trends, create customized strategies for specific locations, and develop future health guidelines (Malik & Ali, 2019).

Abbas, et al., (2022) conducted research that focused on evaluating the consequences of climate change and land-use changes on the water resources of Multan City, Pakistan. To accomplish this goal, the study employed the Statistical Down Scaling Model (SDSM) and Geographical Information System (GIS) to evaluate changing climate conditions and perform spatial studies. The Hydraulic Modelling System (HEC-HMS) proposed by the Hydrologic Engineering Centre is used for implementing runoff from precipitation methods. The investigation's results reveal significant alterations in climatological parameters, with temperature increasing and precipitation decreasing over the past 40 years. Moreover, there has been a notable expansion of urban areas from 2000 to 2020. The rise in temperature and urbanization have led to a decrease in soil infiltration rate and an increase in runoff flows. The outcomes obtained from HEC-HMS demonstrate a gradual rise in surface runoff during the last two decades. The depth of the water table in the shallow aquifer has been gradually decreasing at a rate of approximately 0.3 meters per year. Projections based on climate indices suggest that groundwater depletion will continue to be a concern in the future. The elevated levels of arsenic in the area can be attributed to the unplanned expansion of urban areas and the uncontrolled dumping of industrial effluents. These research results offer valuable insights that can contribute to the implementation of efficient water resources management practices in Multan (Abbas, et al., 2022).

The rapid urbanization trend across the world has caused a detrimental impact on ecosystems, especially vegetation cover and water resources, due to inadequate planning and management. This presents a significant challenge to the sustainable development of urban areas. Identifying and assessing these variations would assist administrators in understanding the factors behind LULCC and implementing suitable strategies. Utilizing GIS and remote sensing techniques has demonstrated its effectiveness in assessing urban planning and changes. Sohail, et al., (2019) assessed the water quality index and analyzed significant changes in land cover types, vegetation cover, urbanization rate, and their potential impact on groundwater resources in Islamabad, Pakistan. The findings indicate a decline in plants, vacant land, and water-based lands, with established lands experiencing significant expansion. In Islamabad, 16 sites were identified as inappropriate for drinking water due to significant human involvement, reflected by a water quality index value of less than 300. The alarming rate at which water quality and vegetation cover are deteriorating is exerting immense pressure on the already scarce groundwater resources. This study offers valuable assistance to decision-makers and planners, equipping them with the necessary knowledge to implement sustainable measures that effectively address the negative consequences of haphazard urbanization and changes in land use, thereby safeguarding the ecosystem (Sohail, et al., 2019).

A study was conducted by Rehman, et al., (2020) to determine the levels of nitrate exposure and assess the potential health implications associated with the consumption of spring water in Harnai, Baluchistan, Pakistan. A total of 24 water samples were procured from four different springs that serve as sources of drinking water. From each spring, three samples were collected at the initial and final points. The DR/890 multi-parameter portable calorimeter was used to measure nitrate levels. The level of nitrate ranged from 0.1 to 1.1 mg/l, with an average of 0.389 mg/l. The results indicate that the level of nitrates in spring water is well below the acceptable limits recommended by both the Pakistan Standards & Quality Control Authority (PSQCA) and the WHO, showing a decrease of 93% and 99% respectively. The physiochemical parameters, namely pH, EC, and TDS, displayed a range of values. The pH values varied between 7.8 and 8.3, while the EC values fluctuated between 564 to 749 µS/cm, and the TDS values varied between 36 and 479 mg/l. The mean values for these variables were found to be 8.025, 630.5 µS/cm, and 403.5 mg/l, accordingly, The chronic daily intake (CDI) values for adults, children, and infants were found to be 0.01, 0.02, and 0.03, correspondingly, across three age groups. Therefore, it can be inferred that the consumption of spring water in Harnai for drinking purposes is considered safe and does not pose any health hazards related to nitrate (Rehman, et al., 2020).

The presence of heavy metals in drinking water has negative impacts on both the environment and human health. A study was conducted by Hussain, et al., (2022) to examine the measurement of heavy metals in specific springs and surface water sources for drinking in Gilgit-Baltistan, Pakistan. A cumulative sum of 66 water samples was collected and analyzed. A total of 20% of the examined samples demonstrated levels of heavy metals that surpassed both the National Standards for Drinking Water Quality (NSDWQ) and the WHO's established guidelines. A significant majority of the samples, 59% to be exact, exhibited levels of heavy metal that were found to be below the acceptable thresholds. On the other hand, a mere 21% of the samples were found to be free from any traces of heavy metals. The Skardu region exceeded the permitted level set by the National Standards for Drinking Water Quality (NSDWQ) with a heavy metal level of 23%, the highest among all regions. The amounts in the Nagar and Hunza regions were also above the limit, both at 15%. The amount of heavy metal in the Gilgit, Diamer, and Ghizer regions was all at 8%. The drinking water sources were discovered to have levels of heavy metals in the following order: aluminum (Al) > boron (B) > manganese (Mn) > zinc (Zn) > barium (Ba) > nickel (Ni) > chromium (Cr) > copper (Cu) > arsenic (As) > mercury (Hg) > antimony (Sb) > selenium (Se). The health risk index (HRI) and chronic daily intake (CDI) were computed for both children and adults. The discovered CDI values were ranked in the following order: Al > B > Mn > Zn > Ba > Cr > As > Ni > Cu > Hg > Sb > Se. Furthermore, the hierarchy of HRI values was seen as follows: Cr > Mn > Zn > Ni > Cu. Based on both single and multivariate statistical analysis, it was determined that geological processes occurring in the layers of that area were the likely cause of high levels of hazardous materials (HM) in drinking water sources (Hussain, et al., 2022).

Ahmad, et al., (2013) carried out a study to examine the standard of drinking water in the valley of Buner, Khyber Pakhtunkhwa (KPK) which has consistently been a matter of great importance for the well-being of the public. An analysis was carried out to evaluate the quality of the drinking water, which included the assessment of total coliform bacteria, total plate count, total fecal coliform, and E. coli levels. The assessment also encompassed the examination of natural springs, locally referred to as Cheena. The goal of these tests was to assess the presence of bacteria in 12 samples collected from different areas of the Buner district. It was found that eight samples met the required standards, while four samples did not meet the criteria established by the WHO after conducting an extensive set of tests. In addition, the presence of microbes was confirmed through biochemical analysis. The water samples collected from Union Council Gul Bandi were determined to be safe for consumption, while samples from other areas of Buner were discovered to be contaminated with animal and human waste. It is worth noting that the water from the springs, which is the main source of drinking water for people living in mountainous areas, is completely free of bacteria and safe to drink. This further highlighted the significance of clean water in maintaining the well-being of the community residing in the mountainous regions. Nevertheless, there have been reports of contamination in springs that flow onto flat regions, potentially due to leaks in the transmission pipes and a lack of knowledge among those living nearby regarding water pollution. The insufficient cleanliness of gutters, which includes the discharge of wastewater and solid waste from humans and animals, is compromising the quality of natural water sources. This issue is concerning for the community, as it highlights the need to enhance their sanitation system to preserve the district's scenic beauty (Ahmad, et al., 2013).

1.6 Problem Statement

In Pakistan, poor water quality is the main issue affecting both the environment and public health. Both groundwater and surface water in the country have been polluted with many toxic substances and microbes that make them unfit for drinking. Drinkable water has become contaminated due to poor living circumstances and some lack of attention (Azizullah, et al., 2011). Muzaffarabad, AJK, along with other neighboring regions, are dealing with the issue of poor drinking water and contamination. The primary sources of pollution in waterways are bacterial contamination, turbidity, electrical conductivity, and hardness, as they are frequently discharged into the water supplies. Assessing the relation between LULC, and water quality is important as it provides insights into safeguarding freshwater resources, thereby addressing the increasing need for water in different sectors such as industry, agriculture, municipalities, recreational activities, and especially for the communities using water for drinking purposes (Ullah, et al., 2018). Therefore, this present study aims to determine the impact evaluation of LULC on water quality and characteristics of spring water and the resulting health impacts of contaminated water in the city of Muzaffarabad Azad Kashmir, Pakistan. The goal is to evaluate the nature of the relationships between land utilization and water resources inside the city while identifying areas of water pollution and their related impacts in the region. The selection of Muzaffarabad as our study region was based on the significant fluctuations in the quality of groundwater levels, the ongoing infrastructure development, and the lack of adequate awareness and sustainable water management regulations. The insights of the present study can help mitigate spring (underground) water contamination by enhancing current water management practices. Therefore, this study is likely to assist pertinent authorities in formulating decisions on sustainable water management and protecting the current potable water supplies.

1.6.1 Research Objectives

The study aims to achieve the following research objectives:

1. To Assess biological parameters, Physio-Chemical, and selected heavy metals (Lead, Chromium, Cadmium, Manganese, Nickel, Iron, and Arsenic) concentration in the drinking water quality of springs in the city of Muzaffarabad.
2. To characterize the conditions of springs used for drinking purposes and analyze their water quality that is affected by land use change.
3. To ascertain the potential health risks of heavy metals (HMs) and biological concentrations to the local population.

CHAPTER 2

MATERIALS AND METHODS

2.1 Study Area

Muzaffarabad is the main city of Azad Kashmir. It is 138 kilometers away from Rawalpindi and Islamabad. The city's coordinates are 34.359688 latitude and 73.471054 longitudes. It marks the meeting point of the Jhelum and Neelum rivers. Muzaffarabad is strategically situated in the heart of AJK’s capital. The AJK region covers a vast area of 13,297 square kilometers. The area is subdivided into 10 districts, each containing 1,771 villages. The Muzaffarabad district covers an area of 2496 square kilometers, accounting for 19% of the total area of AJK state (Shafi, et al., Drinking water quality and possibility of water borne diseases in village Khillah, Muzaffarabad, Azad Jammu And Kashmir, , 2018). Muzaffarabad has a population of 770,000 people, which is 21% of the total population of AJK. The majority of the population, around 88%, resides in rural areas while only 12% reside in urban areas. The literacy rate stands at 74%, while the primary enrollment rate is 94%. The total number of people living in AJK is about 4.1 million according to the 2017 census. Muzaffarabad District is a part of Azad Kashmir in the disputed Kashmir region in Pakistan. It is among the 10 districts within this territory. The region is located alongside the Jhelum and Neelum rivers and is abundant in hilly terrain. The temperature is typically mild and comfortable, neither too hot nor too cold. In Muzaffarabad, it usually rains, even in the driest month. The usual yearly temperature in Muzaffarabad is 12.6 °C. It rains 1308 mm every year. The region is located in the northern hemisphere. Summer starts in late June and ends in September. The summer season goes from June to September. In October, it usually rains the least, with an average of 30 mm (1.2 inches). March is the wettest month with an average of 194 mm (7.6 inches) of rain. The best time to visit is in the spring and summer months of May to September. It is at a higher altitude than the rest of Muzaffarabad district. Many mountains in the area are taller than 5000 meters above the sea. The mountains under 4000 meters have several pine trees. The height of Muzaffarabad district is usually about 1,530 meters. The lowest point is 611 meters, and the highest point is 3,809 meters (Ali, et al., Assessment of heavy metal contamination in the drinking water of muzaffarabad, Azad Jammu and Kashmir, Pakistan., 2019).

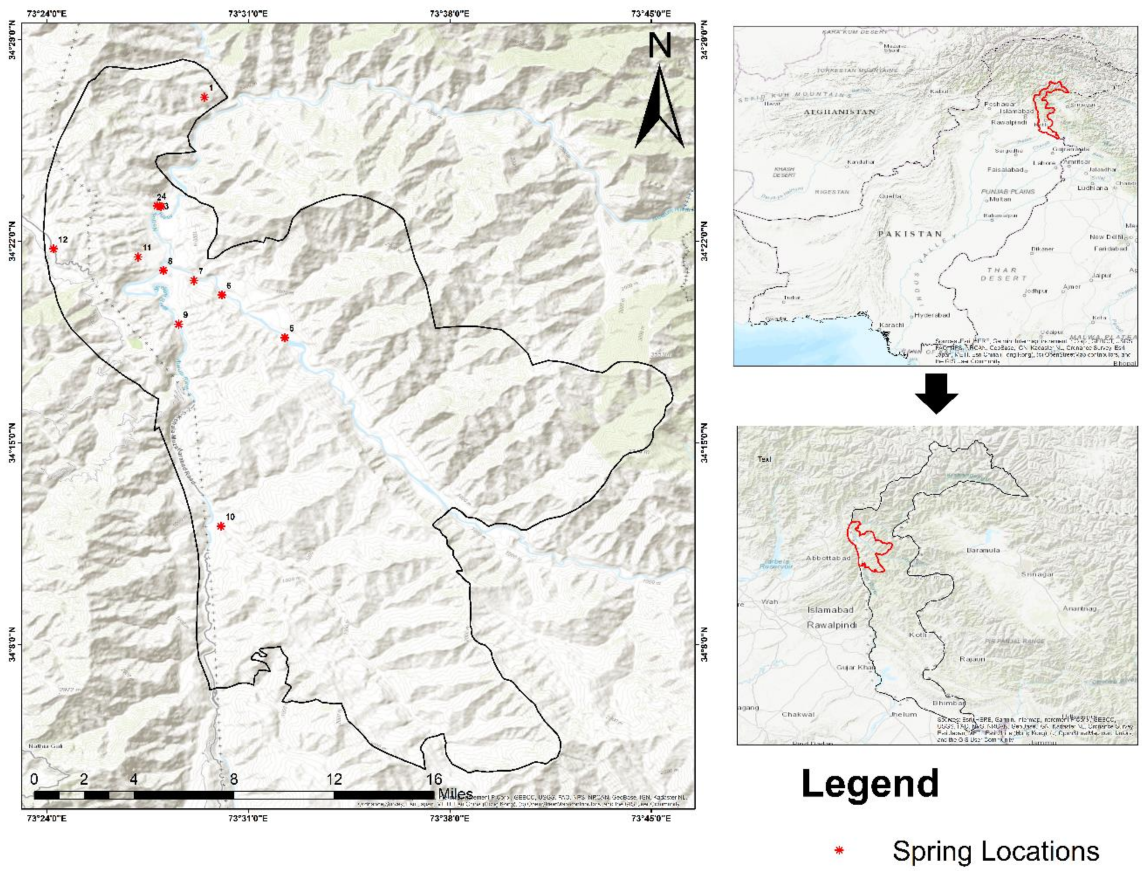

Figure 2.1: Map of study area showing the sampling points of natural springs, district Muzaffarabad

2.2 Sample Collection

A total of 40 samples were collected from selected springs in the district of Muzaffarabad. 3 to 6 samples were collected from each spring to test different parameters i.e., biological, physical, chemical, and heavy metals. Water Samples were collected as per the sampling protocols of Pakistan Environmental Protection Agency (Pak EPA). Samples were collected in sterilized plastic bottles for biological analysis. After water collection, the bottles were sealed securely, and placed in a sample storage container. At each sampling point, GPS coordinates were also recorded. These samples were brought to Bahria University Environmental Sciences Lab for Physical, chemical, and biological analysis. Metal concentrations in samples were analyzed through atomic absorption spectroscopy. For heavy metal analysis, samples collected were digested and sealed before their transportation to PAK EPA lab Islamabad.

