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Relationship of Drinking Water Quality with the Prevalence of Waterborne Diseases in Tehsil Haripur

ARSLAN ALI
The Department of Environmental Sciences, The University of Haripur, Pakistan.

ALIA NAZ
(Corresponding Paper)
The Department of Environmental Sciences, The University of Haripur, Pakistan.
Email: alianaz@uoh.edu.pk

SADIA ALAM
The Department of Microbiology, Haripur, Pakistan.

WISAL SHAH
The Department of Environmental Sciences, The University of Haripur, Pakistan.

MISBAH KHALIL
The Department of Microbiology, Haripur, Pakistan.

SALMA KHALID
Prime Institute of Public Health, Prime Foundation, Riphah International University, Islamabad.

AISHA BIBI
The Department of Microbiology, Haripur, Pakistan.

Abstract

This study investigates the relationship between drinking water quality and the prevalence of waterborne diseases in Tehsil Haripur, Pakistan. The physicochemical study of water samples from various sources revealed variances in parameters such as pH, turbidity, and bacterial contamination. Microbial investigation detected dangerous bacteria such as E. coli, Campylobacter, and Salmonella typhi in drinking water sources, with tap water having the highest bacterial concentration. Regression analysis revealed a substantial relationship between waterborne disease patients and bacterial counts, highlighting the importance of microbial contamination in disease transmission. The findings highlight the critical need for enhanced water quality management and infrastructure in the region to reduce health hazards and ensure safe drinking water for all populations. Targeted interventions and long-term water management techniques are critical for preserving public health and fostering community well-being. Water is necessary for all life on Earth, and access to safe water is critical for human health. However, there is a wide inequality in availability to clean water. Waterborne infections are a concern to people of all ages. The purpose of this study is to identify waterborne disease hotspots in Tehsil Haripur and establish relationships with drinking water quality. Waterborne disease data were sourced from the district health officer of Haripur district, enabling the identification of disease hotspots based on the number of affected individuals. Subsequently, drinking water samples were collected from these hotspots, encompassing various sources such as open wells, boreholes, tap water, and tube wells. Comprehensive physicochemical analysis, including parameters such as pH, Electric Conductivity (EC), turbidity, and chloride (Cl-), was conducted on the collected samples. Additionally, biological analysis utilizing standard microbiological methods provided further insights into water quality and potential health risks associated with the presence of pathogens. The pH value of well water was the highest among all drinking water sources. Additionally,

the highest EC value was observed in water samples collected from four studied sources in KTS. Similarly, well water samples collected from Mang had the highest turbidity, while those from Dingi had the highest chloride levels. Dominant bacteria in drinking water samples include E.coli, Shigella, Campylobacter, Salmonella typhi and Vibrio cholerae. A strong correlation between waterborne diseases and bacterial count in drinking water was observed (R2 values range 0.05-0.92). The study identified tap water as the most contaminated source among all studies drinking water sources. Therefore, it is recommended to use boiled water for drinking purposes.

Keywords: *Waterborne Diseases, Drinking Water Quality, Physicochemical Analysis, Microbial Contamination, Health Risks, Sustainable Practices.*

Introduction

Water is the most important natural resource, covering 71% of the Earth's surface (Khalid et al., 2018). However, only 3% is freshwater, and only 0.01% is accessible to humans. It is mostly stored in galleries, ice caps, and soil (Qasim et al., 2014). Despite this, 844 million people lack access to safe drinking water, and 6000 children die each day as a result of poor sanitation and quality (WHO, 2017). These diseases affect people of all ages around the world, but children under the age of five are most vulnerable (Brubacher et al., 2020).

Water, which is necessary for life, can harbor pathogens that cause serious sickness or even death when contaminated by bacteria, protozoa, or viruses (Ullah et al., 2014). Significant health concerns are posed by biological impurities, which can originate from sewage, industrialization, and wildlife waste. In developing nations, biological pollution is the primary cause of 80% of waterborne infections (WHO, 2017).Microbial contamination is a big worry when it comes to water quality and quantity in Pakistan, where 40% of deaths and 30% of diseases are waterborne (Azizullah et al., 2011). The nation has significant hurdles, particularly in rural areas, with 50 million people lacking access to safe drinking water and only 42 percent having access to sanitary facilities (Pakistan Economic Survey, 2008). These issues are particularly acute in Haripur, where contaminated water sources and inadequate sanitation lead to heighted disease risks, especially during the rainy season (Khan et al., 2016).

