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Mini Review

Mini Review on Monitoring of Drinking Water Quality in Karachi's Rural Areas

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Abstract. Due to population crisis and use of increasing number of artificial and un-natural components in our daily lives as well as in industry might result in toxic waste discharged leading to poor water quality. This in turn destroys lives and might end up in our rivers, therefore leading to monitoring water quality in the 21st century becoming more difficult. As per UN Sustainable Developments Goals (SDG) 6.3, the 2030 agenda includes a dedicated goal on water and sanitation that sets out to ensure availability for safe and clean drinking water for everyone and appropriate methods to improve water quality. It is shown in the paper to what measures and steps can be taken in order to avoid unhealthy water for drinking and domestic use. Further, an attempt has been made to present a summary of the ambient water quality of Gulistan e Johar, Karachi. Monitoring water quality aims to gather quantitative data on the physical, chemical and biological properties of water by statistical sampling. An evaluation and analyzation of Karachi Water and Sewerage Board (KWSB) water with World Health Organization (WHO) standards is shown to conclude if it is safe for drinking purposes and consumption. This paper possesses water treatment methods along with its research problem. It further aims to review and propose for implementation of water quality objectives to ensure safe and clean drinking water. In the last section, a recommendation has been given to KW&SB for what steps should be taken to make the water safe for drinking purpose.

Keywords: microbiological and physiochemical properties, water quality, *E-coli*

Introduction

Water is a basic necessity of survival for all living beings. On average 5 L of water is consumed by every person falling which the human health is compromised. In 2021, world population was around 7.7 billion which makes water consumption upto 10 billion liters of water every day for humanity (Counts, 2022). This itself speaks of the importance of water and its consumption in our lives. To ensure safe and clean water access, water quality has been a major issue throughout the world. Recent reports suggest that only 20% of people in Pakistan have access to pure drinking water and 80% people consume unsafe water for drinking Daud *et al*. (2017). Each year 2.5 million deaths are linked with diseases due to unclean water. This demonstrates the gravity of situation with respect to health and sanitation.

Use of contaminated water and unclean practices results in water borne illnesses like cholera and typhoid which frequently break out, especially during the dry season. Every year, illnesses brought on by drinking unclean water kill 5 million children and sicken 1/6 of the world's population. Microbial contamination in distribution systems is a potential threat to public health. The aim of the research is to address the aforementioned problems which described by Hussain *et al*. (2016).

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The aim of this research is to provide a framework for monitoring water quality based on actual test data from site around Karachi. The variables under study include pH, turbidity, carbonate, bicarbonate, TDS, total *Colifom* and various chemical properties.

Most consumers' opt for bottled water in Karachi due to unhealthy drinking water and poor tap water quality. For instance, tube well or borehole (51%) is the predominant source of drinking water, followed by piped water (23%), while filtered drinking water is used by only 9% of households as stated by the Maternal Mortality Survey, 2019 (Mordor Intelligence, 2022). This has lead to health concern.

In the urban regions of Pakistan, people mostly prefer to buy mineral water from companies such as Aquafina, Nestle, Dasani, etc. In Karachi, a major problem is seepage of waste water which gets mixed with the drinking water. Karachi Water and Sewerage Board (KWSB) is the body responsible for generation and dissipation of clean water to the residents of Karachi. Hence the tap water coming into homes of Karachiites *via* KWSB is considered unsafe.

There are health standards as developed by World Health Organization (WHO) to recommend and benchmark the quality assurance of clean drinking water.

Specifically in this paper reference has been provided of different water related parameters to declare whether water is safe for drinking purposes. Each sample contain physical, chemical, microbial testing and the results were compared to drinking water standards set by the World Health Organization (WHO) reported in Table 1.

To facilitate industry development and compliance to the UN SDG goals, Pakistan Standards and Quality Control Authority (PSQCA) was established in 1996 through a government act, to provide a single source of information to enable Standardization and Conformity Assessment.

This work focuses on assessing water quality in Karachi using KWSB as water carrier and tests performed as well as benchmarked using standards developed by WHO and PSQCA.