Table 2.1: Names of parameters, and instruments used to analyze the collected spring water samples.

S. No	Parameters	Methods/Instruments	Laboratory
1	Temperature	Thermometer	Bahria University Laboratory
2	Turbidity	Turbidity Meter	Bahria University Laboratory
3	pH, TDS, EC, Salts	Multi-Parameter Tester	Bahria University Laboratory
4	Chloride, Hardness, Alkalinity	Titration	Bahria University Laboratory
5	Nitrates	UV Spectrophotometer	Bahria University Laboratory
6	Total coliform, E. coli, Total Bacteria	Plate Count Method	Bahria University Laboratory
7	Heavy Metals	Atomic Absorption Spectroscopy	PAK EPA Laboratory, Islamabad.

2.3 Analytical Procedures

Heavy metals like Cadmium (Cd), Chromium (Cr), Iron (Fe), Manganese (Mn) and Lead (Pb), were analyzed using an Atomic Absorption Spectrometer (ASS) in the Pak EPA laboratory and Arsenic (As) was analyzed by using Arsenic kit in Bahia University Laboratory. The analysis of the bacteria in the drinking spring water samples was carried out using the plate count method. For the analysis of bacteria, culture media (agar) solution was prepared for specific bacteria. MacConkey agar, and Nutrient agar (NA) were used. All of these materials including test tubes, flasks, distilled water, etc. were placed in the Autoclave for 2 hours at 121˚C to sterilize all the apparatus. Samples were diluted 7 times and then spread on various media in the Petri dishes to check the presence, growth, and quantity of Total bacteria, Total coliforms, and E. coli. Once the spreading was done, the petri dishes were covered with a lid and sealed with tape. After tapping, each petri dish was labeled according to agar solution, sample, time, and location of sample. The same procedure was repeated for all remaining samples. After preparing all the Petri dishes, they were then placed in the incubator for 24 to 48 hours at a temperature of 37˚C. The dishes were placed inverted in the incubator to prevent any excess moisture from accumulating on the culture media. The time, date, and number of the samples were labeled on the petri dishes before placing them in the incubator.

Chemical parameters like Total Solids, Total Dissolved solids, alkalinity, chlorides, carbonates, hardness, and nitrates were analyzed in Bahria University Lab following the standard protocol procedures by Pak-EPA. Physical parameters like pH, Electrical Conductivity, TDS, Salts, and Temperature were also measured in Bahria University Laboratory and were measured using Multi Parameter Tester. Turbidity was measured through Turbidity meter. The results were noted, and calculations were performed to find out the concentration of each parameter in the collected drinking spring water samples.

2.4 Analysis of Physical Parameters

2.4.1 pH, EC, TDS, Salts, Temperature

The parameters measured were Potential for pH, Temperature, Electrical Conductivity, Salts, and Total dissolved solids, for spring water samples.

Reagents

1. Distilled water
2. Water sample

Procedure

The multi-parameter tester was calibrated using standards before analyzing our sample. A 50 ml water sample was measured in a graduated cylinder and transferred to a beaker. Subsequently, a multi-parameter tester was immersed in the water sample, providing the value of each physical parameter after one minute. The values were recorded.

2.4.2 Turbidity

Reagents

1. Distilled water
2. Water sample

Procedure

10 milliliters of the sample were placed in the provided vial from the kit. The bottle was inserted into the turbidity meter, and the Test/CAL button was pressed to enable light to pass through the sample. The particles in the water dispersed a concentrated laser beam aimed at the sample. The light that is dispersed is measured at different angles from the original route, and the measurements are recorded.

2.5 Analysis of Chemical Parameters

To assess the quantity of salts and other chemicals in water samples following tests were performed on collected water samples, Hardness test, Alkalinity test, Chloride test, and Carbonates test.

2.5.1 Carbonates Test

Reagents

1. Hydrochloric acid (HCL 0.1 M)
2. Methyl Orange

Calculation

$m_1v_1 = m_2v_2$

m = Molarity

v = Volume of Solution

Procedure

For the carbonate test, burettes were filled with a 0.1 M solution of hydrochloric acid. 10 ml of water was measured in a graduated cylinder and transferred to an Erlenmeyer flask. Two drops of methyl orange indicator were added using a dropper. Upon titration, the sample changed color from orange to pink, indicating the endpoint. Three readings were collected for each sample to prevent human error. We determine the amounts of Na_2CO_3, $NaHCO_3$, HCO_3, and CO_3 in our water samples using this procedure.

2.5.2 Chloride Test

Reagents

1. Silver nitrate (Ag_2NO_3 0.01 M)
2. Potassium Chromate

Calculation

Chloride (mg/L) $= \frac{V \times N \times 35.54 \times 100}{Sample\ Volume}$

N= Normality of silver nitrate

V= Volume of reagent used

Procedure

The test was conducted using Mohr's Method. A burette was filled with a 0.01 M solution of $AgNO_3$. Approximately 10 ml of the water sample was transferred from a graduated cylinder to an Erlenmeyer flask. Three drops of phenolphthalein indicator were added using a dropper, causing the sample to turn light yellow. The endpoint was reached when the sample turned reddish. Three readings were collected to prevent human mistakes. We determined the quantities of chloride (Cl), sodium (Na), and sodium chloride (NaCl) in our water samples using this method.

2.5.3 Alkalinity Test

Reagents

1. Sulfuric acid (H_2SO_4 0.02M)

2. Phenolphthalein ($C_2H_{14}0_4$)

3. Methyl Orange

Calculation

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

N= Normality of sulfuric acid

V= Volume of reagent used

Procedure

The burette was filled with sulfuric acid (H_2SO_4) with a concentration of 0.02 M. A volume of 50 ml of the water sample was measured in a graduated cylinder and added to a beaker. The pH of the sample was checked, and if it was below 8.5, a methyl orange indicator was used; if it was above 8.5, a phenolphthalein indicator was used. The water sample was then transferred to an Erlenmeyer flask with the chosen indicator. After titration, the endpoint was reached when the color changed from orange to yellow or peach. Three readings were obtained to prevent human error.

2.5.4 Total Hardness Test

Reagents

1. Ethylene Diamine Triacetin Acid (EDTA)

2. Ammonium Chloride (NH4CL)

3. Eriochrome Black T (EBT)

4. Buffer Inhibitor

Calculation

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

A= mL titration for sample

B = mg $CaCO_3$ equivalent to 1.00 ml EDTA titrant

Procedure

In this experiment, the burette was filled with Ethylene Diamine Triacetic Acid (EDTA), and a 50 ml distilled water sample was transferred from a graduated cylinder to an Erlenmeyer flask. Using a 1 ml syringe, 2 ml of Ammonium Chloride (NH_4Cl) was added to the blank water sample. The pH of the solution was then measured using a pH meter to determine if it was equal to or greater than 100. We added two drops of Eriochrome Black T (EBT) indicator using a dropper. The sample went red first and then changed to blue at the end point of titration. The technique was repeated for the water samples, and the amount of EDTA used for the black sample was subtracted from the amount used for the water samples. We determine the overall hardness and the levels of calcium and magnesium in our water samples with this technique.

2.5.5 Nitrates

Nitrate is a crucial nutrient required by live bacteria. It is essential for the physiological functions of bacteria. If the concentration exceeds the allowed limit, it is classified as a pollutant. Nitrate levels were determined using a UV spectrophotometer. The spectrophotometer operates on the Beer-Lambert law, which establishes a direct correlation between the concentration and absorption of a sample. The volumetric flask, beaker, and measuring cylinder were cleaned and cleaned with distilled water.

Reagents

1. Distilled water

2. Water sample

Procedure

Initially, blank is run as it contains all the components except for the component being measured. The blank correction was applied. Add the sample to the cuvette and note the reading at 275 nm in the UV 4000 spectrophotometer.

Calculation

$$Conc.\ of\ sample = abs.\ of\ sample \times conc.\ of standard /\ abs.\ of\ standard$$

2.6 Analysis of Biological Parameters

Two methods were used for the assessment of biological parameters.

2.6.1 Plate Count Method

Reagents

1. Nutrient Agar
2. MacConkey agar
3. Distilled water
4. Methylated Spirit

Procedure

Three media culture plates were produced in the lab for the sample collection. Nutrient Agar is abbreviated as NA, whereas MacConkey agar is abbreviated as Mac. The agar was made in glass reagent vials of appropriate size and sealed with cotton plugs. The items were sterilized in the autoclave at 121°C for 30 minutes and then opened in the laminar flow. The petri plates were filled with individual culture media.

Biological parameter samples were gathered and placed in a laminar flow on the same day. Each sample was sequentially opened, obtained using a pipette from a bottle, poured onto the media, and evenly dispersed with a glass spreader. After each dish, the spreader was disinfected with spirit, dried with a spirit lamp, and cooled. After each sample, petri dishes were sealed, labeled, inverted, and placed in the incubator at a temperature of 30-36°C. After 24 hours, the petri dishes were examined, and the bacteria were quantified by marking them on the dishes using a marker.

2.7 Heavy metals

The drinking spring water samples from 12 natural springs and surrounding regions were subjected to testing for heavy metals, specifically Cadmium (Cd), Chromium (Cr), Iron (Fe), Magnesium (Mn), Lead (Pb), and Arsenic (As).

2.7.1 Determination of Cr, Cd, Fe, Mn, and Pb through Atomic Absorption Spectroscopy (AAS)

One of the most often employed methods for analytical purposes is atomic absorption spectrometry (AAS). It has been extensively employed in research labs, as well as in the fields of food, the environment, medicine, petroleum, and other industries (Sergio, et al., 2018). Measurement of element concentrations is done analytically using atomic absorption spectroscopy (AAS). It uses the light absorption caused by various substances to calculate the concentration of each. The absorption of ground-state atoms in the gaseous state can be measured by atomic absorption spectroscopy. The atoms move to higher electronic energy levels after absorbing ultraviolet or visible light (Ahmed M. M., 2012). Once the instrument has been calibrated using standards of known concentration, concentration measurements are typically made using a working curve. A highly popular method for finding metals and metalloids in environmental materials is atomic absorption (Ahmed & Ishiga, Trace metal concentrations in street dusts of Dhaka city, Bangladesh., 2006). Four main parts make up an atomic absorption spectrometer: a light source (often a hollow cathode lamp), an atom cell (atomizer), a monochromator, a unit for detection, and a read-out device. All prepared drinking spring water samples were evaluated and analyzed using Atomic Absorption Spectroscopy (AAS) in the Pak-EPA lab, for seven selected heavy metals named Chromium (Cr), Cadmium (Cd), Iron (Fe), Nickel (Ni), Manganese (Mn), and Lead (Pb).

2.7.2 Arsenic Testing Procedure

For best results, the water temperature was 25°C to 28°C (77°F to 82°F). We used a thermometer to verify the temperature of the sample. To the Reaction Bottle, we slowly added the water sample to the upper marked line on the bottle (50 mL). Added 1 level pink spoon of the First Reagent to the Reaction Bottle. Capped it securely with the red cap and shake vigorously, with the bottle upright, for 15 seconds. Uncapped the Reaction Bottle and added 1 level red spoon of the second reagent. Recap securely with the red cap and shake it vigorously, with the bottle upright, for 15 seconds.

To minimize H_2S interference, we allowed the sample to sit for 2 minutes before performing Step 5. Next, we uncapped the reaction bottle and added 1 level white spoon of the third reagent. Then capped securely with a red cap and shaken vigorously with the bottle upright for 5 seconds. Immediately uncapped and recapped securely using the white turret cap. The turret cap must be dry. Removed one Arsenic test strip from its bottle. Inserted the test strip into the turret. Positioned the strip so that the test pad and red line are facing the back of the white cap. Insert the strip into the turret until the red line is even with the top of the turret, and now close (flip down) the turret. This will hold the test strip in place. Allowed the reaction to occur in an undisturbed, well-ventilated area. The test strip must be inserted and oriented correctly, and to the correct depth, for the results to be accurate. Waited 10 minutes. After the 10-minute wait, we pulled up the turret and carefully removed the test strip. Then we used the Arsenic Test Kit Color Chart to match the test strip pad color within the next 30 seconds. Lastly, we viewed the center of the test strip pad through the hole to confirm the color match and arsenic level. Then the results. For best accuracy above 0.5mg/L dilute the samples 1 to 5 and repeat the test as follows, fill the reaction bottle to the bottom line with the sample to be tested. Added arsenic-free water to the top line (50mL) of the bottle and then ran steps 2 to 9. Multiplied the result by 5 to determine the actual arsenic value and recorded the result.

2.8 Questionnaire surveys

To assess the health impacts related to waterborne diseases among the consumers, the study area from where the spring water samples were collected in the Muzaffarabad district was subject to questionnaire surveys. A total of sixty surveys were conducted in the surrounding areas of district Muzaffarabad and random sampling was done in the study area.Surveys from different areas of the city were conducted to inquire about any health conditions, diarrhea, cholera, typhoid, and other waterborne diseases in the consumers possibly due to the bacterial and heavy metal contamination of drinking spring water. Direct questions and interviews were done to collect the information.

CHAPTER 3

RESULTS AND DISCUSSION

The chapter discusses the results of spring water quality i.e. physical, chemical, biological, and heavy metal analysis of 12 springs and respective samples collected from each spring and the drinking water quality of these springs in Muzaffarabad district. Additionally, the chapter also discusses the impact of heavy metals, and microbial contamination of water on the consumers and the potential health risk. Questionnaire surveys were also conducted to know about any health conditions among consumers. All the results are discussed below.

3.1 Results of physical parameters of spring water samples

The water samples from the 12 springs in some areas of Muzaffarabad district were assessed for physical parameters i.e., pH, temperature, EC, turbidity, salts, and TDS. The results of the physical parameters of all water samples are discussed below. The mean values of each spring were taken and shown in the graphs of each parameter. The spring water samples were taken at a distance of 10m.

3.1.1 Results of pH

The pH of a water sample indicates the quantity of hydrogen ions. The pH level, which indicates the concentration of hydrogen ions, is crucial for water quality. Various pollutants, like microbiological processes and the solubility and stability of metal salts, mostly rely on the pH level of the water. The pH value must fall within the range of 6.5-8.5 according to Pak EPA water rules (Batool, et al., 2019). According to the results of pH for 12 spring water samples, the mean pH values of the samples exceeded the recommended lower limit of 6.5.

