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AN EXTENSIVE WATER QUALITY ASSESSMENT OF POTABLE WATER COLLECTED FROM DOMESTIC AND COMMERCIAL LOCATIONS: A CASE STUDY OF LARKANA CITY, PAKISTAN

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Article Info

Abstract
This study assessed water quality in Larkana by analyzing various parameters. Samples from domestic and commercial sites were tested for color, odor, turbidity, temperature, pH, conductivity, TDS, hardness, Dissolved Oxygen, iron, alkalinity, and salinity. Results indicated that some samples met WHO and PCRWR standards, while others exceeded safe drinking limits. Tap water in U-1, U-2, and U-3 residential zones was deemed satisfactory, but further research on other pollution sources, including chemicals and microbiological agents, is essential. The study suggests a need for extended investigations, potentially involving human bodily fluids, to comprehensively evaluate water quality in Larkana..

Keywords: *Water Quality; Evaluation; PH; Drinking Water.*

Introduction

Water is crucial for the survival of all living organisms on Earth, accounting for 60% of an individual's total body weight. Human activities, such as waste disposal, have significantly impacted the quality of surface water, including direct waste discharge into streams and polluted surface runoff. Groundwater quality is also affected by waste disposal and land use. Improper waste disposal, such as storing waste materials in excavations, can lead to saturated water (Akhter, Ahmed, and Akhter 2021; Chinchmalatpure et al. 2019a).

Inappropriate dumping of waste items directly onto the ground surface, such as manure, sludge, rubbish, and industrial waste, can lead to water pollution. Fertilizers and pesticides have high levels of toxicity and mobility throughout the subsurface, causing substances to rapidly adhere to sediments with small particle sizes. The intrusion of nitrate, a byproduct of ammonia fertilizer, has negatively impacted groundwater in highly fertilized regions (Chinchmalatpure et al. 2019b). To improve water quality for human consumption and agriculture, accurate and reliable analytical data is essential. Analytical water quality criteria, such as pH, electrical conductivity (EC), turbidity, color, taste, and odor, are crucial for assessing water quality. Alkalinity, carbonate, calcium, and magnesium are key chemical factors that significantly contribute to soil texture changes. The hardness of water is mainly influenced by the presence of sodium, potassium, chloride, and total dissolved solids (TDS), with iron being a significant trace and ultra-trace element (Ilyas et al. 2017). Providing safe drinking water is a significant challenge, particularly in developing nations. The intake of filthy water has been found to cause significant health concerns, potentially contributing to high mortality rates in developing nations. Most cities worldwide rely on subterranean water sources for daily use, which becomes tainted by sewage. Around 800 million people worldwide lack access to a sufficient water supply, with a lack of filtration infrastructure resulting in polluted water usage by the population (Akhter et al. 2021; Fida et al. 2022).

Pakistan faces water pollution from two primary sources: point sources and nonpoint sources. The quality of water in the Indus Basin exhibits variability, with salinity absent close to recharge sources and rising with depth. The inadequate microbiological quality of drinking water is a significant concern, as no metropolitan water supply currently satisfies the World Health Organization's drinking water quality guidelines (Khalid et al. 2018). Factors contributing to this issue include the sporadic provision of water due to pipe leakage and the occurrence of cross-connections with adjacent sewer lines. The majority of individuals residing in the district rely on subterranean water sources for their drinking needs, except for several communities that have implemented water delivery systems using surface water for this purpose. Pollution in Pakistan varies, with a significant portion of the rural population relying on groundwater due to limited access to treatment and safe drinking water. Waterborne infections account for over 40% of fatalities in Pakistan. Further, the prevalence of diarrhea in Pakistan is attributed to the use of polluted water (Daud et al. 2017).

Urbanization and industry are significant contributors to contamination of surface and ground water. Water serves as a vector for the transmission of numerous pathogenic bacteria, viruses, and protozoa, and the consumption of contaminated drinking water is a significant contributor to the prevalence of waterborne diseases. Access to microbial-safe drinking water is a fundamental entitlement for individuals (Qadri and Faiq 2020).

In Pakistan, the primary sources of potable water supply are derived from groundwater and surface water bodies, encompassing rivers, lakes, and reservoirs Larkana, the fifteenth most populous city in Pakistan, is experiencing significant commercial and household growth, making it imperative to assess the quality of drinking water to ensure safe drinking water for the local population (Chandio et al. 2020).