Resources of water in Karachi. The Indus river rises in China's southwest and runs through the disputed Kashmir area before entering Pakistan and draining into the Arabian sea. Pakistan has the world's biggest integrated irrigation system, Indus river and its tributaries. Three large storage reservoirs, 19 barrages, 12 inter-river link canals, 43 irrigation canal commands and over 107,000 water courses make up the system (UN Environmental Programme, 2022).

As water demand is high in Karachi during the dry season. This is in sharp contrast to greater volume of water in wet season as Indus river being the essential surface water. Apart from summer flood season, little water escapes to the sea. In Karachi, the main surface water resources are Haleji lake, Keenjhar lake and river Hub on which city relies.

Surface water is collected in Karachi's lakes and dams, like as lake Haleji, lake Keenjhar and Hub dam, while groundwater comes from the Dumlottee well-fields. However, after the rainy season, it barely delivers 1.4 million gallons per day (MGD) of water and remains dry for the rest of the year (UN Environmental Programme, 2022). This is a negligible sum. Furthermore, due to over extraction and sea-water intrusion, the quality of groundwater in most areas is salty.

Need for quality assessment. It is assuredly noticed that it is unhealthy and unfit for humans to consume groundwater in Karachi without preceding treatment. This is because of excessive pumping of groundwater by farmers, seepage of domestic wastewater in groundwater and dumping of huge amounts of chemical constituents in industrial wastewater makes it harmful (Bhutto *et al*., 2019).

A study was conducted by Pakistan Council of Research in Water Resources (PCRWR) in 2015-2016 to evaluate the water quality and it was concluded that 24 samples of surface and groundwater in Karachi include *E. coli*. This was attributed to the poor maintenance and bacterial

Table 1. Guideline values for naturally occurring chemicals that are of health significance in drinking-water

	Guideline		
Chemical	µg/L	mg/L	Remarks
Inorganic			
Arsenic	10 (A,T)	0.01 (A.T)	
Barium	700	0.7	
Boron	2400	2.4	
Chromium	50 (P)	0.05 (P)	For total chromium
Fluoride	1500	1.5	Volume of water consumed and intake from other sources should be considered when setting national standards
Selenium	40 (P)	0.04 (P)	
Uranium	30 (P)	0.03 (P)	Only chemical aspects of uranium addressed
Organic			
Microcystin-LR	1 (P)	0.001 (P)	For total microcystin-LR (free plus cell-bound)

contamination of sewerage discharge mixing in drinking and household water. It was revealed that no improvement took place from 2002 till 2015. According to a World Bank study conducted in 18 towns of Karachi, it was found that in 89% of the samples blood lead levels were found to be greater than WHO guidelines. Increased lead levels result in learning disabilities in children which in turn reduces their income in later life (Table 2).

Water quality monitoring and justifications. The primary goal of water quality monitoring is to determine if the water being examined is appropriate for critical purposes. Monitoring, on the other hand, it was determine trends in the quality of the aquatic environment and how it is influenced by toxins released *via* various human activities and/or waste treatment operations. Impact monitoring is the term used to describe this type of monitoring. Water quality monitoring and assessment are ultimately dependent on the physical, chemical and organic qualities of water WHO (1996). However, water quality monitoring and assessment in the context of human recreation and environmental protection necessitates a complex inter connectedness of investigation, interpretation and communication.

Water availability - a regional comparison. When compared to other south Asian countries, Pakistan, as a dry country which gets the majority of its water from river flows. Several south Asian countries experience tropical monsoon weather, with annual rainfall reaching 1,000 mm on average. Pakistan, on the other hand, receives less than 500 mm of rain every year. Pakistan's water issues are worsened by the country's reliance on the Indus river and its tributaries. At the other hand India relies on numerous river basins, along with the Ganges river and the Godavari river, both are shown in the 12 major river basins and hence has a sufficient yearly river flow supply Syed *et al*. (2017). Similarly, Bangladesh receives its river flow from three basic basins results shown in Table 3.