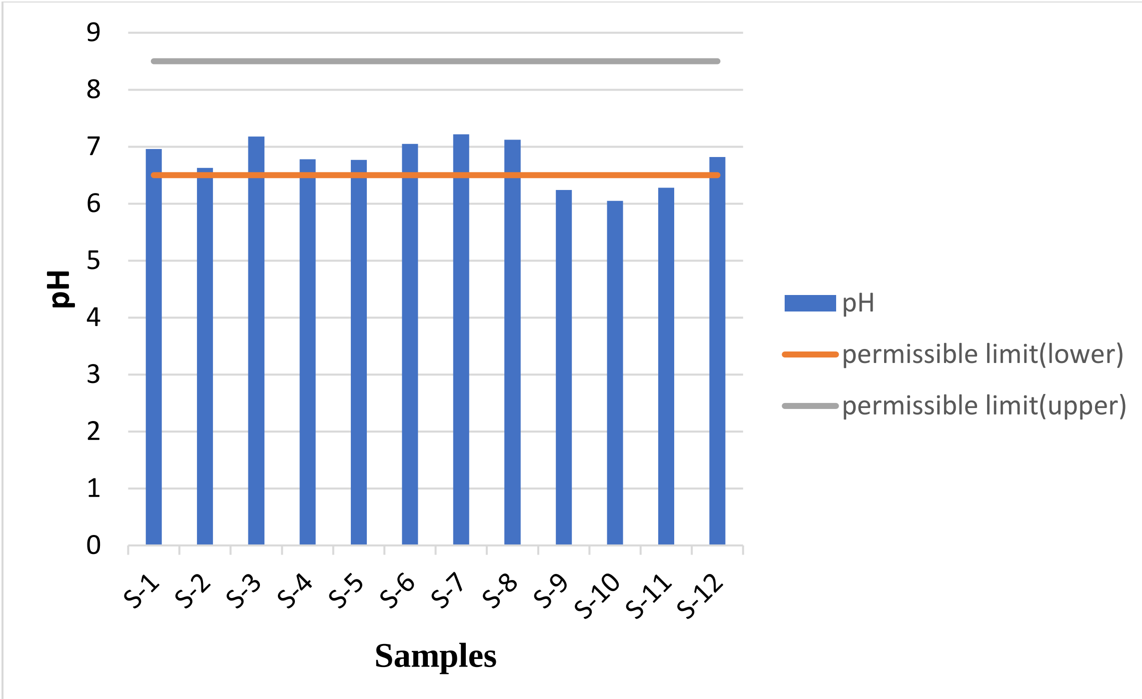

Figure 3.1: Levels of pH in collected 12 spring water samples.

3.1.2 Electrical Conductivity (EC)

Electrical conductivity is the capacity of a material to carry current. It quantifies the charge level in water. The number serves as a clear indication of the mineral salts present in the water. Conductivity is directly associated with the total dissolved solids (TDS). The recommended electrical conductivity value for water by Pak EPA is 1000 µS/cm^3 (Adegbola, et al., 2014). The results of all spring samples for electrical conductivity were within the permissible range.

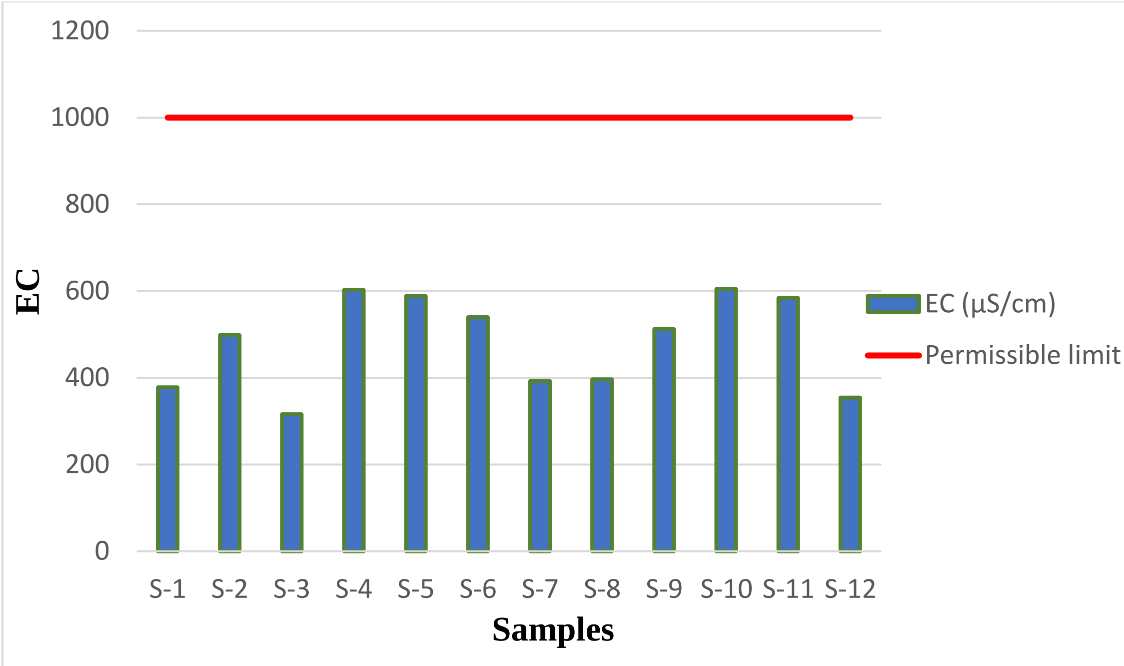

Figure 3.2: Levels of EC in collected 12 spring water samples.

3.1.3 Total dissolved solids (TDS)

Total dissolved solids give an approximation of both inorganic and organic soluble salts present in water. The Pak EPA has recommended an acceptable level of 500 mg/L for drinking purposes. High TDS in water implies a high mineral content (Payment, et al., 2003). The results of TDS in all spring water samples were within the permissible limit.

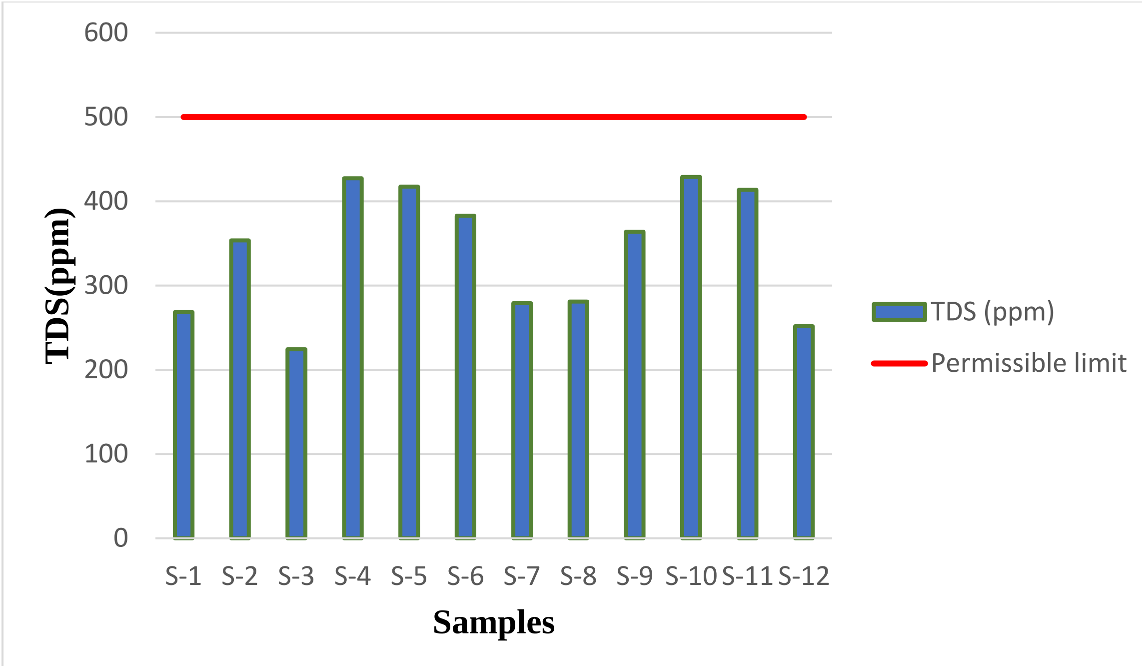

Figure 3.3: Levels of TDS in collected 12 spring water samples.

3.1.4 Salts

Salts primarily consist of carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, calcium, magnesium, sodium, potassium, iron, manganese, and other elements. They are devoid of gases, colloidal particles, debris, or any other materials present on the exterior of the earth. The dissolved minerals can cause a bad taste or color (Poonam, et al., 2013). Pak EPA's recommended permissible salt limit is 200 mg/l. The results of spring water samples S2, S4, S5, S6, S9, S10, and S11 for salts exceeded the permissible limit of 200 mg/l.

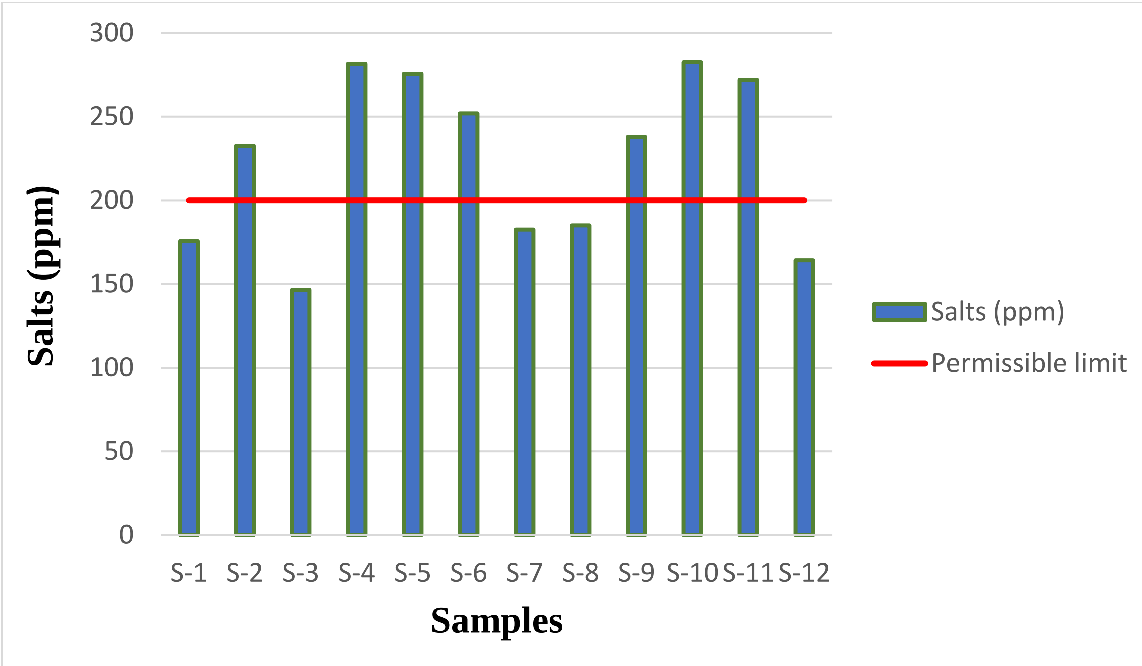

Figure 3.4: Levels of salts in collected 12 spring water samples.

3.1.5 Temperature (°C)

Temperature serves as an indirect sign of pollution. High temperatures provide optimal conditions for bacteria to thrive and facilitate the proliferation of diverse microorganisms (Gorde & Jadhav, 2013). The temperature of all the collected spring samples was within the permissible limit of Pak EPA (30°C).

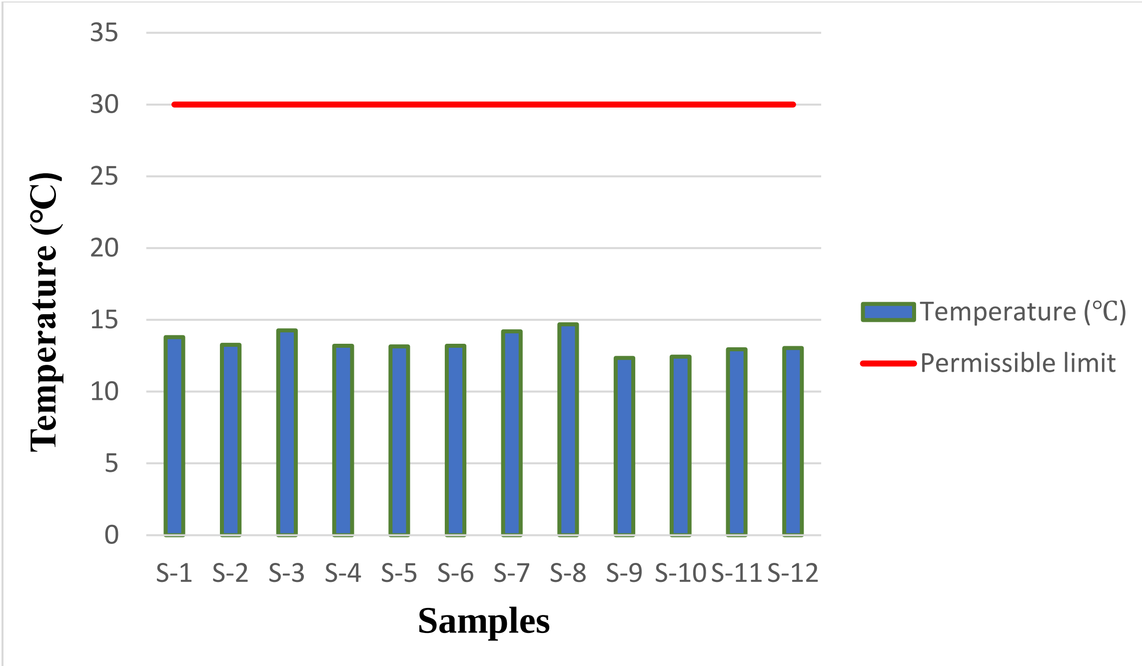

Figure 3.5: Levels of temperature in collected 12 spring water samples.

3.1.6 Turbidity

Turbidity is the opacity of water due to suspended particles that are often opaque to the naked eye and do not readily settle, maybe induced by phytoplankton growth. Increased turbidity in drinking water raises the risk of digestive tract diseases (Azis, et al., 2015). The EPA sets a maximum turbidity limit of 5 NTU, and water with turbidity below 1.00 NTU is considered excellent for household usage. No turbidity was found in the collected spring water samples.

3.2 Results of Chemical Parameters

The 12 spring water samples were analyzed for chemical parameters chlorides, alkalinity, nitrates, total hardness, and carbonates. The results of all chemical parameters from the springs and their respective samples are discussed further. For all 12 springs, mean values from each spring are plotted in graphs for each chemical parameter. The spring water samples were collected at a distance of 10m from each spring.