2. Research Methodology

2.1 Collection of Water Samples

The experimental work i.e. water samples were collected, labeled, and preserved in Larkana city. Larkana is a city located in the Sindh province of Pakistan. It is the 15th largest city in the country with a population of 490,508 as per a 2017 population survey. The required parameters were tested in the laboratories of the Environment laboratory of Civil Engineering Department QUEST Campus Larkana, Water testing laboratory of the Chemistry Department of Sindh university Jamshoro and Water testing laboratory of US- Aid Project Jacoababad. Larkana city is the 15th largest city of Pakistan by population and is divided into 22 union councils. Water samples were collected randomly from the various sites carefully from the main population zones from each union council. Samples were collected in pre-sterilized of size one liter of each bottle. The bottles were washed with deionized water to remove dirty objects. After collecting water samples in bottles, they were labeled with white stickers marked with the simple code of each union council of the city. The labeled samples were preserved at room temperature to make the necessary preparation of testing. The physio-chemical water quality parameters were tested using standard sampling methods adopted by American Public Health Association (APHA) (Farooq Mustafa et al. 2016).

The water samples collected from this area in polyethylene bottle washed with deionized water. After collecting samples in the bottles, the white sticker was attached on it. A simple code of each union council such as U-1- U22 was marked on the container that indicated the water samples of the respective union council or area. Figure 1 and Table1 indicate the union council number and densest or famous area of that union council. The water samples were collected from these areas which are listed below:

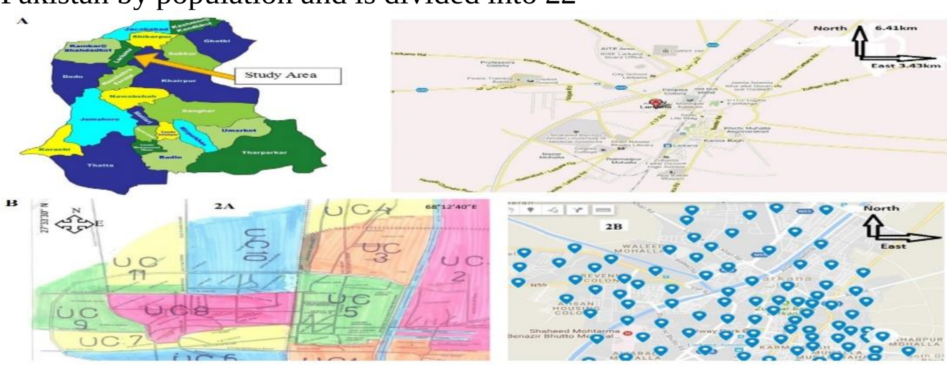

Figure 1. (A) Map of Sindh Province showing the Study Area of Larkana City (B) Unions Councils of Larkana City and Water Sampling Locations

3. Results and Discussions

Initially water samples were collected from the different sites of the Larkana and were checked for different parameters related to the quality of water in environmental laboratory of QUEST campus Larkana, US aid water testing laboratory Jacobabad and Chemistry department of Sindh University Jamshoro. Finally, the tested results were compared with the WHO/PCRWR standards.

3.1. Color

The color of water is determined by a device named Tintometer. The Color of water is measured in TCU where 1TCU (True Color Unit) is equivalent to color produced by 1 mg of platinum cobalt in 1l of distilled water. The colors of twenty two water samples were tested in US-AID water testing laboratory Jacobabad. The color of water samples was analyzed through sensory evolution test method. It was perceived from investigational results that all the samples were found to be colorless meaning no any type of colors were detected in any samples. Furthermore all samples superlative fit on the World Health Organization and Pakistan Council of Research in Water Resources standards.

3.2 Taste

Tastes of 22 samples were examined with at the US-AID water testing laboratory Jacobabad. The experimental results reveal that all the samples were found to be tasteless means no type of taste was detected in any samples. Further, all samples best fit the World Health Organization (WHO) and Pakistan Council of Research in Water Resources (PCRWR) standards.