According to the World Health Organization (WHO) (2017), over 4 billion people worldwide suffer from diarrhea and other waterborne infections each year, with 760000 children dying in third-world nations. The availability of safe drinking water is a global concern, but third-world countries such as Pakistan are particularly vulnerable. Pakistan confronts threats to both water quality and quantity (Butt and Khair, 2016). According to Khwaja and Aslam's (2018) findings, patients with waterborne diseases such as dysentery, cholera, hepatitis, diarrhea, and typhoid occupy 40% of hospital beds in Pakistan. In Pakistan, waterborne infections include diarrhea (47%-59%), gastroenteritis (40%-50%), dysentery (28-35%), hepatitis A (32%-38%), and hepatitis B and hepatitis C (6-7%) (Khan et al., 2015). Similarly, it was found that Pakistan incurs a loss of 25-28 billion rupees yearly related to water related diseases, which accounts for 0.6-1.44% of the country’s GDP (Tahir et al., 2010). Over 660,120 cases of acute, diarrhea, skin infections, typhoid fever, malaria, and dengue fever have been reported in Pakistan after floods (Atif et al., 2024).

Pakistan Economic Survey (2008) revealed staggering numbers of 50 million people deprived of safe drinking water. Furthermore only 42% of people in the country are able to use sanitation services, which further breakdown into 65% of people in urban areas and 30% in rural areas. Numbers related to living conditions revealed that 30% of rural as well as urban people live in slums, with insufficient sanitation and sewage dumping facilities (Zahid, 2018).

According to annual estimates in Pakistan, waterborne diseases account for 30% of all illnesses recorded in hospitals and 40% of all deaths. Patients suffering from watery diseases such as dysentery, cholera, hepatitis, diarrhea, and typhoid account for up to 40% of hospital beds in Pakistan (Khwaja and Aslam, 2018). On a national basis, Pakistan loses 25-28 billion rupees every year, accounting for 0.6-1.44% of its GDP. This loss is associated to water-related disorders (Tahir et al. 2010). The majority of residents in Haripur utilize contaminated water for drinking and other uses (Khan et al., 2016). In addition, people in Haripur get water from open sources, and a rise in excreta during the rainy season contributes to water contamination, which in turn makes drinking water dangerous for a variety of illnesses (Ziad et al., 2016). As a result, the current study was done to identify hotspots of waterborne diseases in Tehsil Haripur and to analyze the drinking water quality of identified sites in the aforementioned area.

Material and Methods

Study Area Description

Tehsil Haripur, located in the Hazara Division of Khyber Pakhtunkhwa (KPK) Pakistan, has a population of approximately 1.01 million, as per the 2017 census. With a literacy rate of 72.21%, Haripur district boasts a well-educated populace. Within Tehsil Haripur itself, the population is estimated to be around 857,664 making it a significant urban center in the district (2017).

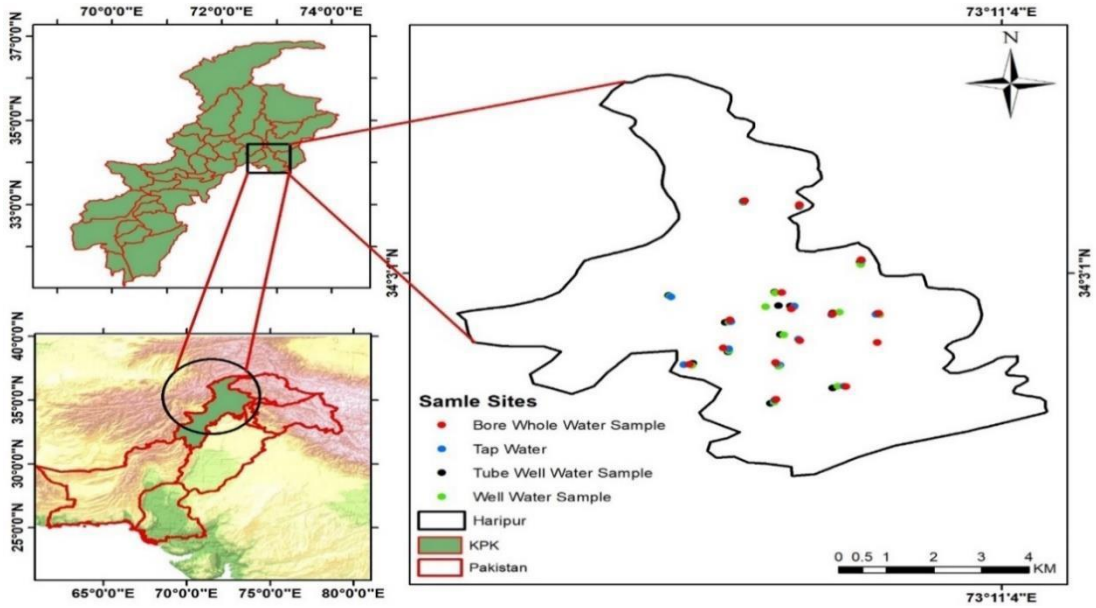

Figure 1: Study Area Map

Identification of Hotspots Yearly record of patient's data were collected from District Health Officer (DHO) to identify the major hotspots of waterborne diseases in Tehsil Haripur. Data comprised of "Age, Disease, Village, Town and City area were collected.