3.2.1 Alkalinity (mg/L)

Alkalinity is the capacity of water to neutralize acids. Chloride, bicarbonate, and sulfate ions are the primary contributors to alkalinity. Water system alkalinity originates from various causes such as soil chemical ion exchange behaviors, mineral and rock weathering, accumulation of minerals and evaporation, biological processes, reduction of strong acidic anions, and deposits of air dust particles (Qureshi, et al., 2021). The Pak EPA recommends a permissible alkalinity limit of 200 mg/L. All spring water samples had an acceptable level of alkalinity.

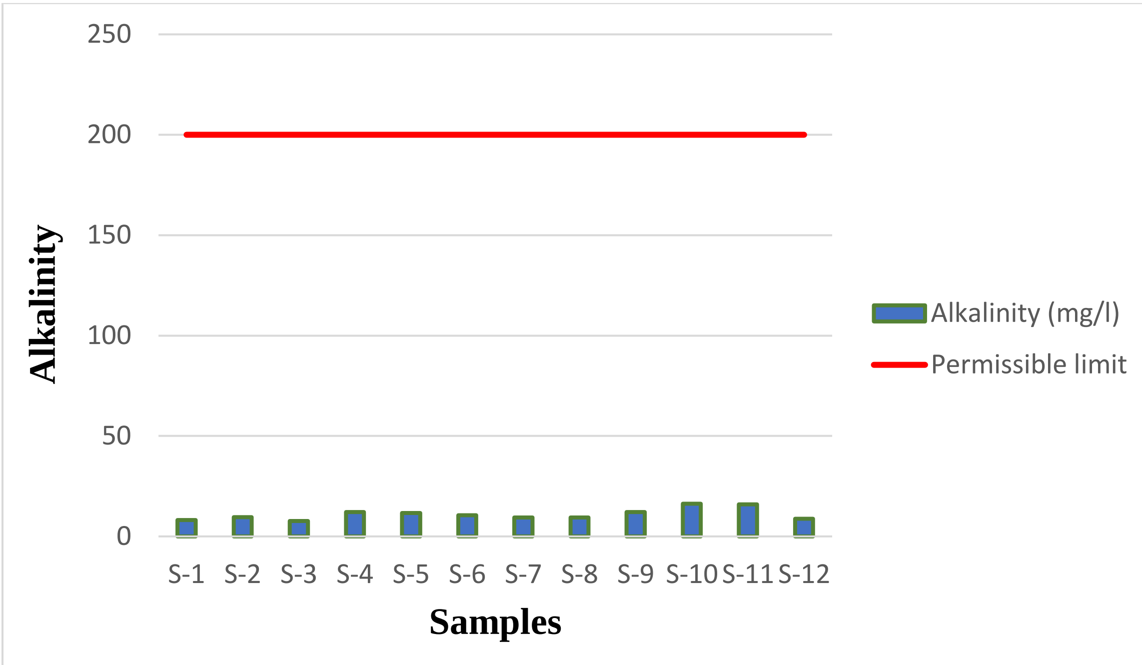

Figure 3.6: Levels of Alkalinity in collected spring water samples.

3.2.2 Results of Total Hardness

Water hardness is mainly caused by the existence of carbonate, bicarbonates, chlorides, and sulfates of calcium and magnesium. The maximum permissible quantity of hardness in water is 500 ppm, as stated by Pak EPA and PCRWR. High mineral content in water causes scaling, corrosion, and blockage of tubes or appliances, leading to increased financial loss. Extreme hardness can lead to diarrhea, gas issues, kidney infections, and cardiac difficulties. (Hori, et al., 2021). The hardness of all the spring water samples was within permissible limits.

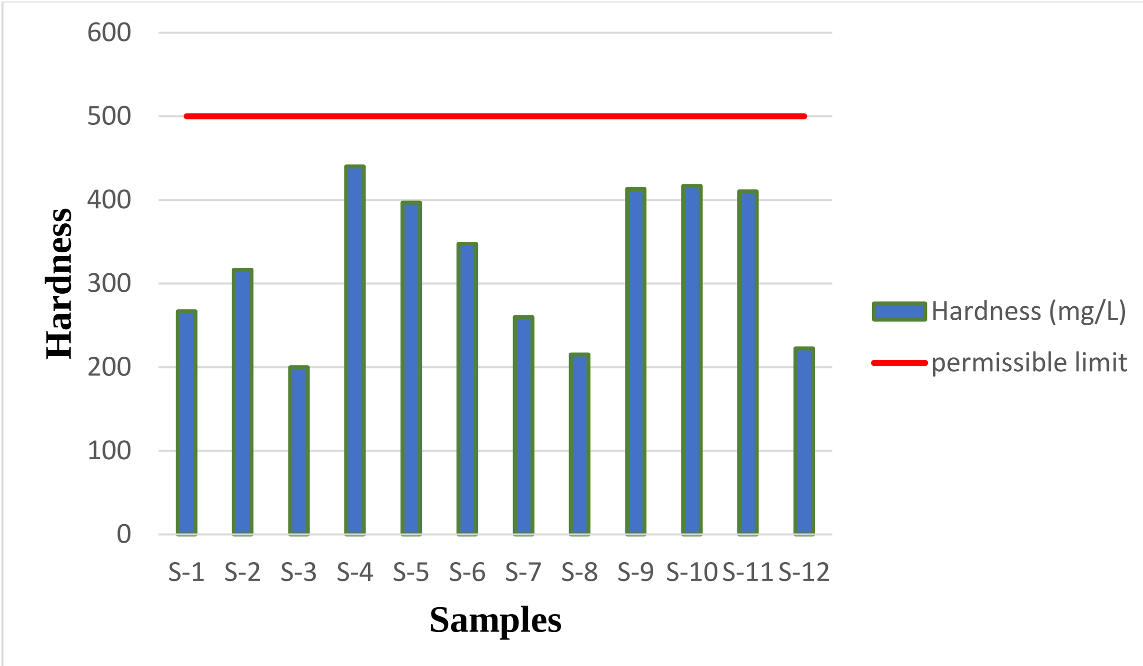

Figure 3.7: Levels of Hardness in collected spring water samples.

3.2.3 Nitrates (mg/L)

The results of all spring water samples were within the permissible limit of Pak EPA 50 mg/L. If the value of nitrate in water increases above the recommended limit it can cause fatigue, muscle aches, weakness, dizziness, and excess heart rate (Alahi & & Mukhopadhyay, 2018).

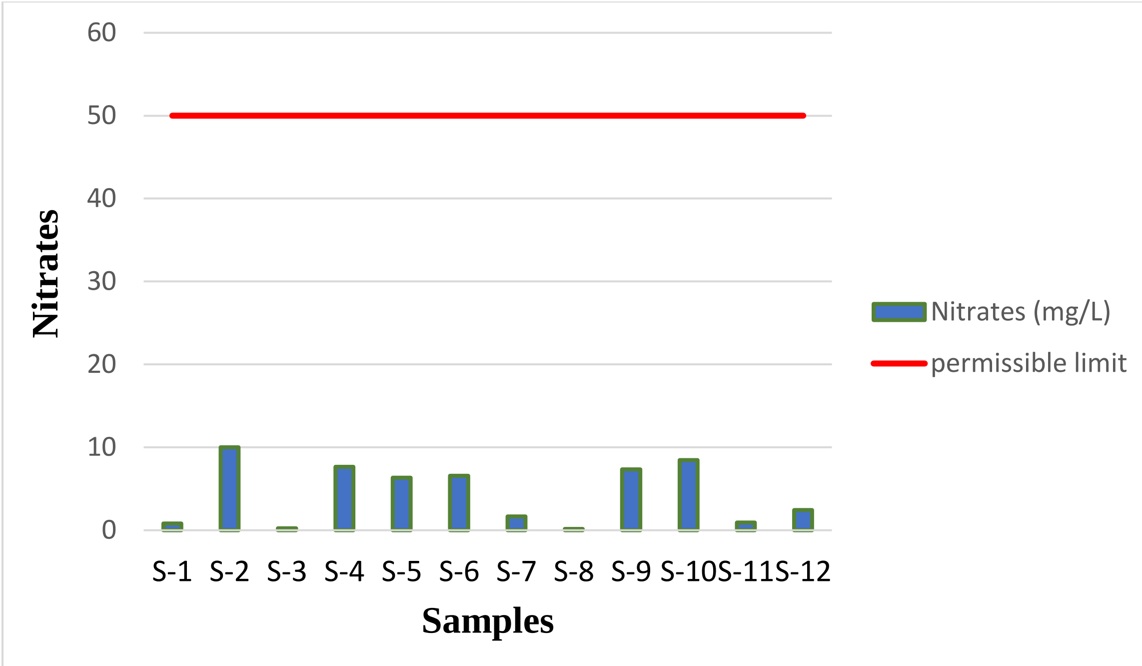

Figure 3.8: Levels of Nitrates in collected spring water samples.

3.2.4 Chlorides (mg/L)

Hydrochloric acid salts like sodium chloride, potassium chloride, and calcium chloride dissociate from rock layers to create chlorine. Wastewater, waste from industry, and ocean or salt water also contribute. Compared to water in the ground, water on the surface has less chloride. The body needs chloride for metabolism. It also maintains body acid-base balance (Nasir, et al., 2012). Pakistan's EPA proposed a 250 mg/L chloride limit for water. The chlorides in all spring water samples were acceptable.

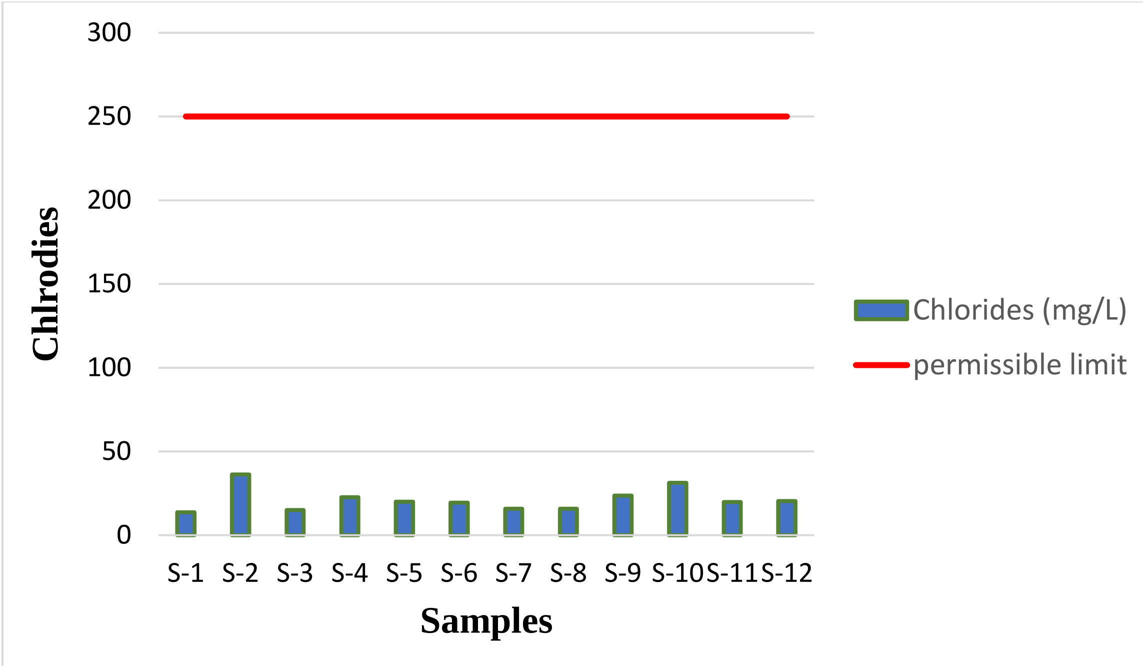

Figure 3.9: Levels of Chlorides in collected spring water samples.

3.2.5 Sodium (mg/L)

The results of all collected spring water samples were within the permissible limit of Pak EPA i.e., 200mg/l. Sodium is required for the normal functioning of the human body but, if the concentration of sodium exceeds the defined limit it causes harmful effects on human health. Sodium is required for the normal functioning of the human body. Whereas, if the concentration of sodium exceeds it can cause health-related issues like blood pressure, strokes, and cardiovascular diseases (Iqbal, et al., 2023).

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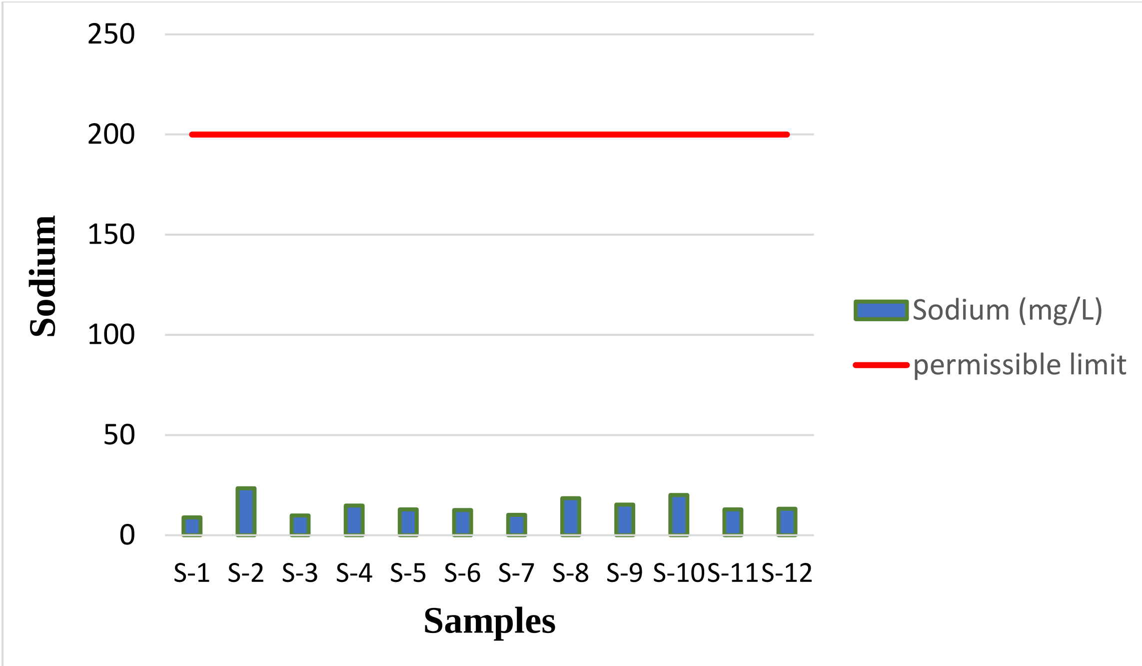

Figure 3.10: Levels of Sodium in collected spring water samples.

3.2.6 Results of NaCl

There is no recommended limit by Pak EPA for NaCl in water, however, the values of sodium (Na) and Chloride (Cl) were within the permissible limits. The results of water samples tested for sodium chloride are shown in the table below.

Table 3.1: Results of NaCl (mg/L) in collected spring water samples.