3.3 Odor

Odor in water usually implies the existence of hydrogen sulfide in the water supplies since it dissolves various types of metals and can produce black stains on the material (Khattab, Abdelrahman & Rehan 2020). Odor of 22 samples was analyzed at the US-AID water testing laboratory Jacobabad with an olfactometer. It was detected from experimental results that all the samples were odorless means no any kind of odor was noticed in any samples. Furthermore, all samples best fit on the World Health Organization (WHO) and Pakistan Council of Research in Water Resources (PCRWR) standards. Table No.1 Measured Parameters in Water Samples

3.4 Temperature

Temperature of water measures the degree of hotness and coldness. The temperature of the samples was analyzed at the time of collection and during the testing. The temperature of water was measured with a digital thermometer of model TP101. It was found that the temperature of all the samples was normal and within the standards of WHO and Pakistan Council of Research in Water Resources (PCRWR) standards. It was detected from the results that the average measured temperatures of all the samples were observed around 26^0C.

3.5 pH

The pH is a quantitative measure of the acidity or basicity of aqueous or other liquid solution. If the pH value is less than 7 the water is acidic and if PH is more than 7 the water is alkaline (Abril et al. 2015). The pH of all water samples was measured with a digital pH meter AS218 at QUEST campus Larkana. It was observed from the experimental results that the highest value of pH was recorded in the samples of U-1, U-9, U-10 and U-12 of about 7.9 while the lowest was observed in the sample of U-20 of about 7.5. It was analyzed from the testing results that all the samples are within the safe limits of 6.5-8.5 set by WHO and Pakistan Council of Research in Water Resources (PCRWR). Table 1 and Figure 2 indicate the testing results of pH of all samples.

3.6 Electrical Conductivity

The electrical conductivity of water samples is measured with a digital conductivity meter.

Initially10 ml volume of every sample is taken.
The electrode of the conductivity meter was

Sample ID	SITE FOR SAMPLE	pH	E.C (us/cm)	TDS (mg/l)	Total Hardness (mg/l)	Ca Hardness (mg/l)	Mg Hardness (mg/l)	Ca Ions (mg/l)	Mg Ions (mg/l)	Total Alkalinity (mg/l)	Salinity (%)	D.O (mg/l)	Iron (mg/l)	Turbidity (NTU)
U-1	WAPDA Colony	7.9	678	434	200	72	128	28.8	30.72	225.3	1.3	7.81	0.04	0.68
U-2	QUEST Hostel	7.6	907	580	290	68	132	46.4	41.76	156.7	1.1	7.91	0.09	0.6
U-3	Shehbaz Colony	7.6	907	581	270	80	190	32	45.6	135	0.8	8.3	0.25	0.38
U-4	Nazar Area	7.7	1750	1120	630	204	426	81.6	102.24	283.2	0.4	8	0.075	0.56
U-5	RehmatPur	7.8	1641	1081	450	175	275	64	70	167.3	0.7	7.69	0.104	4.21
U-6	Bhais Colony	7.7	2016	1385	750	256	496	102.4	119.04	172.5	1.7	6.99	0.22	0.85
U-7	Mumtaz Colony	7.7	1987	1272	610	200	410	80	98.4	177.1	1	8.1	0.079	0.85
U-8	Lahori Area	7.8	1826	1168	600	196	404	78.4	96.96	134.7	0.9	8.2	0.12	5.3
U-9	Peoples Colony	7.9	1296	829	330	108	222	43.2	53.28	267.8	0.6	8.33	0.089	0.91
U-10	Luhur Colony	7.9	1405	902	500	148	352	59.2	84.48	146.3	1.9	7.82	0.077	2.35
U-11	SiddiqueColony	7.8	1405	899	490	144	346	57.6	83.04	176.9	2.1	7.95	0.109	2.43
U-12	Shah Baharo	7.9	435	278	200	80	120	13.2	28.8	233.6	0.4	7.65	0.091	0.71
U-13	ShewaMandi	7.8	906	580	310	76	234	30.4	56.16	145	1.63	8.24	0.23	0.54
U-14	Fish Market	7.8	647	414	300	116	247	46.4	66.24	162.4	0.3	8.35	0.104	0.53
U-15	Ali Gohar Abad	7.7	1420	909	570	132	438	52	105.12	268.2	2.1	6.95	0.064	0.43
U-16	Murad Wahn	7.7	1278	818	510	160	350	64	84	188.1	1.72	8.03	0.045	0.6
U-17	Dari Muhalla	7.6	1114	713	400	120	280	48	67.2	145.7	0.8	6.87	0.103	0.6
U-18	QUEST	7.7	772	558	390	80	120	32	28.8	261.5	0.9	7.83	0.21	0.62
U-19	Karmabad	7.6	1554	1001	500	160	340	64	81.6	154.1	1.59	7.93	0.079	0.87
U-20	Khaliq colony	7.5	1721	1101	590	108	482	43.2	115.68	186.3	1.4	7.87	0.069	0.54
U-21	Shaikh Zaid	7.6	847	542	380	79	220	32	52.8	157.1	1.6	6.54	0.051	0.55
U-22	Allahabad	7.7	1102	645	399	70	544	46.4	130.56	189.3	2.2	7.93	0.063	0.64