Lately it has been found that presently in Pakistan, 40.5 MAF groundwater is being pumped annually in which 36% of groundwater is highly saline and 60-80% saline reported by Murtaza and Zia (2012). It is being suggested that in year 2025, the availability of water will be less than 700 m^3 per capita against the international standard of 1500 m^3 per capita.

Problem statement. *Rising concern of measurable drinking water quality.* Water quality has deteriorated over time due to the release of untreated industrial waste, hazardous sewage systems, farm run-off and unplanned urbanization, depriving almost two-thirds of Pakistan's population of drinkable water. As per the Pakistan Council of Research of Water Resources data, out of the 29 cities where underground water was tested, 50% of water obtained from various sources was found to be unsafe in more than 20 cities and in cities like Mirpurkhas and Shaheed Benazirabad (Nawabshah) in Sindh and Gilgit, 100% of underground water is unsafe for drinking (Mordor Intelligence, 2022).

Lack of implementation for safe drinking water quality in Karachi. Some of the key problems related to the governance affecting the water supply system in Karachi are discussed in below.

Poor condition of water distribution system. The major problem that people of Karachi face regarding water supply is poor condition of water distribution system. The symptom of this issue is that water inflow is of 665 MGD that is resulting in a shortfall of 155-165 MGD (WWFASIA, 2022). According to the recent studies, it shows from 2017 to 2030, the population will grow by 30%. The output is that there will be an increased demand of water on already in short supply of water resources.

Lack of management. Another major issue is lack of autonomy and authority. The main indication for this issue is irregular water supply that is only 2 h per day. The leakages are of high level and have low system

Table 2. Guideline values for verification of microbial quality

Organisms	Guideline value
All water directly intended for drinking	
E. coli or thermo tolerant coliform bacteria	Must not be detectable in any 100 mL sample
Treated water entering the distribution system	
E. coli or thermo tolerant coliform bacteria	Must not be detectable in any 100 mL sample
Treated water in the distribution system	
E. coli or thermo tolerant coliform bacteria	Must not be detectable in any 100 mL sample

pressure. Since less than 60% people have access to sewerage facilities, recent studies shows around 30,000 people, mostly children suffer and die each year in city. The unequal distribution of water in different areas of Karachi. The consequences of this issue will be insufficient revenues; people will be reluctant to pay for the services. People will not trust KW&SB services. Because of this less than 10% of sewage water is treated.

Weak financial capacity. The other point at issue is weak financial capacity and it is because of immeasurable water supply for retail customers and only 25% of commercial and industrial customers have metered supply. There is high demand of tanker suppliers and low tariffs result in weak financial capacity. The out turn will be that no data of water consumption will be available of these sectors.

Table 3. Water availability in south Asia (water sustainability in Pakistan - key issues aud challenges 2011)

	Precipitation (millimeters)	Ground water (million acres feet)	River flow
India	1083	350	1515
Bangladesh	2666	17	978
Nepal	1500	16	170
Sri Lanka	1712	6	42
Bhutan	2200	6	63
Maldives	1972	0.02	0
Pakistan	494	45	194

Absence of measured supplies and volumetric changing system. Lastly the delay in capital replacement and in system is because of absence of measured supplies and volumetric charging system. The other reason is poor current maintenance and poor working environments. The reliance and dependency on government funding (for capital and operational expenditure) is another indication for this issue. These issues will all result in deteriorating services and assets. The outstanding arrears are estimated at $460M: 179M (retail); 281M (bulk), non-water revenue estimated to 60% (or USD 420 million in 2015).

Literature review. In this section we perform a literature review of the current methods to ensure attainment of water quality standards.

Review of methods and equipment for water quality monitoring. The detailed parameterization of standards, methods and equipment adopted for water quality monitoring described by Eaton *et al*. (2018) used for are as follow (Panjwani, 2018), reported in Table 4.

Analytical procedure. The analytical procedures for analysis of water samples followed as under:

pH. The pH of water is a measurement of the concentration of hydrogen ions in the water. It establishes whether the water is alkaline or acidic in nature. The pH range for water, according to the World Health Organization (WHO) is 6.5 to 8.5.