Spring no	Sample Id	NaCl
Spring 1	A1	21.06
	A2	23.4
	A3	23.4
Spring 2	B1	54.40
	B2	58.5
	B3	66.10
Spring 3	C1	35.1
	C2	25.3
	C3	21.06
	C4	25.1
	C5	19.30
	C6	21.06
	C7	23.4
	C8	26.91
Spring 4	D1	38.61
	D2	38.61

	D3	35.1
Spring 5	E1	31.0
	E2	35.1
	E3	32.76
Spring 6	F1	36.85
	F2	31.0
	F3	29.25
	F4	31.0
Spring 7	G1	25.15
	G2	26.91
Spring 8	H1	25.15
	H2	26.91
Spring 9	I1	42.70
	I2	36.85
	I3	36.85
Spring 10	J1	48.55
	J2	56.16
	J3	48.55
Spring 11	K1	32.76
	K2	32.76
Spring 12	L1	35.1
	L2	35.1
	L3	29.25
	L4	35.1

3.2.7 Results of Carbonates

There is no recommended limit by Who or EPA for Carbonates in water, however, the values of NaHCO3, Na2CO3, HCO3, and CO3 are shown in the table. The results of water samples tested for carbonates are shown in the table below.

Table 3.2: Results of Carbonates (mg/L) in collected spring water samples.

Spring no	**Sample Id**	**$NaHCO_3$**	**$Na2CO_3$**	**HCO_3**	**CO_3**
Spring 1	A1	1.848	2.32	1.34	1.32
	A2	1.932	2.43	1.40	1.38
	A3	2.1	2.64	1.52	1.5
Spring 2	B1	0.42	0.52	0.305	0.3
	B2	0.42	0.52	0.305	0.3
	B3	0.42	0.52	0.305	0.3
Spring 3	C1	1.764	2.22	1.28	1.26
	C2	1.848	2.32	1.34	1.32
	C3	1.848	2.32	1.34	1.32
	C4	1.68	2.11	1.22	1.2

	C5	1.68	2.11	1.22	1.2
	C6	1.68	2.11	1.22	1.2
	C7	1.68	2.11	1.22	1.2
	C8	1.596	2	1.159	1.14
Spring 4	D1	3.108	3.9	2.25	2.22
	D2	2.772	3.4	2.013	1.98
	D3	5.46	6.8	3.96	3.9
Spring 5	E1	2.856	3.6	2.074	2.04
	E2	2.77	3,4	2.013	1.98
	E3	2.77	3.6	2.013	1.98
Spring 6	F1	2.52	3.17	1.83	1.8
	F2	2.52	3.17	1.83	1.8
	F3	4.53	5.71	3.294	3.24
	F4	2.52	3.17	1.83	1.8
Spring 7	G1	2.43	3.0	1.769	1.74
	G2	2.43	3.0	1.769	1.74
Spring 8	H1	2.18	2.75	1.586	1.56
	H2	2.18	2.75	1.586	1.56
Spring 9	I1	0.50	0.63	0.366	0.36
	I2	0.58	0.74	0.427	0.42
	I3	0.58	0.74	0.427	0.42
Spring 10	J1	0.75	0.95	0.549	0.54
	J2	0.67	0.84	0.488	0.48
	J3	0.67	0.84	0.488	0.48
Spring 11	K1	0.58	0.74	0.427	0.42
	K2	0.75	0.93	0.549	0.54
Spring 12	L1	0.33	0.42	0.244	0.24
	L2	0.42	0.52	0.305	0.3
	L3	0.423	0.52	0.305	0.3
	L4	0.42	0.52	0.305	0.3

3.3 Results of Biological Parameters

The 12 spring water samples collected from different areas in Muzaffarabad District were subject to bacterial analysis using Nutrient agar for total bacteria growth, and MacConkey agar for coliform growth. The results are tabulated in the table below. Samples from Spring 1, 2, 3, 4, 5, and 6 had exceeded the values for total bacterial growth which should be less than 500 CFU/ml. The higher counts indicate the poor quality of water which may cause health-related problems in consumers who consume it for drinking purposes. The results for Mac agar showed that many samples had coliforms, including spring 1, 2, 3, 4, 6, 7, 8, 9, 10 and 12. The highest values were found in springs 3, and 6 with 358

CFU/ml and 380 CFU/ml. Only spring 5 and spring 11 had shown zero counts for coliforms. According to WHO and EPA, the water should have no presence of coliforms.

Table 3.3: Results of biological parameters (CFU/ml) in collected spring water samples.

Spring no	Sample Id	Nutrient Agar	MacConkey Agar
Spring 1	A1	Uncountable	153
	A2	180	06
	A3	680	272
Spring 2	B1	323	19
	B2	147	05
	B3	95	0
Spring 3	C1	07	0
	C2	116	0
	C3	45	0
	C4	190	09
	C5	932	380
	C6	60	0
	C7	52	03
	C8	20	09
Spring 4	D1	670	0
	D2	02	0
	D3	400	26
Spring 5	E1	920	0
	E2	720	0
	E3	150	0
Spring 6	F1	730	66
	F2	140	09
	F3	672	358
	F4	237	49
Spring 7	G1	682	28
	G2	640	155
Spring 8	H1	314	08
	H2	126	0
Spring 9	I1	91	21
	I2	205	15
	I3	26	0
Spring 10	J1	39	04
	J2	11	04
	J3	04	0
Spring 11	K1	Nill	0
	K2	16	0
Spring 12	L1	15	0
	L2	39	16

	L3	160	0
	L4	285	0
Permissible limits		>500 CFU/ml	0 CFU/ml

3.4 Results of Heavy Metals

40 samples taken from 12 springs were subject to heavy metal analysis through atomic absorption Spectroscopy (ASS). Cadmium (Cd), Chromium (Cr), Lead (Pb), Manganese (Mn), and Iron (Fe) were analyzed in the collected spring water samples. Arsenic (As) was not tested through (ASS), it was tested separately through Arsenic kit. Arsenic (As) was not detected in any of the water samples. The results of all elements are tabulated in the table. For springs 1 and 7, all samples had Fe values below the detection limit (BDL). In springs 2, 3, 4, 6, 8, 10, and 11 the values were within the permissible limit of 0.3 mg/L. However, Spring 3, 5, and 9, had values that exceeded the recommended limit as given by WHO. All spring samples had shown below detection limit values for lead (Pb) except for one sample of spring 10 which had a small concentration (0.009mg/L) within the permissible limit of 0.01. The results of chromium (Cr) showed that the water samples from the springs had values below the detection limit and some values within the permissible limit of 0.05 mg/L. Only one sample of Spring 12 had a value of 0.054 which surpassed the recommended limit. The results of cadmium (Cd) showed that all water samples from springs have values below the detection limit (BDL), only samples from Spring 3, 4, and 5 had values that surpassed the recommended limit of 0.003 mg/L. Three samples from Spring 3 had surpassed the recommended limit of Manganese (Mn), the rest had values below the detection limit and within the permissible limit. One sample from Spring 6 had also surpassed the recommended value of 0.1mg/L other values were below BDL. 2 samples had values below BDL and 1 sample exceeded the permissible limit of Spring 1. Spring 4 had one sample whose value exceeded the limit of 0.1mg/L. Spring 8 had one sample value of 0.13mg/L exceeded the value of 0.1 mg/L Spring 7 had both values below the detection limit. Spring 9 had 2 sample values 0.1 and 0.2 which exceeded the permissible limit. Spring 10 had samples within the limit and below the detection limit. Spring 11 had values BDL and within the permissible limit. Spring 2 and 5 had values

Below BDL and within the limit. Spring 12 had two sample values that surpassed the permissible limit of Mn in water.

Table 3.4: Results of heavy metals(mg/l) in collected spring water samples.

S. No	**Sample id**	**Fe**	**Cr**	**Cd**	**Mn**	**Pb**
	Limit	**0.3**	**0.05**	**0.003**	**0.1**	**0.01**
1.	**C1**	BDL	BDL	BDL	0.212	BDL
2.	**C2**	0.052	BDL	BDL	0.153	BDL
3.	**C3**	0.121	BDL	BDL	BDL	BDL
4.	**C4**	0.022	BDL	BDL	BDL	BDL
5.	**C5**	BDL	BDL	BDL	BDL	BDL
6.	**C6**	BDL	0.021	0.008	0.225	BDL
7.	**C7**	0.411	BDL	BDL	0.098	BDL
8.	**C8**	BDL	BDL	BDL	0.088	BDL
9.	**F1**	BDL	0.041	BDL	BDL	BDL
10.	**F2**	BDL	BDL	BDL	BDL	BDL
11.	**F3**	BDL	BDL	BDL	0.108	BDL
12.	**F4**	0.132	BDL	BDL	BDL	BDL
13.	**A1**	BDL	BDL	BDL	0.139	BDL
14.	**A2**	BDL	BDL	BDL	BDL	BDL
15.	**A3**	BDL	BDL	BDL	BDL	BDL
16.	**D1**	BDL	BDL	BDL	0.028	BDL
17.	**D2**	BDL	0.038	BDL	0.096	BDL
18.	**D3**	0.112	BDL	0.005	0.191	BDL
19.	**H1**	0.038	BDL	BDL	0.087	BDL
20.	**H2**	0.086	0.0223	BDL	0.133	BDL
21.	**G1**	BDL	BDL	BDL	BDL	BDL
22.	**G2**	BDL	BDL	BDL	BDL	BDL
23.	**I1**	BDL	BDL	BDL	0.11	BDL
24.	**I2**	0.369	BDL	BDL	0.217	BDL
25.	**I3**	BDL	BDL	BDL	BDL	BDL
26.	**J1**	BDL	BDL	BDL	0.221	BDL
27.	**J2**	0.118	BDL	BDL	BDL	BDL
28.	**J3**	BDL	BDL	BDL	0.052	0.009
29.	**K2**	BDL	0.041	BDL	BDL	BDL

30.	**K1**	0.0224	BDL	BDL	0.0421	BDL
31.	**B1**	BDL	BDL	BDL	BDL	BDL
32.	**B2**	BDL	BDL	BDL	BDL	BDL
33.	**B3**	0.071	BDL	BDL	BDL	BDL
34.	**L1**	BDL	BDL	BDL	BDL	BDL
35.	**L2**	BDL	0.054	BDL	0.512	BDL
36.	**L3**	BDL	0.022	BDL	0.048	BDL
37.	**L4**	0.147	BDL	BDL	0.388	BDL
38.	**E1**	0.158	BDL	BDL	BDL	BDL
39.	**E2**	0.384	BDL	0.003	0.177	BDL
40.	**E3**	BDL	BDL	BDL	BDL	BDL

3.5 Questionnaire survey

To assess the health impacts related to waterborne diseases among the consumers, the study area from where the spring water samples were collected in the Muzaffarabad city was subject to questionnaire surveys. A total of sixty surveys were conducted in the surrounding areas of city Muzaffarabad and random sampling was done. Surveys from random areas of the city were conducted to inquire about any health conditions, diarrhea, cholera, typhoid, and other waterborne diseases in the consumers possibly due to the bacterial and heavy metal contamination of drinking spring water. Direct questions and interviews were done to collect the information. This survey was conducted in the city Muzaffarabad and following are the graphs that were made by using Chi- square test. Questionnaire survey was conducted randomly in the city from different people and graphs represent age-wise that are from 15 to 70 years of age. following are the questions and their respective graphs showing the answers that were asked during the survey. Based on the survey conducted in the Muzaffarabad district areas regarding spring water usage for drinking purposes, it appears that most consumers find the physical appearance of the water satisfactory, with no detectable odor. However, some individuals have reported experiencing waterborne diseases because they don’t boil water before consumption. Although no fatalities have been reported due to contaminated water consumption, and some waterborne diseases have affected numerous people. It's positive to note that people in the area have access to sanitation facilities and are aware of the potential risks associated with contaminated water.

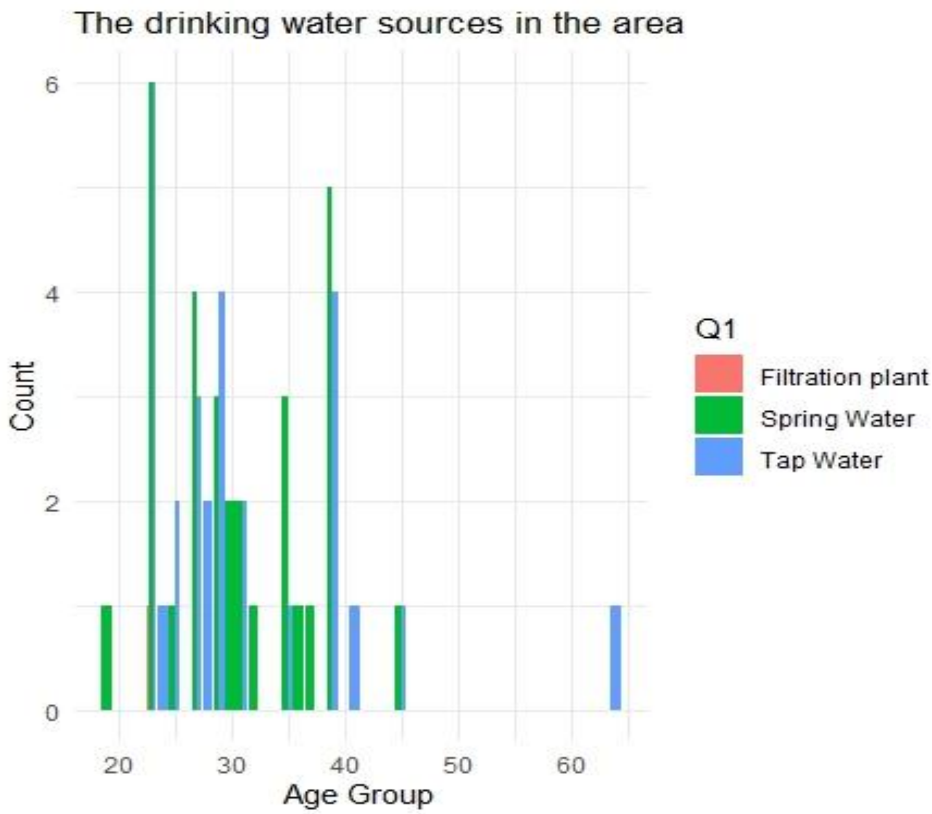

Figure 3.11 (a): The drinking water sources in the area.