dipped into the beaker and kept that electrode in the beaker for 30 and measured values were noted. This test was performed in the laboratory of US-AID water testing laboratory Jocababad.

It was observed from the experimental results that the highest value of electrical conductivity was recorded in the samples of U-15 of about 1420 while the lowest was observed in the sample of U-12 of about 435. It was analyzed from the testing results that some samples are within the safe limits of 30-1500(us/cm**)** set by WHO and Pakistan Council of Research in Water Resources (PCRWR) and some samples i.e. U-4, U-5, U-6, U-7, U-8, U-19 and U-20 exceed the safe limits. If the water has high electrical conductivity or an unbalanced ionic composition, aquatic creatures may be unable to get the essential nutrients and ions needed to survive, which negatively impacts biodiversity and habitat integrity. With their high electrical conductivity, U-4, U-5, U-6, U-7, U-8, U-19, and U-20 samples may pose health risks and environmental impacts. It can cause dehydration, heart problems as well as disturb reproductive ability in fish making it dangerous for them to inhabit their native waters. Furthermore drinking insufficient salty water tasting may discourage consumption which will lead to further dehydration. This calls for improved farming systems that minimize salt leaching from fields as well as better wastewater management contributing towards pollution reduction. The measured electrical conductivity of water samples is given in Figure 2 and Table 1.

3.7 Total dissolved Solids (TDS)

Total dissolved solids mean the amount of material disbanded in water. The Chemistry Department of Sindh University Jamshoro conducted TDS analysis on water samples using a calibrated conductivity/TDS meter. The process involved immersing the electrode in a beaker, adjusting the scale, and iterating for each sample. It was observed from the outcomes that the highest value of total dissolved solids was recorded in the samples of U-10 and U-15 of about 909 while the lowest was observed in the sample of U-12 of about 278. It was analyzed from the testing results that some samples are within the safe limits of <1000 mg/lit set by WHO and Pakistan Council of Research in Water Resources (PCRWR) and some samples i.e. U-4, U-5, U-6, U-7, U-8, U-19 and U-20 exceed the safe limits. Excessive level of total dissolved solids (TDS) in drinking water in mentioned specimens has serious impacts on individuals' health households or communities at large. Higher rates of TDS can provoke gastrointestinal distresses like kidney stones as well as urinary tract infections. Heavy metals and salts are some of the pollutants which worsen these conditions even more and result into cardio vascular diseases besides neurologically defective disorders or chronic illnesses. Such effects strain healthcare facilities thus increasing the cost burden on societies due to increased expenditure on care giving services provided during such times. The measured total dissolved solids of water samples are given in Figure 2 and the Table 1