Table 4. Standard methods and equipment American Public Health Association (APHA) (1992)

Parameters	Standard method used	Equipment used
pH		pH meter, model6230N, JENCO
Turbidity		Turbidity meter, Lamotte, model 2008, USA
Bicarbonate	2320, Eaton *et al*. (2018)	
Calcium	3500-Ca-D, Eaton *et al*. (2018)	
Chloride	Titration (silver nitrate), Eaton *et al*. (2018)	
Magnesium	2340-C, Eaton *et al*. (2018)	
Potassium		Flame photometer DN7101, Italy
Sodium		Flame photometer DN7101, Italy
Sulphate		Turbidimetric method, HACH 8051(DR- 2800 HACH)
Nitrate		4500-B using UV Spectrophotometer Eaton *et al*. (2018)
Fluoride		4500-F-D, SPADNS method using Colorimeter (DR-2800 HACH), Eaton *et al*. (2018)
Iron		Standard method HACH 8008 (DR-2800 HACH), Eaton *et al*. (2018)
Arsenic	Merck test kit 1.17927.0001	
TDS	2540C, Eaton *et al*. (2018)	
Chloride	Titration (silver nitrate), Eaton *et al*. (2018)	
Total *Coliforms*	3M™ Petrifilm official methods of analysis OMA #991.14	

Principle: Add standard alkali in doses of 0.5 mL or less, ensuring that each addition results in a pH adjustment of no more than 0.2 units. Use a magnetic stirrer to fully but gently combine after each addition. Don't splash. When a consistent reading of pH is achieved, note it. Up till pH 9, keep adding titrant and measuring pH. Plot the measured pH values against the cumulative milliliters of titrant applied to construct the titration curve.

$$\text{Acidity, as mg } CaCO_3/L = \frac{[(A \times B)-(C \times D)] \times 50000}{\text{mL sample}}$$

where:

A = mL NaOH titrant used; B = normality of NaOH; C = mL H_2SO_4; D = normality of H_2SO_4

Turbidity. Turbidity is a water quality metric that is simple to measure and is frequently used as an indication of the general health of drinking water. Water safety plans (WSPs), recommended method for maintaining drinking water quality in the WHO guidelines for drinking water quality are frequently used for operational monitoring of control actions that are included in turbidity (WHO, 1996). It may be used as a foundation for comparing the performance of various control methods, including as coagulation and clearing, filtration, disinfection and distribution system management, as well as for selecting between different source waters.

Principle: For waters containing 0.10 to 1.00 mg B/L, use 1.00 mL sample. For waters containing more than 1.00 mg B/L, make an appropriate dilution with boron-free distilled water, so that a 1.00 mL portion contains approximately 0.50 μg boron

$$\text{mg B/L} = \frac{A_2 \times C}{A_1 \times S}$$

where:

A_1 = absorbance of standard; A_2 = absorbance of sample; C = μg B in standard taken; S = mL sample.

APHA colour method. The cleanliness of waste water is assessed using the APHA (American Public Health Association) colour scale, which may also be used to find any evidence of organic materials or other undesirable pollutants. The APHA colour measuring method compares a platinum cobalt reference solution to liquid samples to determine how yellow they are one of the most often used methods for determining the colour of liquids is this method.

Principle: Using the DE values for each standard, calculate a calibration factor Fn for each standard from the following equation:

$$F_n = \frac{(APHA)_n(b)}{(DE)_n}$$

where:

(APHA)n = APHA colour value for standard n; (DE)n = intermediate value calculated for standard n; b = cell light path, cm

Procedure for total *Coliform* and *E. coli* analysis. For the *E. coli*/*Coliform* count, pour 1 mL of the sample onto a 3 m Petri film. After that, put it in the fridge at 37 °C for 24 h and then after, calculate the results.