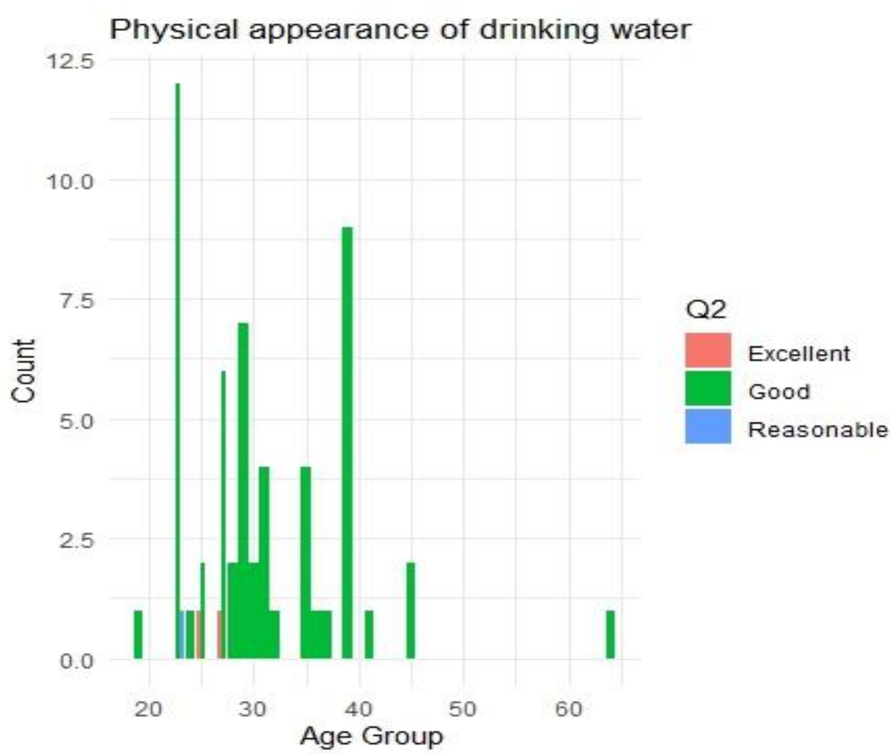

Figure 3.11 (b): The physical appearance of drinking water

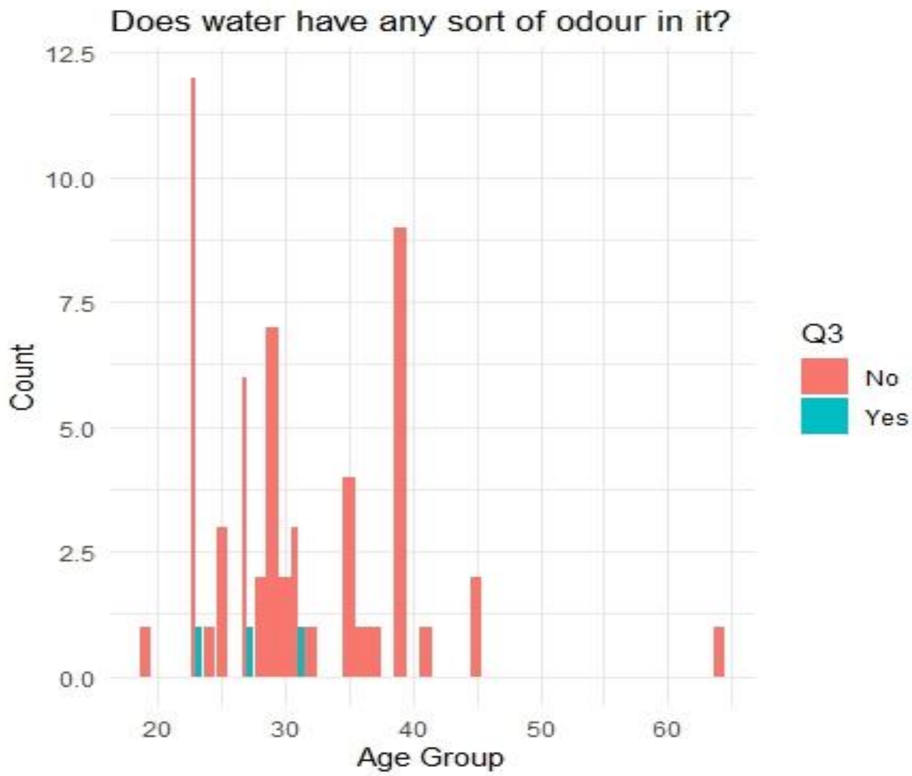

Figure 3.11 (c): The odor in drinking water

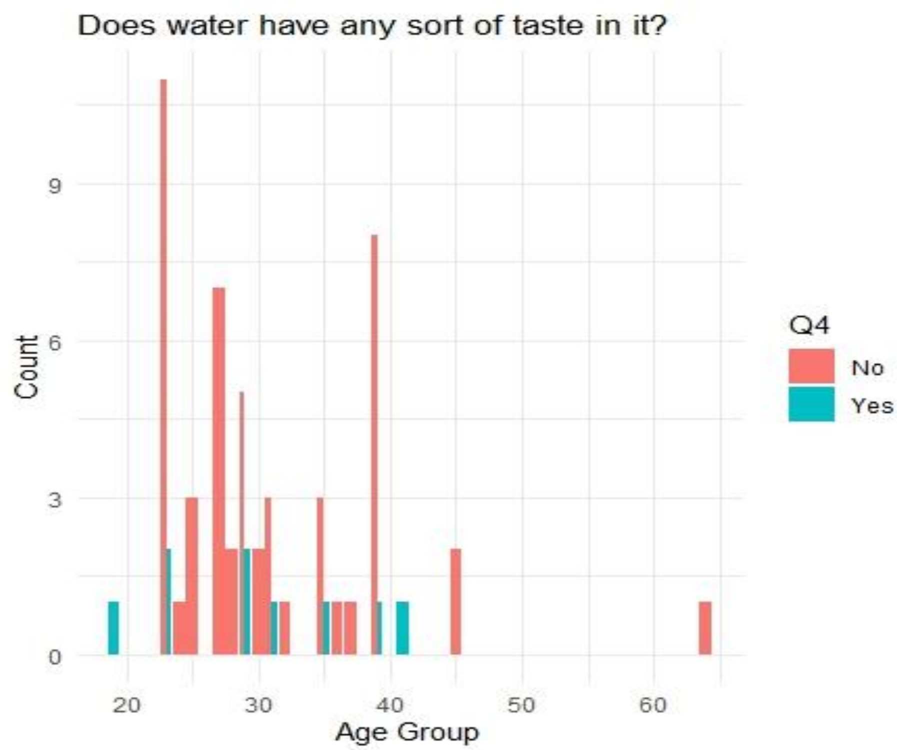

Figure 3.11 (d): The drinking water taste

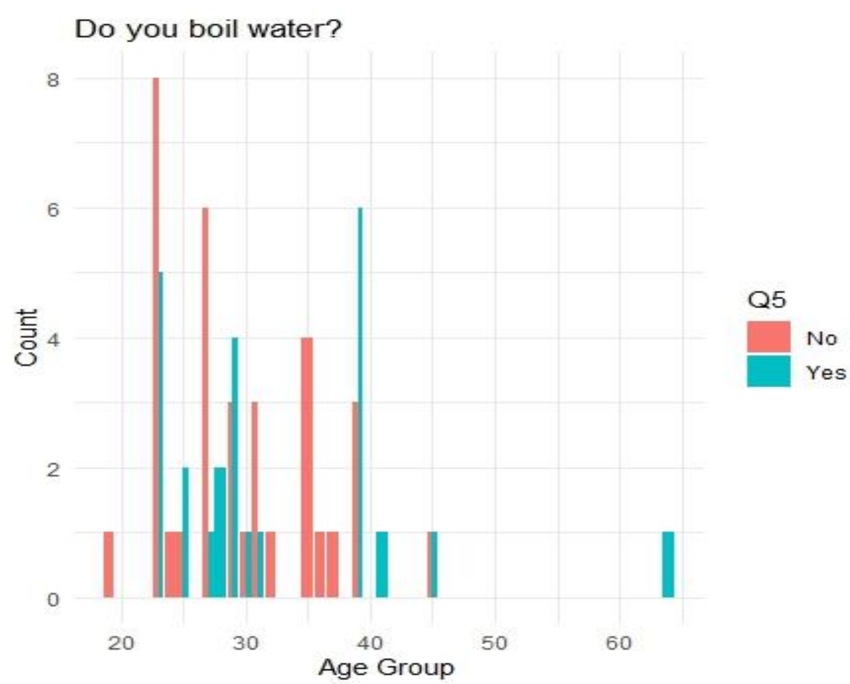

Figure 3.11 (e): The practice of boiling water before drinking

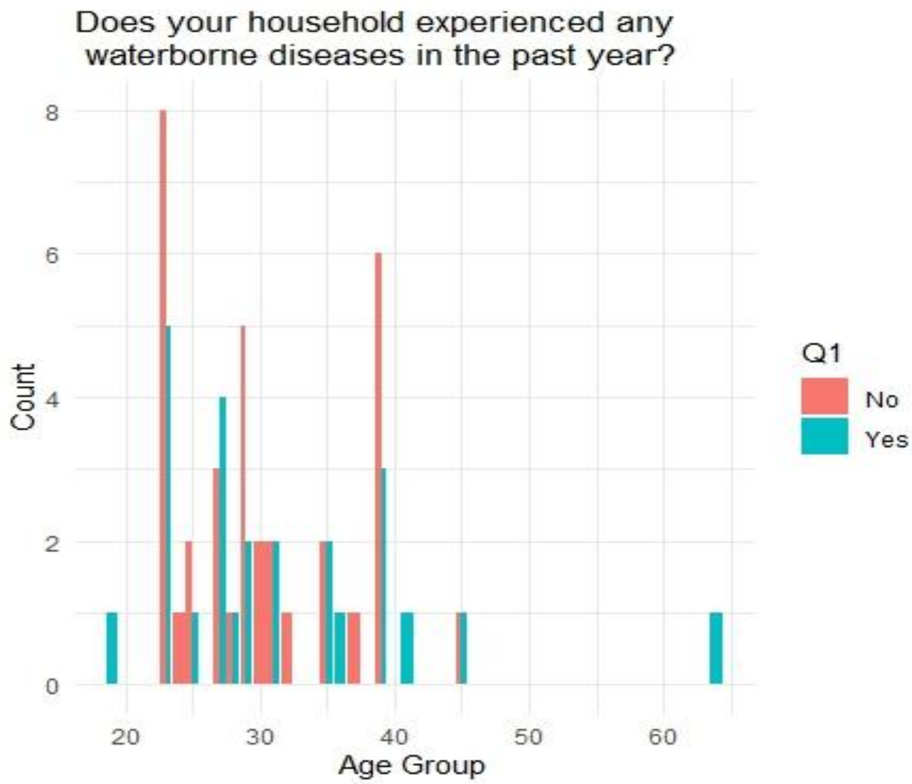

Figure 3.11 (f): Waterborne diseases in drinking water

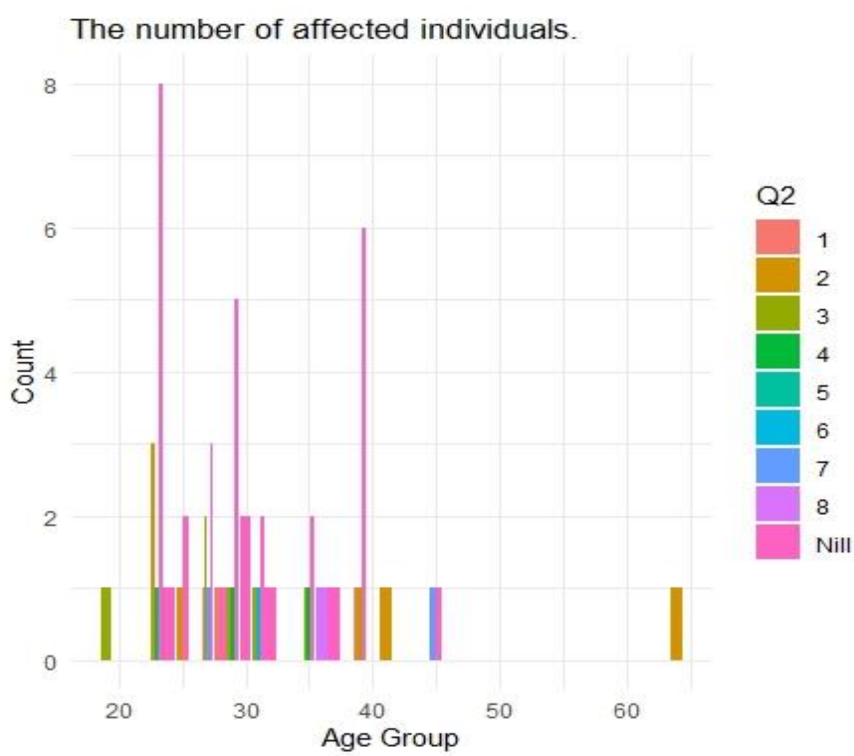

Figure 3.11 (g): The number of affected people due to waterborne diseases

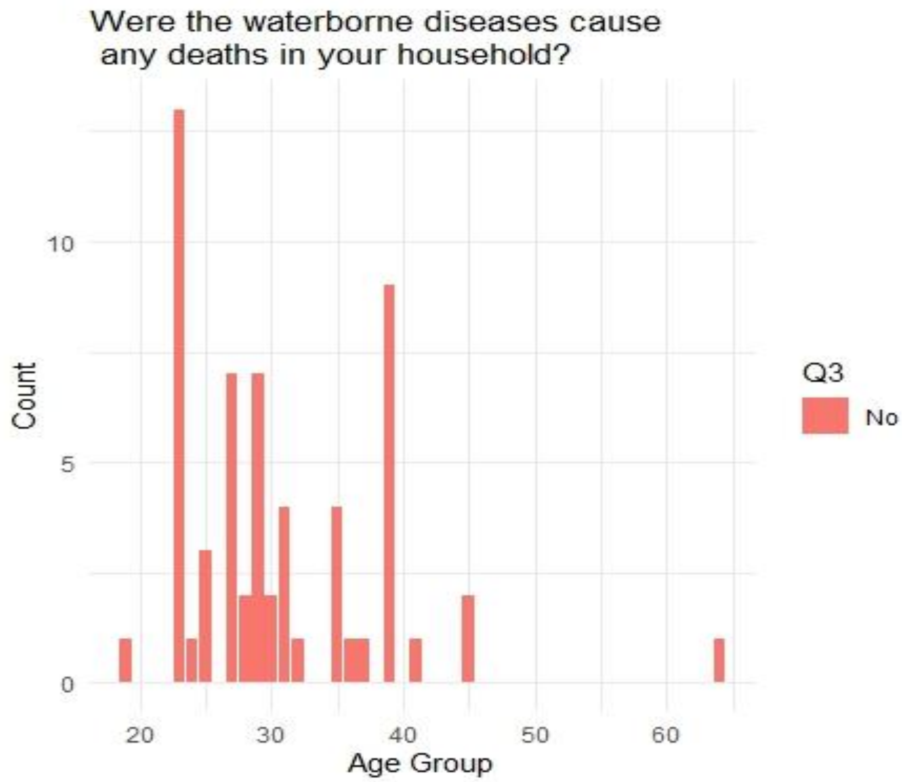

Figure 3.11 (h): The deaths due to waterborne diseases

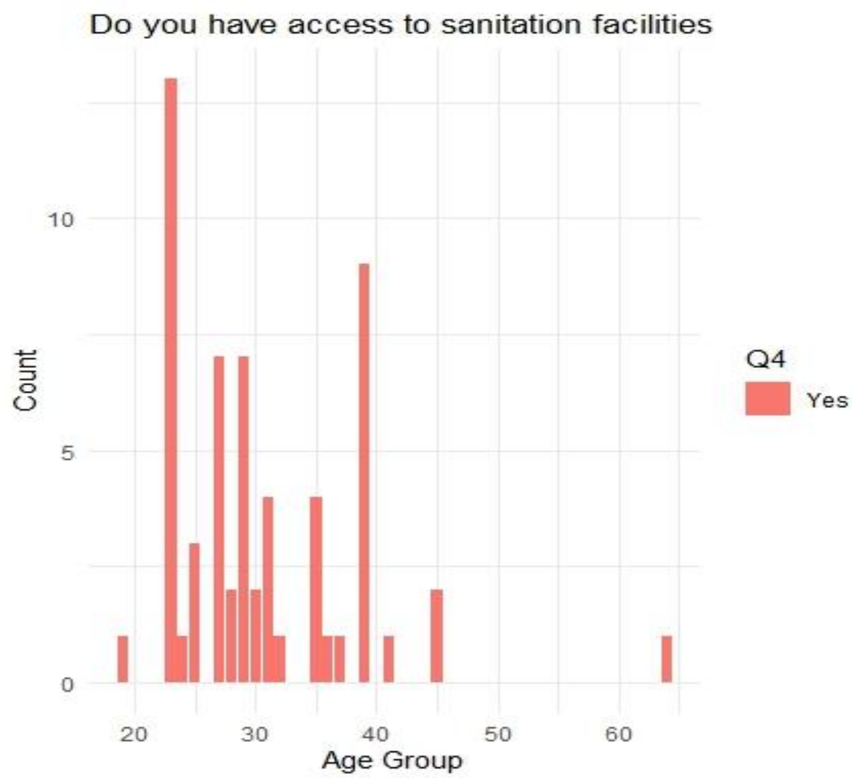

Figure 3.11 (i): Access to sanitation and hygiene facilities in the area

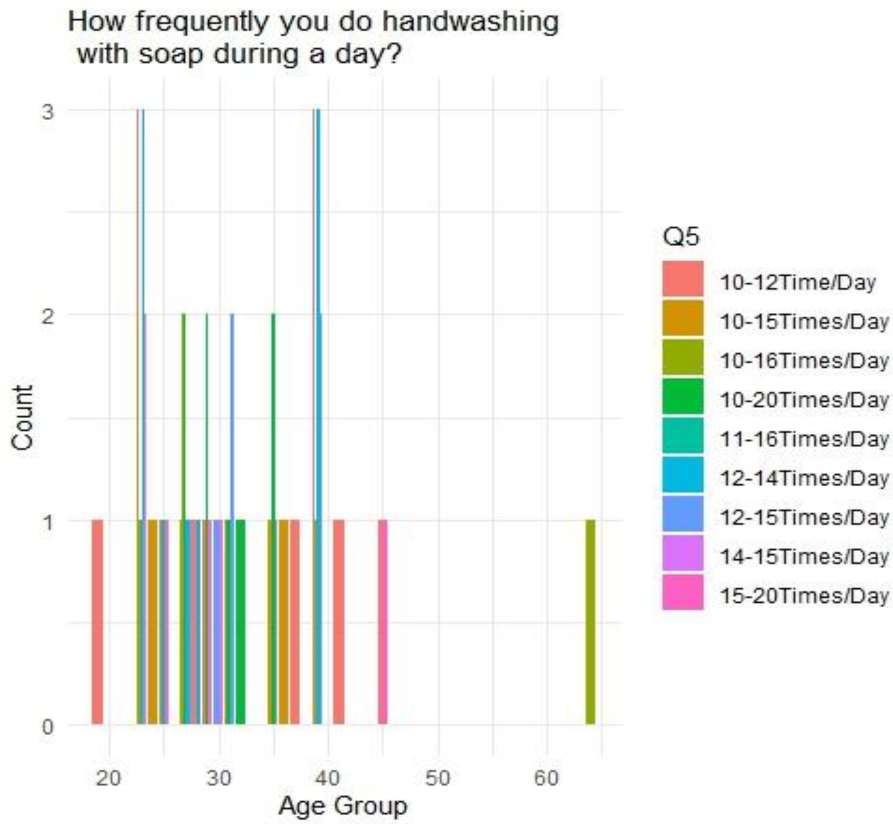

Figure 3.11 (j): The practice of handwashing in the area

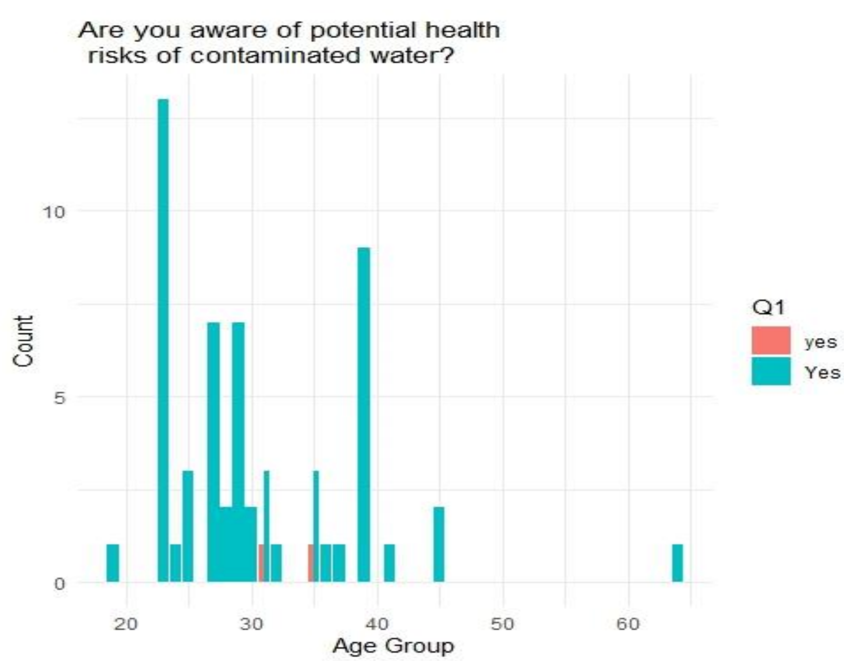

Figure 3.11 (k): Awareness regarding the potential health risks

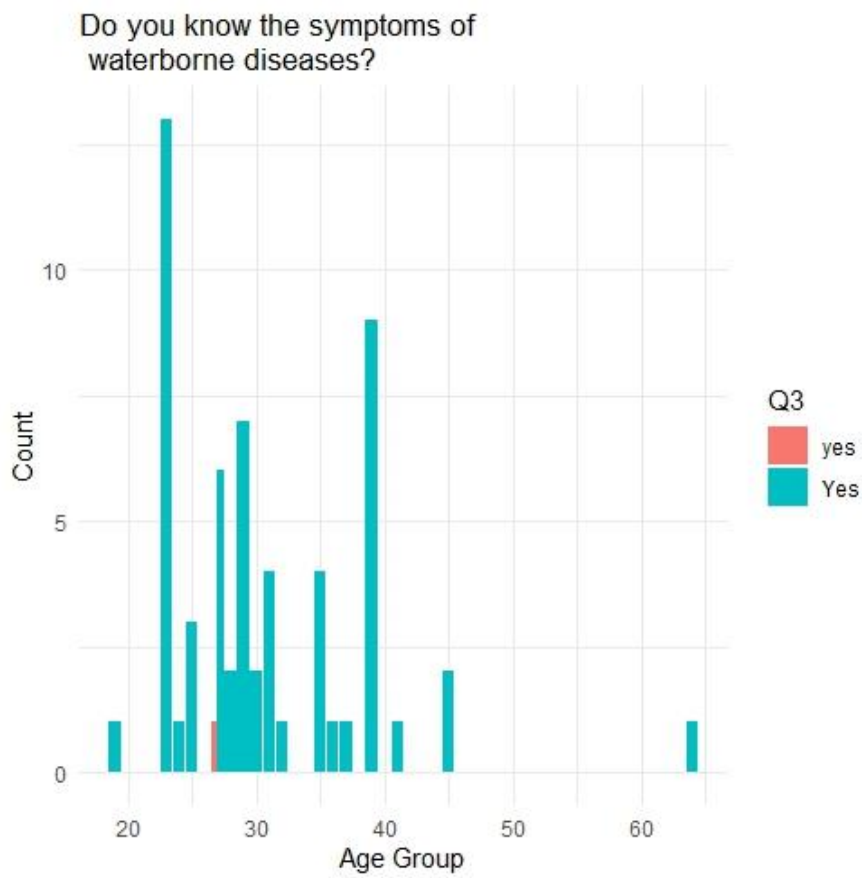

Figure 3.11 (l): Symptoms of waterborne diseases

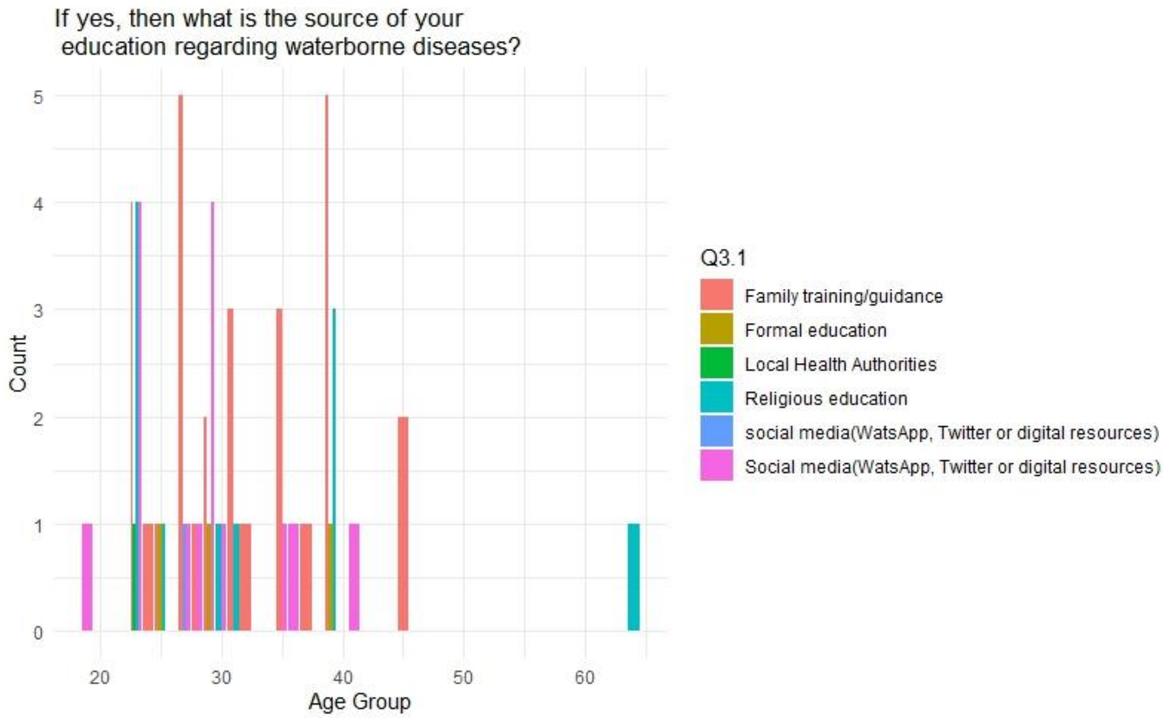

Figure 3.11 (m): Sources of information regarding the waterborne diseases

3.6 Effect of LULCC on water quality

Springs located near heavy traffic areas and roadsides are particularly vulnerable to pollution from waste dumping. The proximity to these areas increases the likelihood of pollutants such as oil spills, litter, and chemicals being washed into the spring waters during rainfall events or through runoff. Additionally, the disposal of solid waste directly into these water bodies exacerbates the contamination, as plastics, metals, and other debris can degrade water quality and harm aquatic life. The indiscriminate dumping of waste near these springs not only poses a threat to the environment but also jeopardizes the health of communities relying on these natural water sources (Hartmann, et al., 2021). Effective waste management practices, including proper disposal facilities, regular clean-up efforts, and community awareness campaigns, are essential for protecting the integrity of springs located near high-traffic areas and preventing further pollution of these valuable water resources. Contamination of natural springs waters by animal waste and improper human waste disposal poses significant risks to public health and environmental integrity (Zeng, et al., 2021). Animal waste, rich in pathogens and nutrients, can leach into groundwater sources and contaminate springs, leading to outbreaks of waterborne diseases and degradation of water quality. Similarly, improper disposal of human waste, whether through inadequate sanitation systems or sewage leaks, can introduce