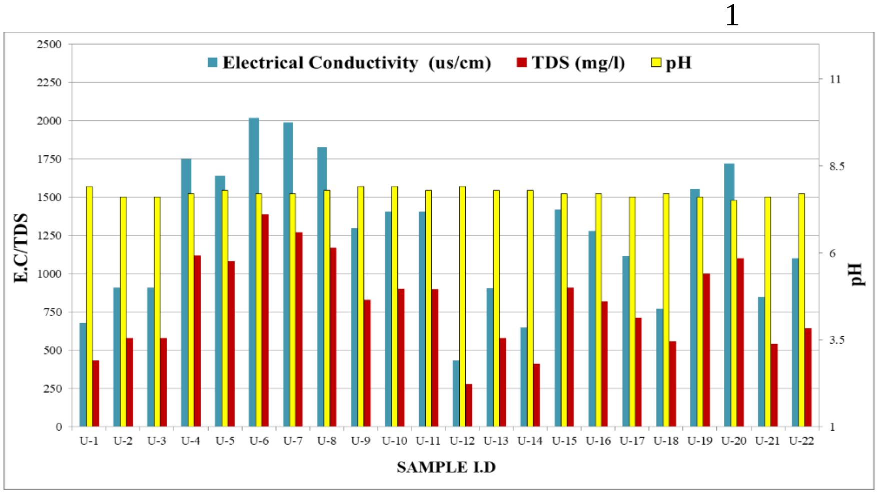

Figure 2.Electrical. Conductivity, TDS and pH Measured Levels of Water Samples

3.8 Total Hardness

The primary contributors to the hardness of natural water include carbonates, bicarbonates, sulfates, calcium, chlorides, and magnesium. The property of hardness often signifies the presence of calcium and magnesium ions in a solution (Silva et al. 2019). The total hardness of all the samples was checked in the chemistry department of Sindh University Jamshoro by titration method. It was analyzed from the calculated results that the highest value of hardness was recorded in the samples of U-10 and U-19 of about 500 while the lowest was observed in the sample of U-1, U-12 of about 200. It was examined from the results that some samples are within the safe limits of <500 mg/lit set by WHO and Pakistan Council of Research in Water Resources (PCRWR). Further, results indicated that specific water samples including U-4 ,U-6, U-7,U-8,U-15,U-16 and U-20 were above safe levels set by WHO (World Health Organization) and PCRWR (Pakistan Council of Research in Water Resources). In communities, this problem can cause such diseases as scaling in pipes and appliances, decreased flow rates among others which lead to unpleasant smell and taste. High hardness level in drinking water or cooking can result in kidney stones formation urinary tract infections skin irritations or worsening effects on conditions like eczema or psoriasis. On top of this yet is the fact that repairing damaged appliances/fixtures and plumbing systems may cost a fortune. The measured hardness of water samples is given in Figure 3 and in the Table 1.

3.9 Calcium Hardness

Water described as ‘‘hard’’ is high in dissolved minerals, specifically calcium and magnesium Hard water is the biggest health risk (*Hardness in Drinking-Water, Its Sources, Its Effects on Humans and Its Household Treatment* 2018). The test was conducted in the Chemistry Department of Sindh University Jamshoro. It was observed from the experimental results that the highest value of calcium hardness was recorded in the samples of U-3, U-12 and U-18 at about 80 while the lowest was observed in the sample of U-2 at about 68. It was analyzed from the testing results that some samples are within the safe limits of <100 mg/lit set by WHO and Pakistan Council of Research in Water Resources (PCRWR) and some samples i.e. U-4, U-5, U-6, U-7, U-8, U-9, U-10, U-11, U-14, U-15, U-16, U-17, U-19, and U-20 exceed the safe limits. Going beyond safe levels for calcium hardness observed in said samples could have negative effects on human health. High level of calcium hardness in water can cause skin irritation including dryness also increase severity other skin condition such as eczema or psoriasis. In addition, scaling inside pipes and appliances reduces flow rates with low efficiency impacts daily routines such as bathing cooking cleaning etc. The presence of scales in water heaters or boilers reduces energy efficiency hence increasing utility bills. These health issues and practical matters stress the need to talk about levels of calcium hardness within our waters so that individuals and families live comfortably. The measured hardness of water samples is given in Figure 3 and Table 1

3.10 Magnesium Hardness

It was observed from the calculated results that the highest value of magnesium hardness was recorded in the samples of U-2 at about 132 while the lowest was observed in the samples of U-12 and U-18 at about 120. The magnesium hardness in samples U-3 to U-20 (except U-12 and U-18) is high enough to cause some gastrointestinal difficulties, formation of renal calculus, and urinary tract infections. The unpleasant taste associated with excessive levels of magnesium may hinder sufficient consumption of water for dehydration. Monitoring and management of the magnesium hardness in drinking water are fundamental in order to prevent such health problems as well as ensure people’s wellbeing. Efficient water treatment methods and public awareness programs can minimize the negative impacts brought about by increased levels of magnesium hardness hence safe community drinking water. The measured hardness of water samples is given in Figure 3 and Table 1. The magnesium hardness of the samples was calculated from the following equation:

Total Hardness (H) = Calcium H + Magnesium H

3.11 Calcium Ions

It was detected from the experimental results that the highest value of calcium ions was recorded in the samples of U-5, U-16, and U-19 of about 64 while the lowest was observed in the sample of U-12 of about 13.2. The outcomes reveal that specimens U-1 to 3, U-5, and U-9 to 22 are within the permissible limits while samples U-4, U-6, U-7, and U-8 exceed the recommended limits. Excessive calcium ions in said samples have negative impacts on human health. Drinking water that has a higher calcium content increases the risk for developing kidney stones, causes digestive system discomfort as well as urinary track issues. Besides, prolonged exposure to high levels of calcium might worsen conditions like hypertension or heart diseases known to affect the heart and other major blood vessels. Consequently, it becomes crucial to address and abate risks related to excessive Ca^{2+} concentration in drinking water so as to ensure safety of human life and sound health. The investigational test was carried out in the Chemistry Department of Sindh University Jamshoro. The measured calcium ions of water samples are tabulated in Table 1 & and Figure 3.

3.12 Magnesium Ions

The magnesium ions test was performed in the Chemistry department of Sindh University Jamshoro. The measured values show that the highest value of magnesium ions was recorded in the samples of U-1 at about 30.72 while the lowest was observed in the samples of U-12 and U-18 at about 28.8. Magnesium ion levels are high in samples U-2 to U-20 except U-12 and U-18, indicating possible health risks for human beings. Magnesium is usually present in drinking water, which when taken excessively can disrupt the body's electrolyte balance leading to gastrointestinal disorders such as stomach pain, queasiness and loose bowel movements. Prolonged contact may contribute to stone formation in the kidneys and susceptibility to urinary tract infections. Another problem is that people may not drink enough water if it tastes awful because of high magnesium content thereby worsening the dehydration-related health problems. To solve these issues requires vigilance about water safety and public health protection measures. The measured magnesium ions of the samples are presented in Table 1 and Figure 3.

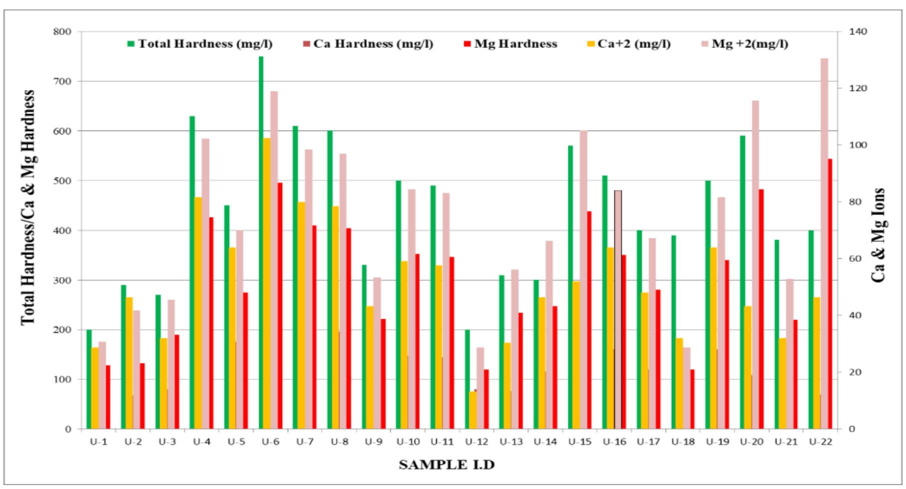

Figure 3. Total Hardness, Calcium Hardness/Magnesium Hardness & Calcium/ Magnesium Ions in Water Samples

3.13 Total Alkalinity

Total alkalinity in water samples was measured by chemical titration method in the Chemistry Department at Sindh University Jamshoro. It was observed from the experimental results that the highest value of total alkalinity was recorded in the samples of U-15 of about 268.2 while the lowest was observed in the sample of U-8 of about 134.7. It was analyzed from the testing results that all samples are within the safe limits of <300 mg/lit set by WHO and Pakistan Council of Research in Water Resources (PCRWR) and some samples i.e. U-9, U-12, and U-18 exceed the safe limits. Water with a great amount of alkalinity causes regular pH imbalances that can irritate both digestive system and skin when used for bathing purposes. Furthermore, excessive amounts of alkali may hinder normal body pH regulation processes resulting in metabolic disordering. Persistent exposure to increased levels of alkalinity through drinking water could increase prevalence rates for urinary tract diseases especially kidney stones as well. In order to address these concerns effectively, alkalinity should be returned back within safe limits by application of appropriate treatment steps towards safeguarding public health. The measured total alkalinity of water samples is given in Figure 4 & Table 1.