Collection of Drinking Water Samples

Total sixty four (64) number of drinking water samples was collected from different sources like open wells, tap water, tube wells and boreholes in clean, dried and UV sterilized polyethylene terephthalate (PET) bottles from identified hotspots in the study area.

Physio-chemical analysis of water samples

Physio-chemical parameters like pH, electrical conductivity and total dissolved solids were measured on spot with the help of portable pH meter (model HI 98129). And other physio-chemical and biological parameters like T.S.S, Alkalinity, Total Hardness, chloride and nitrate was done in lab.

Total Suspended Solids (TSS)

Drinking water sample of 100ml was filtered through paper. On an electronic digital balance, the filter paper was weighted before and after the filtrate were poured. Water samples were carried out according to the standard methods of APHA.

Total Hardness

Drinking water sample of 100 ml sample was taken in conical flask, added buffer solution and some drops of Eriochrome black T after that sample were titrated against standard (0.01M) EDTA waiting until color was changed from wine red to blue. EDTA volume was noted used in procedure.

Alkalinity

Drinking water sample of 100 ml was taken in conical flask, phenolphthalein drops were added as an indicator to check it, and all samples were absent P-alkalinity. Methyl Orange indicator drops were added for Bicarbonate alkalinity and titrated alongside H_2SO_4 until yellow color change to orange. Used quantity of H_2SO_4 were noted.

Chloride (Cl-)

Drinking water sample of 100 was taken in a beaker, some quantity of potassium dichromate indicator were added, titrate to $AgNO_3$ waiting black red color appear. $AgNO_3$ amount were noted from burette.

Nitrate

Drinking water sample 10 ml was into a beaker and add 50 ml 0.02 N $CuSO_4.H_2O$ solutions. Shake it for 15 minutes and filter through a filter paper. 3ml filtrate into a 50 ml conical flask and add 0.1% choromotropic acid solution, drop by drop and mix solution and 6ml concentrated H_2SO_4 and leave it for 45 mints yellow color appear then it was ready for run on spectrophotometer at 430-nm wavelength.

Turbidity

Drinking water sample of 100 ml was taken into a beaker and put this sample into turbidity meter and check turbidity level of sample water by naked eye.

Bacterial analysis of drinking water

For analysis of Escherichia coli, Salmonella, Shigella and Campylobacter following procedure were used.

Serial Dilution

Serial dilution was performed to estimate the concentration of bacterial cell in the water sample.

Culturing

Microbial suspension of 1 ml was added in 9 ml sterilized distilled water to get 10 fold serial diluted suspension of which 0.1 ml suspension were poured on the surface of nutrient agar plates using micro pipette. Petri plates were incubated at 37oC for 24 to 48 hrs. After incubation, the colonies were observed and counted using colony counter. For pure culture Eoisen methylene blue agar was used.

Identification: Gram Staining

Gram staining and biochemical test Catalyse, oxidase and indole were used for the identification of bacteria.

Data Analysis

Regression models were performed to find out relationship between waterborne diseases patients and bacterial count of drinking water sources.

Results and Discussion

Physicochemical characteristics of Drinking water of Tehsil Haripur

The analysis of drinking water samples from Tehsil Haripur, Pakistan, revealed various parameters critical for assessing water quality. The pH values ranged from 6.1 to 8.7, within the acceptable range of (6.5-8.5) according to WHO and Pakistan Water Quality Standards (WHO, 2008). However, water from wells in KTS exceeded this limit compared to other sources. Electrical Conductivity (EC) values varies from 247 µS/cm to 726 µS/cm, with the lowest recorded in the borehole of Sarai Nahmat Khan and the highest in the well water of Rehana. Total Dissolved Solids (TDS) ranged from 247 mg/l to 117 mg/l, meeting the WHO's permissible limit of 1000 mg/l. The highest TDS value (717 mg/l) was found in the borehole of KTS, while the lowest (247 mg/l) was found in tap water from Mirpur.

Turbidity, an indicator of water clarity, should not exceed 5 NTU according to WHO guidelines (WHO, 2004). Turbidity levels above 5 NTU are considered unsafe for drinking water, whereas 0.5 NTU is highly desirable to initiate disinfection. The highest turbidity value (15 NTU) was recorded in samples from tap water, well water and tube wells in Panian, Sarai Nahmat Khan and Mirpur respectively.