harmful bacteria, viruses, and chemical pollutants into spring waters, jeopardizing the safety of drinking water supplies and ecosystem health. Effective management practices, such as proper waste treatment and disposal, regular monitoring, and community education, are crucial for mitigating these risks and safeguarding the integrity of natural spring waters for present and future generations (Akhtar, et al., 2021)

The study also highlights the potential impact of land use changes on spring contamination. Rapid urbanization, agricultural expansion, and industrial development can alter land use patterns, leading to increased pollution and runoff into nearby water sources. Agricultural activities may introduce pesticides and fertilizers, while urbanization can result in sewage discharge and solid waste runoff. These pollutants can infiltrate the groundwater and contaminate springs, affecting water quality and posing risks to human health (Moldovan, et al., 2020). Understanding the relationship between land use changes and spring contamination is crucial for implementing effective management strategies to protect and preserve these vital water resources. The contamination of natural spring waters can occur due to various factors, including inadequate maintenance of water storage tanks, proximity to commercial areas, and adjacency to petrol pumps. Tanks used for storing water, if not cleaned regularly, can become breeding grounds for bacteria and other pathogens, leading to contamination of the stored water and potentially contaminating nearby springs when the water is released (Chauhan, et al., 2020). Commercial areas often generate high levels of pollution from human activities such as waste disposal. Waste from these areas can carry pollutants into nearby springs, compromising water quality and posing health risks to consumers.

Petrol pumps are sources of potential contamination due to leaks and spills of fuel and lubricants. The proximity of a spring to a petrol pump increases the likelihood of these contaminants infiltrating the groundwater and subsequently contaminating the spring water. Petroleum hydrocarbons and other toxic chemicals can seep into the groundwater, leading to pollution of the spring water and rendering it unsafe for consumption. Addressing these contamination sources requires proactive measures such as regular maintenance and cleaning of water storage tanks, implementing pollution control measures in commercial areas, and ensuring proper containment and management of hazardous materials at petrol pumps. Additionally, regular monitoring and testing of spring water quality are essential to identify contamination early and mitigate its impact on public health and the environment.