3.14 Salinity

The Chemistry Department at Sindh University Jamshoro tested water samples for salinity using a salinometer. Results showed the highest salinity in U-22 samples at 2.2, while the lowest in U-14 samples at 0.3. Some samples were within WHO and PCRWR allowable standards. Samples U-11 and U-15 have high salt content, which can lead to health problems such as dehydration, imbalance of electrolyte, and possible kidney complications. Having high salinity makes it difficult for people to consume water hence worsening dehydration levels. Prolonged exposure to such conditions worsens cardiovascular condition as well as other existing health issues. To mitigate these risks, there is need to lower the salinity of drinking water availability. Table 1 and Figure 4 display the measured salinity.

3.15 Dissolved Oxygen

Dissolved oxygen is the amount of oxygen present in water. The results indicated that the highest value of DO was recorded in the samples of U-4 and U-13 at about 8.2mg/l while the lowest was observed in the sample of U-7 at about 3.1mg/l. Further, testing results show that some samples are within the safe limits of <8.2 mg/l of WHO and PCRWR and samples U-3, U-9 and U-14 exceed the safe limits. As evidenced by the elevated amounts of dissolved oxygen (DO) in U-3, U-9, and U-14, the water's quality may present some indirect health problems. This suggests that there may be reason to worry regarding the water resources being dangerous to drink. High DO levels could point out the presence of organic material in excess which could contribute to growth of waterborne bacteria and viruses. These diseases can easily break out leading to deadly situations such as diarrhea, gastrointestinal infections or other severe conditions among immuno-suppressed individuals because they are pathogenic; and finally excess amounts of dissolved oxygen serves as a source of food for infectious agents like bacteria that cause cholera and viruses. Also, algal blooms may disrupt ecosystems if DO levels rise excessively, leading to release of algal toxin by certain species. Drinking water contaminated with these toxins over long periods is associated with several health problems including liver damage, neurological disorders and respiratory complications.

Therefore, even while high DO levels may not immediately cause negative health consequences, they are important early markers of possible problems with water quality. In order to address these issues, proactive steps must be taken to reduce hazards and maintain. The measured DO of water samples are given in Table 1 and Figure 4.

3.16 Iron

The iron content in water was tested using a Colorimetric test kit. The highest iron value was recorded in the U-8 samples, while the lowest was in the U-1 samples. The iron content of samples U-3, U-7, U-13 and U-18 exceeded the WHO and PCRWR set limits which raised concerns about gastrointestinal disturbances and possible organ damage. Chronic intake enhances vulnerability to ill health including certain cancers, cardiovascular pathologies and diabetes due to increased oxidative stress. Robust water treatment technologies, maintaining infrastructure soundness and creating public awareness on water quality are necessary measures to ameliorate these dangers and ensure supply of safe drinking water. The results are presented in Table 1 and Figure 4.

3.17 Turbidity:

Turbidity is the cloudiness or haziness of a fluid caused by large number of particles that are generally invisible to naked eye (Amin et al. 2022). The experimental results of turbidity of different water samples are listed in Table 1 and Figure 4. It was noticed from the results that the highest value of turbidity was recorded in the sample of U-5 OF 4.21NTU while the lowest was observed in the sample of U-3 of 0.38NTU. Moreover, it was analyzed that turbidity in all the tested samples was laid in the safe limit of WHO and Pakistan Council of Research in Water Resources (PCRWR) standards except U-8 which crossed the standards limit.

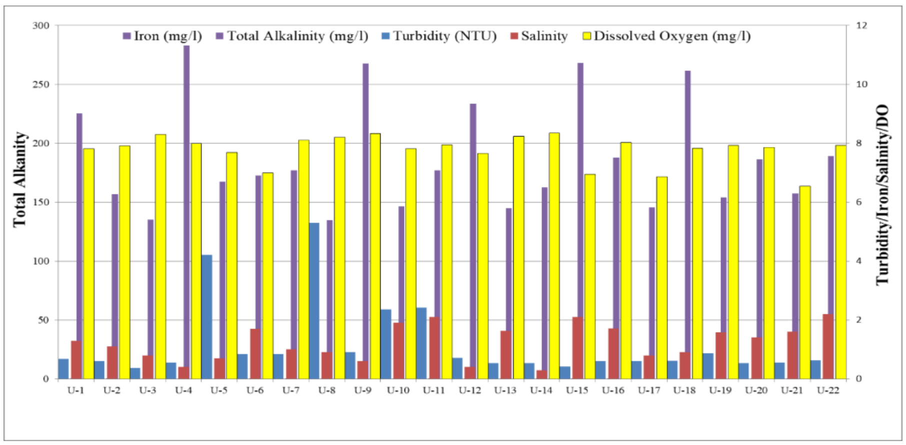

Figure 3. Measured Turbidity/Total Alkalinity/Salinity/Dissolved Oxygen in Water samples