Alkalinity levels ranged from 66 mg/l to 219 mg/l, below the WHO's limit of 500 mg/l and Pakistan's limit of 700 mg/l. Total Hardness ranged from 120 mg/l to 347.1 mg/l, all within the WHO's permissible limit of 500 mg/l, with Kalinger recording the highest and Mirpur the lowest value. Chloride values ranged from 6.7 mg/l to 429 mg/l, with all values within the WHO's limit of 250 mg/l except for well water in Kalinger. Nitrate values ranged from 0.001 to 0.94 ppm, well below the WHO's limit of 10 ppm. The values of nitrate found in the drinking water collected from four sources of different hotspots of Tehsil Haripur highest values is 0.94 is at jab of tube well water source and lowest value is 0.001 is at tap water of Lora chowk. No source exceeded WHO parameters, indicating that the drinking water in Tehsil Haripur meets international standards for safety and quality.

Table 1: Physicochemical analysis of drinking water quality

Parameter	Unit	Min	Max	Mean ±SD	WHO
pH	-	6.1	8.7	7.58±0.11	6.5-8.5
EC	µs/cm	247	726	486.3±57.42	400
TDS	mg/l	247	717	360.67±57.09	1000
Turbidity	NTU	5	15	7.26±1.51	5
Alkalinity	mg/l	66	219	137.10±29.44	700
Hardness	mg/l	120	347.1	221.3±33.04	500
Chloride	mg/l	6.7	492	45.35±26.93	250
Nitrate	Ppm	0.04	0.93	0.15±0.15	10

Microbial Analysis

Waterborne diseases are a significant public health concern, with diarrhea, dysentery, and typhoid fever being the most prevalent in many areas. Data collection from hospitals reveals that diarrhea accounts for 48% of cases, followed by dysentery at 45%, and typhoid fever at 19%. Certain hotspots, such as Kot Najibullah, Sarai Nahmat Khan, and Mang have notably high disease prevalence, while areas like Khoi Nara, KTS and Mirpur experience lower rates.

Bacterial contamination of water sources plays a crucial role in the transmission of these diseases. Microbiological analysis of drinking water from various sources detects pathogenic bacteria such as E. coli, Campylobacter, Vibrio cholerae, Shigella, and Salmonella typhi. Notably, tap water samples exhibit the highest bacterial count, followed by well water, tube well water and borehole water. Tap water samples has Highest bacterial count having S.D Value (55.01) followed by well (44.31), Tube water (36.81) and borehole (7.03) respectively.

Regression analysis was conducted to explore the relationship between waterborne diseases and bacterial counts in different water sources. The results indicate a weak correlation (R2 0.81-0.92) is observed between waterborne diseases cases and bacterial counts in tap water.

Table.2: Prevalence of waterborne diseases in identified sites

S.NO	Locations	Diarrhea	Dysentery	Typhoid Fever
1	Kot Najibullah	1696	1336	163
2	Sarai Nahmat Khan	1002	976	85
3	Mang	592	750	60
4	Lora Chowk	576	495	39
5	Kalinger	550	536	14
6	Rehana	565	452	46
7	Beer	575	589	45
8	Jab	580	591	19
9	Panian	387	483	49
10	Dingi	578	472	20
11	Sarai Salah	573	419	18
12	Mirpur	318	234	13
13	KTS	318	234	13
14	Khoi Nara	103	200	24
	TOTAL	8413	7767	608

These findings underscore the importance of addressing bacterial contamination in water sources to mitigate the risk of waterborne diseases, particularly in area with high disease prevalence. Implementing

effective water treatment and sanitation measures is crucial to safeguard public health and reduce the burden of waterborne illness

Conclusion

This study highlighted the crucial connection in Tehsil Haripur between the frequency of waterborne illnesses and the quality of the drinking water. Diverse water sources showed variations in pH, turbidity, and bacterial contamination, even though the majority of physiochemical characteristics were within allowable bounds. Out of the four drinking water sources under study, tube well water is the most contaminated, with turbidity and pH levels exceeding WHO standards in certain regions. On the other hand, tap water had the highest bacterial counts, suggesting possible health hazards. The findings indicate the critical need for better water quality management and infrastructure in the region. Public awareness campaigns and preventive actions, such as boiling water before consumption, are critical for reducing the incidence of waterborne infections. Furthermore, investing in water treatment facilities and regularly monitoring water quality is critical to ensure that all residents have access to safe drinking water. Through the implementation of focused interventions and sustainable water management strategies, Tehsil Haripur can safeguard public health and enhance the welfare of its residents.

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