DISCUSSION

Spring water quality assessment of different areas in Muzaffarabad District was carried out by taking selected significant parameters, physical, chemical, biological, and heavy metals namely temperature, pH, Electrical conductivity, total dissolved solids (TDS), Turbidity, Carbonates, Nitrates, Sodium, Chlorides, alkalinity, hardness, and total bacteria, coliform count. Heavy metals including Pb, Cr, Cd, Fe, and Mn were also analyzed. All these parameters were analyzed as per the standard protocol of the WHO and Pak EPA guidelines in water.

In the bacterial analysis of water samples from 12 springs in Muzaffarabad District, concerning results were observed. Springs 1, 2, 3, 4, 5, and 6 exceeded the permissible limit for total bacterial growth (less than 500 CFU/ml), indicating poor water quality. Coliform presence was detected in multiple samples, including Springs 1, 2, 3, 4, 6, 7, 8, 9, 10, and 12, with Springs 3 and 6 showing the highest counts. Contamination of water with coliform and bacteria in some water sample sites justifies the occurrence of diseases like diarrhea, dysentery, typhoid, and other water-related diseases.

In the heavy metal analysis of water samples from 12 springs in District Muzaffarabad, it was found that while most springs had acceptable levels of iron, lead, chromium, and cadmium, some exceeded the recommended limits for manganese. Springs 5 and 9 consistently showed higher manganese levels, while other springs generally maintained within permissible limits. Notably, Spring 12 had elevated levels of chromium and manganese. These findings underscore the need for continued monitoring and management to ensure water quality standards are met across all springs in the district.

In the study conducted on the physical and chemical parameters of water samples from springs in Muzaffarabad District, several significant findings emerged. Most notably, the levels of salts and pH exceeded the recommended limits set by Pak EPA across most of the springs. This suggests potential contamination sources or geological factors contributing to elevated levels, with salts potentially accumulating from agricultural runoff or natural mineral deposits, and pH levels influenced by various factors such as soil composition, industrial discharges, or acid rain. However, other physical parameters including temperature, Total Dissolved Solids (TDS), Electrical Conductivity (EC), and Turbidity were all within permissible limits, reflecting natural variations in water quality influenced by seasonal changes and local environmental conditions. Additionally, chemical parameters such as chlorides, sodium, carbonates, NaCl, hardness, and alkalinity were all within acceptable ranges, suggesting minimal anthropogenic contamination and favorable geological characteristics of the area. Overall, these findings underscore the importance of ongoing monitoring and management efforts to mitigate potential contamination sources and ensure the maintenance of water quality standards in Muzaffarabad District's springs. According to a survey carried out in Muzaffarabad city, a significant number of customers still contract waterborne infections even when they boil their spring water before drinking it. However, most consumers find the physical look of spring water adequate and report no noticeable odor. Fortunately, no deaths have been reported, suggesting that locals are aware of the issue and have access to sanitary facilities, however the impact of heavy metal and bacterial contamination on public health is still a concern. Petrol pumps present a potential hazard to adjacent springs as a result of gasoline leaks and spills, hence requiring the implementation of proactive strategies such as maintenance, pollution control, and routine testing to guarantee the safety of water sources. The study emphasized that alterations in land use, such as the process of urbanization, the growth of agricultural activities, and the development of industries, have the potential to add to the contamination of springs using pollutants such as pesticides, wastewater, and discharges of solid waste (Khan, et al., 2019). The presence of contamination in spring water resources presents potential hazards to both water quality and human well-being, underscoring the significance of developing efficient management approaches to safeguard these natural resources. Springs close to high-traffic areas are susceptible to contamination caused by waste disposals, such as oil spills and debris. . Disposing of animal and human waste near springs presents notable contamination hazards, underscoring the significance of appropriate waste management, surveillance, and community awareness in safeguarding the integrity of natural spring water (Bhatti, et al., 2022).

Various researchers have examined spring water quality by analyzing different criteria such as physical, chemical, biological, and heavy metal characteristics. Seben, et al., 2022 examined the relationships among physical, chemical, and microbiological factors in spring water, emphasizing the connections between variables such as total alkalinity, turbidity, and total iron (Seben, et al., 2022). In their study conducted in 2023, Subba et al. examined the physical and chemical characteristics of springs in Sikkim, as well as the presence of harmful bacteria. They found that the springs had significant levels of pollution from bacteria such as *E. Coli* which showed resistance to antibiotics (Subba, et al., 2023). Similar to the present study, a study conducted by Ezea et al. in 2022, spring water in Igbo-Etiti, Nigeria was analyzed for physicochemical parameters, mineral components, pollution indicators, and risk assessment. The results revealed high concentrations of lead and cadmium (Ezea, et al., 2022). In addition, research conducted in the Moscow region analyzed the presence of main ions and trace elements in spring waters, revealing concentrations that are characteristic of groundwater found in temperate regions (Lipatnikova, et al., 2023).

Carreño, et al., 2023 also reported comparable results, demonstrating linear correlations between physical, chemical, and microbiological factors in samples of spring water. This highlights the influence of water-soil interactions on water quality (Carreño, et al., 2023). Similar to the present study which identified the presence of certain heavy metals in springs, a study conducted in Igbo-Etiti, Nigeria, discovered that although most physicochemical qualities adhered to established norms, the quantities of lead and cadmium beyond permissible levels, hence presenting potential health hazards (Seben, et al., 2022). Kothari, et al., 2023 discovered the presence of coliforms that are comparable to those identified in this study. In Buenavista de Cuéllar, Mexico, they evaluated fecal coliforms and non-carcinogenic health hazards in spring water. The assessment revealed moderate to high risks during various seasons (Kothari, et al., 2023).

Research conducted in Pakistan has evaluated the quality of spring water, namely in areas such as Gilgit Baltistan, Neelam, and Khyber-Pakhtunkhwa. A study conducted in

Gilgit Baltistan revealed that the combination of open stream water and spring water has resulted in a decline in water quality, resulting in unsuitable situations for drinking water (Shah, et al., 2023). Studies conducted in Neelam, a region in Northwestern Pakistan, have shown that spring water samples have prominent levels of TDS, and EC, rendering the water unsafe for consumption (Kumar, et al., 2023). Furthermore, a study conducted in KPK examined distinct physiochemical characteristics of water samples from diverse locations, highlighting the significance of implementing effective water treatment methods to guarantee the safety and purity of drinking water (Asif, 2022). These studies emphasize the importance of monitoring and assessing the quality of spring water in Pakistan to protect public health. In their study, Wang et al. (2021) also showed a correlation between LULCC, and water quality, which aligns with our findings. The research conducted by Wang et al., in 2021 and Ghanem et al., in 2019 examined the correlation between LULCC and several water quality metrics in diverse geographical areas. Wang et al. employed Redundancy Analysis (RDA) and Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the influence of LULC patterns on water quality in the sub-watersheds of the Danjiangkou Reservoir during both dry and rainy seasons (Wang, et al., 2021); (Ghanem, et al., 2019).

In line with the findings of the current study, a study conducted by Bratovcic & Petrinic in 2020 in Bosnia and Herzegovina revealed a significantly high pH value of 9.07 and elevated levels of salts such as sulfate (398.34 mg/L) in a sample of natural spring water. These findings render the water unsuitable for consumption due to the presence of ammonium ions, nitrite, and coliform bacteria (Bratovcic & Petrinic, 2020). These results highlight the influence of human activities on the quality of spring water, underlining the importance of strict monitoring and conservation efforts to protect these crucial water sources.

CONCLUSION

1. Biological analysis revealed widespread bacterial contamination in the natural springs, with elevated levels of total bacterial growth and the presence of coliforms, indicating potential health risks for consumers.
2. Physical and Chemical analysis highlighted elevated levels of salts and pH in the springs, exceeding recommended limits. These contaminants may originate from sources like agricultural runoff, industrial discharges, or natural geological factors. However, other physical and chemical parameters were within permissible limits.
3. Certain springs showed the presence of heavy metals, emphasizing the need for ongoing monitoring and mitigation efforts to prevent further contamination and protect public health.
4. Survey findings revealed that some people boil spring water before consumption and are not contracted any waterborne infections. Other than that, a number of people have waterborne infections due to contaminated water of the area. However, most consumers found the physical appearance of spring water satisfactory and reported no noticeable odor.
5. Factors contributing to spring contamination included land use changes and proximity to pollution sources such as petrol pumps, commercial areas, roads near the springs, and improper waste disposal. These findings underscore the importance of proactive management strategies to safeguard water quality and public health.

RECOMMENDATIONS

Based on our research conducted to assess the water quality of natural springs in Muzaffarabad District, the following recommendations are proposed to improve water quality management and ensure the safety of drinking water:

1. Implementing immediate remediation measures for Springs 1, 2, 3, 4, 5, and 6 with bacterial growth exceeding 500 CFU/ml to improve water quality.

2. To conduct regular monitoring and disinfection protocols for all springs to mitigate the risk of waterborne diseases like diarrhea, dysentery, and typhoid.

3. Focusing on reducing Mn levels in Springs 5, 9, and 12 to meet the recommended guidelines and prevent potential health risks associated with heavy metal contamination.

4. To investigate potential contamination sources contributing to elevated salt and pH levels in the springs, particularly from agricultural runoff or geological factors. Implement measures to control and regulate salt accumulation and pH levels to ensure water quality compliance.

5. Establishing a comprehensive monitoring program to regularly assess the physical, chemical, and biological parameters of the spring water to maintain quality standards.

6. To conduct periodic testing for salts, pH, heavy metals, bacteria, and other contaminants to track changes and address issues promptly.

7. There should be proper management of waste disposal near springs and open springs should have proper fencing around them.

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EFFECT OF LAND-USE PATTERNS ON WATER QUALITY CHARACTERISTICS OF SPRINGS AND RELATED HEALTH ISSUES IN CITY MUZAFFARABAD AZAD KASHMIR, PAKISTAN.

Waterborne Diseases Questionnaire

I am a student of MS (Environmental Sciences) at Bahria University Islamabad, and researching, the **"Effect of land-use patterns on water quality characteristics of springs and related health issues in city Muzaffarabad, Azad Kashmir"** for my degree requirements. This questionnaire is a tool for data collection. The objective of this questionnaire is to evaluate the prevalence of waterborne diseases/illnesses in drinking water sources in selected areas of Muzaffarabad. The findings will help with informed assessments and decision-making.

Demographic Profile of Respondents

Serial No	______________________ __	Occupation:	________________________ __
Gender:	Male/ Female/ Transgender	Nature of Job:	________________________ __
Age:	______________________ __	Family Members	________________________ __
Academic Qualification	______________________ __		

1. What is your source of drinking water in this area?
    - Spring Water
    - Tap Water
    - Hand Pump
    - River water
    - Tube well / Boring
    - Filtration plant
2. How you evaluate the Physical appearance of your drinking water?
    - Worst
    - Bad
    - Reasonable
    - Good
    - Excellent
3. Does water have any sort of odour in it?

- Yes
- No

4. Does water have any sort of taste in it?
    - Yes
    - No
5. Do you boil water before use?
    - Yes
    - No
6. Do you know the symptoms of common waterborne diseases?
    - Yes
    - No
7. Have you or any members of your household experienced any waterborne diseases in the past year? Such as diarrhea, cholera, typhoid, hepatitis A, hepatitis E.
    - Yes
    - No
8. If yes, please specify the type **(diarrhea, cholera, typhoid, hepatitis A, hepatitis E) and** the **number of** affected individuals.

___

9. Were there any deaths in your household due to such waterborne diseases? If yes, please provide details.

___

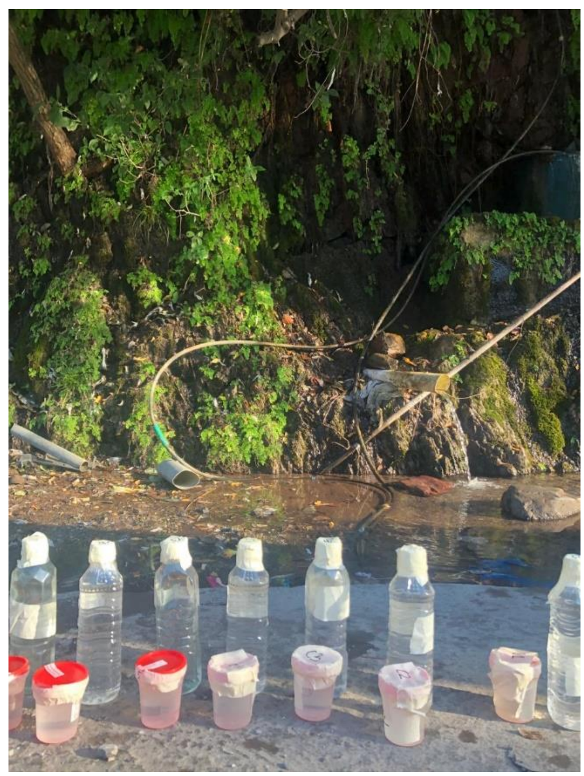
10. Do you have access to proper sanitation facilities such as toilets, handwashing stations, etc.?
    - Yes
    - No
11. How frequently do you practice handwashing with soap during a day?

    ____
12. Are you aware of the potential health risks associated with consuming contaminated water?
    - Yes
    - No
13. Have you received any health education or information regarding waterborne diseases?
    - Yes
    - No

14. If yes, then what is the source your education or information regarding waterborne diseases?
    - Local health Authorities
    - Formal education
    - Family training/guidance
    - Religious education
    - Mass media (Newspaper, Television, Radio)
    - Social media (WhatsApp, Twitter or related digital resources)

APPENDICES


VERTICAL LAMINAR FLOW CABINET
TECHNICO SCIENTIFIC SUPPLY



Coordinates of springs in Muzaffarabad

Spring#	Location	Coordinates
Spring 1	Chalpani	34 26 39 N 73 30 40 E
Spring 2	Chella	34 23 12 N 73 27 58 E
Spring 3	Chella masjid	34 23 14 N 73 27 55 E
Spring 4	Near Petrol pump	34 23 14 N 73 27 50 E
Spring 5	Dhani	34 18 39 N 73 32 16 E
Spring 6	Rashedabad	34 20 8 N 73 30 5 E
Spring 7	Domail	34 20 38N 73 29 7 E
Spring 8	Upper Domail	34 20 59 N 73 28 3 E
Spring 9	Garhi Habibullah road	34 19 7 N 73 28 35 E
Spring 10	Chatter class	34 12 6 N 73 30 3 E
Spring 11	Gojra	34 21 27 N 73 27 10 E
Spring 12	Abbottabad road	34 21 44 N 73 24 14 E