3.18 Comparison with WHO and PCRWR Standards

Water samples were collected from Larkana and tested for various physical and chemical parameters to determine whether the water is safe for human consumption to monitor the quality and creation of drinking water for the protection of public health, these parameters should be compared with the stringent criteria established by WHO-PCRWR This will focus on samples such as U-6, U-8, U-20, U-22 which exceeded both WHO and PCRWR maximum levels. Conversely, samples U-1, U-2, U-3, U-4, U5, U7, U9, U10, and 11 complied with prescribed limits hence making them useful for drinking.

The consequences of crossing safe limits is multiple and deep. First there is an immediate danger to public health where elevated levels of contaminants ranging from microbial pathogens to heavy metals can cause a range of waterborne diseases. In particular children; old people; immune compromised persons etc. are susceptible to this kind of situations

Beside these critical health issues, there are economic costs that are related to spending on healthcare as well as the loss of productivity due to water borne ailments. Likewise, environmental consequences result from polluted water sources which threaten aquatic life, harm bio-diversity and compromise living standards for both man and animals.

Policymakers, stakeholders in policy making and ordinary people must be enlightened about the significance of this problem through a deeper analysis and discussion of its implications. Such consultations can encourage measures that are proactive aimed at solving the root causes of contamination like strengthening of water treatment infrastructures, regulating industrial and agricultural activities or advocating for community-based interventions. Moreover, public enlightenment campaigns and civil society mobilization programs play an instrumental role towards influencing behavioral change necessary for ensuring equitable access to drinking water worldwide. Thus, a comprehensive examination and discussion concerning the impacts of exceeding safe drinking levels is essential for protecting public safety, maintaining environmental sustainability and promoting community welfare.

In conclusion, the analysis of water samples from Larkana city highlights the importance of careful monitoring and strict adherence to water quality standards in order to protect public health. The detection of samples greater than WHO and PCRWR thresholds emphasizes the need for effective interventions to improve water quality and guarantee the welfare of people.

4. Conclusion

In this study, various water quality parameters such as color, odor, turbidity, temperature, pH, electrical conductivity, total dissolved solids (TDS), calcium hardness, magnesium hardness, total hardness, calcium ions, magnesium ions, dissolved oxygen (DO), iron (Fe), alkalinity, and salinity were assessed in samples collected from various domestic and commercial sites in Larkana. It was determined that samples U-1, U-2, U-3, U-4, U-5, U-7, U-9, U-10, and U-11 met the recommended limits set by WHO and PCRWR. However, samples U-6, U-8, U-20, and U-22 were found to be unsuitable for drinking purposes as they exceeded the safe limits established by international and local standards. The study revealed that tap drinking water quality in residential areas of U-1, U-2, and U-3 was safe. Nonetheless, it is essential to conduct further investigations over an extended period to assess overall water quality, including potential contaminants such as chemicals, microbes, and radiological materials.

5. Future Recommendations

Many suggestions for the Larkana City water should be taken into account as a study has indicated. Such a move would mean many more local locations are covered hence the trends in that area will be easily understood as well as sources of pollution identified. A long-term approach towards monitoring water quality changes can highlight seasonal variations and human activities. The integration of microbiological analysis could assist in estimating potential dangers linked to waterborne diseases. Consequently, effective management of water supply is an essential aspect of community involvement whereas real time data acquisition through remote sensing and GIS has been suggested by technological innovations. It also calls for evidence based decision making process and strong legislation framework to prioritize public health, and clean drinking water. Capacity building and dissemination of knowledge are necessary ingredients of proactive culture in Water Quality Management

Declarations

Conflict of Interest

The authors do not have any conflict of interest

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Data Availability

No third party data was used. All data is included within the text of this manuscript.

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