For the determination of physical, chemical and biological parameters, one can trace major ions and elements along with the total, inorganic and organic carbon ions. For these advanced instrumental methods are used as described in the following section. Many of the prescribed methods are especially valuable for comprehensive analyses of sediments, in particular sediments for biospheric analysis of ingredients and particles. The instruments and techniques mentioned here are categorized under chemical and physical and microbiological as following:

Chemicals. Atomic absorption spectrophotometry (AAS). Atomic absorption spectrophotometry is a well-known method that is frequently used in laboratories to evaluate components in a water sample and in acid digest of sediments or biological tissues.

Principle: It applies the principle that tells us certain wavelength of light can absorb light at a specific, unique region of wavelength. Here the energy (light) is absorbed by the atom. Most atomic absorption instruments are also provided for operation in an emission mode.

Gas chromatography. Gas chromatography is a relatively sophisticated analytical procedure to detect the chemical components of a water sample mixture and then determine their presence or absence determining the strength how much is present. The molecules it detects are mainly organic molecules. It must be used only with the help of analysts experienced in the methods required and equipped to assess and distinguish the records of data.

Principle: Partitioning derivative distribution of a volatile component (gas) into two phases—a liquid phase relating to absorbance of surface and a gaseous phase of eluting liquefied gas chromatography.

Flame photometry. Flame photometry helps achieve the confirmation of trace amounts of lithium, potassium, sodium and strontium, in samples of water, CSF and other body fluids.

Principle: The principle of flame photometer is based totally on the dimension of the emitted light when a metallic is added into the flame. The wavelength of the colour records about the factor and the coloration of the flame give information about the quantity of the aspect element present in the specimen.

Infrared spectroscopy. Infrared spectroscopy is commonly utilized in both business and research. It is a simple and reliable approach for determining molecular structure, chemical species identification and quantitative/qualitative chemical species determination in solid, liquid and gaseous states.

Principle: Infrared spectroscopy relies on the theory that certain bands of frequencies can absorb molecules specific to their structure. At temperatures above absolute zero, all atoms in molecules are vibrating in proximity of each other.

Physical. Volumetric determination. It is defined as the hardness of water as assessed by an EDTA titration buffered at pH 10. (this is a alkalinity condition for optimizing complexing). Metal complexes are formed in an order by EDTA and with EDTA, calcium forms a more stable combination than magnesium titeration.

Thermal conductivity. When a temperature gradient exits, thermal conductivity of water is defined as the rate at which heat is transferred across x-section based on unit surface area using conduction. Water has a typical thermal conductivity of 0.6 W/m K at 20 °C.

Specific CO_2 electrode. Water electrolysis is the process of utilizing electricity to breakdown water into oxygen and hydrogen gas.

Flame ionization following methanisation. A flame ionization detector (FID) is a scientific device that detects analytes in gas and water streams. In gas chromatography, it is widely utilized as a detector. This is a mass sensitive tool because it measures ions per unit time.

Microbiological. Since the removal of bacteria found in water has expensive methods to filter out, one needs to make sure that the coliform bacteria result you have received is accurate. The comparison between to methods that can be adopted to detect *Fecal coliform* and *E. coli* bacteria from drinking water is given in Table 5.

The above section is a review of the different methods that apply for detection clean and safe drinking water.

Research design/methodology. Rising concern of measurable drinking water quality. To evaluate the quality of drinking water provided by KWSB in Karachi, water samples should be tested for the physical, chemical, and microbiological parameters to get a clear picture of the cleanness and purity of water. 4 physical parameters including colour, odour, pH and turbidity, 13 chemical parameters including bicarbonate, calcium, carbonate, chloride, hardness as $CaCO_3$, magnesium, potassium, sodium, sulphate, nitrate, fluoride, iron and TDS and 2 microbiological parameter which includes total *Coliform* and *E. coli* will be tested.

Method. The source of water collection was tap water and samples were collected in sterilized water bottles (PET) of 0.5 L. The area targeted for the research is Gulistan-e-Jauhar, Karachi. The taps through which the samples were collected must not contain any corrosion or leakage that may lead to any external contamination in the water. Each tap was opened and the water was allowed to drain for around 30-60 s to flush the lines properly before sampling.

Table 5. Comparison between two microbiological methods

Multiple fermentation tube technique	Membrane filter technique
Slower: a good result takes 48 h	More quickly: quantitative or presumed positive findings in roughly 18 h
Requiring more effort	Requiring less effort
More culture medium is required	Less culture medium is required.
Field adaptation is difficult	Field adaptation is easy.
Consumables readily available in most Countries	Cost of consumables is high in many Countries
Applicable to all types of water	Not applicable to turbid waters

Sample size. 15 samples of tap water were collected for the detection of physical, chemical and microbiological parameters from a select source of water supply.

City wide safe drinking water samples. Because of limited facilities and slum areas having poor infrastructure in Karachi, water shortage is a major issue. The physio-chemical analysis of drinking water supply lines in Malir, SITE area and orangi town showed the physio-chemical properties within WHO permissible limit except the total coliform, Fecal coliform and *E. coli* UN Environmental Programme (2022). To provide safe and clean drinking water, the water treatment plants should be increased as day by day the contamination is getting higher. The filtration plants should be installed for softening water to remove calcium and magnesium.

Results and Discussion

Observation of rising concern of measurable drinking water quality. On the basis of results from Table 6, it is clear that most of the parameters of chemical such as bicarbonates, calcium, chloride, magnesium, potassium, sodium, sulphate, nitrate, fluoride, iron, arsenic and total dissolved solids (TDS) of water are within the ranges comparing to WHO standards for the collection of all 15 samples. The physical parameters such as pH, turbidity are also found to be within limits for all the samples collected and detected. The alarming situation is in microbiological parameters as except for few samples, total *Coliform* and *E. coli* have been found.

Water treatment methods for findings from the samples collected. Since in Pakistan, the water quality is poor therefore it is necessary to remove unwanted constituents such as dissolved organic and inorganic material, bacterial and fine solids, to make it fit for drinking purpose. The most common methods for water treatment that are available in Pakistan are flocculation and coagulation methods, three phase filtration system, chlorination tablets, safe storage, solar disinfection, UV disinfection, bio sand filtration, reverse osmosis, ion exchange for water softening, filtration for water softening.

The most widely used water treatment method followed in Pakistan is flocculation and coagulation.

Domestic garbage in Pakistan is either released directly to a sewage system, a natural drain or water reservoir or a neighboring field or an indoor septic tank containing household effluent and human waste. Ordinarily, municipal wastewater is not treated and apart from Islamabad and Karachi, none of the cities house biological treatment mechanisms. The cities included involve a small wastewater process before disposal. It is anticipated that around 8% of urban wastewater is processed in municipal treatment facilities, assuming that all of the installed treatment plants are operating

Table 6. The water data collection to detect parameters relating to WHO standards

Parameters	Unit	Permissible Limit (WHO)	Permissible Limit (PSQCA)	Samples														
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
pH	-	6.5-8.5	6.5-8.5	7.6	7.2	7.1	7.5	7.4	7.6	7.5	7.6	7.5	7.6	7.2	7.1	7.6	7.4	7.2
Turbidity	NTU	5	<5	2.5	3.2	1.2	2.5	2.5	1.2	1.6	1.5	1.8	1.5	3.4	2.8	1.5	2.5	2.7
Bicarbonates	mg/L	NGVS	NGVS	500	650	530	540	600	640	620	600	550	570	550	580	630	590	640
Calcium	mg/L	NGVS	NGVS	120	150	153	145	100	125	135	130	135	145	132	117	134	127	140
Chloride	mg/L	250	250	200	222	200	210	245	180	198	190	188	200	197	215	185	235	225
Magnesium	mg/L	NGVS	NGVS	90	98	102	88	86	73	98	90	95	98	87	95	100	85	88
Potassium	mg/L	NGVS	NGVS	15	16	22	24	14	20	22	23	25	27	21	17	19	27	24
Sodium	mg/L	200	NGVS	400	425	410	400	380	378	388	400	350	320	395	380	400	372	415
Sulphate	mg/L	250	NGVS	200	210	233	189	195	198	185	180	175	170	184	212	195	187	190
Nitrate	mg/L	10	10	2.9	3.8	5.7	6.8	7.7	5.8	6.7	6.6	6.5	6.5	5.5	6.2	5.9	7.1	5.9
Fluoride	mg/L	1.5	1.5	1	0.7	0.8	0.9	1.2	1.3	0.8	0.7	0.6	0.7	1	0.8	0.6	1.1	0.8
Iron	mg/L	0.3	0.3	0.1	0.2	0.12	0.21	0.15	0.2	0.11	0.1	0.2	0.2	0.1	0.23	0.18	0.2	0.21
Arsenic	ppb	10	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDS	ppm	1000	1000	320	400	280	330	285	420	250	300	350	320	370	350	250	410	300
Total Coliform	CFU/100 mL	0	0	2	5	0	0	0	5	0	0	0	0	0	0	3	0	0
E. Coli		0	0	0	7	0	0	0	0	0	3	0	0	0	0	0	0	0

at full capacity. The cleaned wastewater is often discharged into open drains, with no preparations for reuse in agriculture or other municipal applications. Only a small percentage of wastewater in Pakistan, about 8%, is treated to a primary level by sedimentation ponds, but because most treatment plants are not operational, the value can be estimated to be around 1%. In this country, there is no prevailing treatment philosophy at the secondary and postsecondary levels. Although there are treatment centers in roughly a dozen large cities, they have been closed in some circumstances.

Because biological factors such as *E. coli* and variations of coli forms were found in water samples based on the above findings, these bacteria are not normally prevalent in groundwater and are a signal that additional hazardous organisms may be present. Fever, flu-like symptoms, and other gastro-intestinal disorders can be caused by drinking water contaminated with coliform bacteria.

Chlorination. By the operation of extremely efficient water filtration systems, bacteria such as *E. coli* is purified which does not require any chemical or power in most of the cases. One of the approaches to treating *E. coli* is with the addition of chlorine. Chlorine chemical dosing pumps, which act as a disinfectant that kills the bacteria are often used for water sources. However, chlorine is considered an effectual treatment for *E. coli* but there are also two other water purification systems that can be implemented to remove bacteria.

The first one is reverse osmosis systems which are highly efficient in removing *E. coli* from drinking water. Pollutants such as *E. coli* cannot pass though filtration membranes by using reverse osmosis method.

UV system. UV systems, on the other hand, are a type of filtration that efficiently removes all *E. coli* from drinking water. UV systems are the most effective and cost-effective in segregating germs from water using radiation. Water passes via the UV system, where it is exposed to ultraviolet rays, which kill any bacteria that are present (Pure Aqua, 2022).

There are numerous other treatment processes that can be used to disinfect water are boiling, ozonation and iodination but they are not preferred to use for continuous disinfection (Swistock *et al*., 2013).

Most of the water-borne diseases are due to microbiological contamination in the water source. Total *Coliform* and *E. coli* are the parameters that reflect the presence of microbiological contamination in the water. The acceptable range of these parameters in the drinking water is 0/100 mL. It can be removed through proper chlorination of the water or UV light is used to remove it completely from the water. These results conclude that the quality of water provided by KWSB in Gulistan-e-Jauhar is microbiologically unsafe as 11 out of 20 samples deviated from the set range by WHO. The reason to this microbiological contamination can be leaked pipelines. In addition to that sewerage lines are also closed to the pipelines that can lead to the microbiological contamination. Hence the proposed research methods would go a long way to solve the water quality problem linked to Human Development indexing especially targeting urban metropolis of developing countries.

Conclusion and Recommendations

It is concluded that the quality of ground water found in Karachi's major urban metropolis is unsuitable for drinking. After analyzing the samples, the presence of *coliform* and *e-coli* was detected which is harmful for the human health. It is a recommendation to KWSB to develop a strategy to outline the performance standards, capital investment needs, systems and procedures. The KWSB should revisit financial sustainability arrangements with the provincial and municipal partners. They should also invest in pumping efficiency improvement and rehabilitation. According to the results, several filtration systems and water treatment plants should be installed in Karachi.

Conflict of Interest. The authors declare that they have no conflict of interest.

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