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Physicochemical and Microbiological Water Quality of PWD, Gulberg and Korang River, Islamabad, Pakistan

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Abstract: This study evaluated the physicochemical and microbiological quality of water from PWD Colony, Gulberg Green and the Korang River (n = 36 samples) collected during April–May to determine suitability for domestic use and public-health risk. Samples were analyzed for pH, temperature, electrical conductivity, total dissolved solids, turbidity, alkalinity, hardness, chloride, fluoride, arsenic, and total bacterial count and indicator/pathogenic bacteria (*Escherichia coli*, fecal coliforms, *Salmonella*, *Shigella*). Results showed variable water quality across sites: pH ranged between 5.8–8.5 (mean = 7.4), TDS 230–858 mg/L (mean = 544 mg/L) with elevated EC/TDS in Korang samples. Extremely high turbidity in Korang River samples was determined (92–201 NTU), fluoride content reached up to 3.4 mg/L (exceeding WHO guideline of 1.5 mg/L) and arsenic peaking at 0.10 mg/L (far above the WHO limit of 0.01 mg/L). The microbiological contamination was widespread with frequent detection of fecal indicators and pathogenic genera, and in several cases reported as "too many to count," indicating fecal intrusion and sanitary failures. On the basis of comparisons with WHO/national standards, the Korang River exhibited the poorest physicochemical quality while PWD and Gulberg point sources often suffered microbiological contamination. The findings call for source protection, repair and monitoring of distribution systems, targeted treatment like turbidity control, de-fluoridation and arsenic mitigation, and routine microbial surveillance to reduce waterborne diseases risk in the study area.

Keywords: Physicochemical, microbiological characteristics, water quality, Islamabad.

Introduction

Presently, drinking water quality is an emerging challenge all over the world. Poor quality drinking water undermines the economic growth and environmental and physical health of billions of people (Ji et al., 2020). At present, approximately two billion people (about 26% of the global population) do not have access to safe drinking water, and around 771 million people do not have access to basic drinking water facilities (Kashiwase, 2023). Like, rest of the developing world, Pakistan is also currently facing severe water crises in terms of quality and quantity. Demand for drinking water is rapidly increasing in Pakistan mainly due to population increase and lifestyle changes (Bashir et al., 2021). According to WHO and UNICEF reports, Pakistan ranks 80th out of 122 countries in drinking water quality (Zeb et al., 2023). It is estimated that poor water quality contributes to about 40% of diseases and 30% of deaths in Pakistan (Nadeem et al., 2025). Common water contaminants include toxic metals (arsenic and lead), pesticides, and microbial pathogens such as *E. coli* and other coliform bacteria (Iqbal et al., 2024), all of which pose serious health risks. In fact, waterborne diseases (dysentery, diarrhea, typhoid and hepatitis etc.) outbreaks have been reported frequently in Pakistan for the past few years (Butt and Khair, 2014).

Biochar-based adsorbents have also been reported to effectively remove pesticide contaminants from water, for example lambda-cyhalothrin using Parthenium hysterophorus biochar (Khalid et al., 2025). These facts highlight the pressing need for regular water quality monitoring based on various physicochemical parameters (pH, EC, TDS etc.) and microbiological indicators (total bacterial count, fecal coliforms, E. coli, Salmonellae and Shigella) (Jalees et al., 2021).

The Islamabad Capital Territory, much like the other urban areas of Pakistan, has many water quality issues. Primary sources of water for drinking in Islamabad include reservoirs (such as the Simly and Khanpur dams) and groundwater; however, surveys show that much of this is contaminated. PCRWR (2016) reported that only about 32% of water sources

tested in Islamabad were fit for drinking. Some local estimates highlight that about 60–70% of the city's drinking-water sources are contaminated with chemical or microbiological pollutants (Shahzad et al., 2019).

For instance, widespread arsenic and lead harmful metals as well as fecal coliform bacteria have been identified in different water supplies of Islamabad (Azam et al., 2024). Aging or leaky distribution infrastructure and unplanned development contribute to these problems. Collectively, this means that a large section of the population may be consuming water that does not meet WHO or national quality standards.

This study focuses on three key areas within Islamabad: Gulberg Green, PWD Housing Society and the Korang River surroundings. Gulberg Greens and PWD are new residential sectors which receive water through city pipelines and local tube wells. The Korang River travels through Margalla Hills and flows into Rawal Lake, one of the major water reservoirs that provide drinking water to Islamabad. But the Korang River has been polluted with a large amount of encroachments and pollution dumped into it. The Supreme Court observed in 2018 that illegal construction and discharge of raw sewage along the Korang River were among the major causes of contamination downstream at Rawal Lake (Altaf, 2018). Therefore, pollution in the Korang catchment has an immediate impact on drinking water quality. In this context, the quality of water in different areas of Gulberg, PWD and Korang needs to be assessed for safe drinking to protect public health.

Present study aims to assess the physicochemical and microbiological quality of water within Gulberg Green, PWD Society, and Korang River areas of Islamabad. All gathered water samples will be tested in a broad-based set of parameters. Physical and chemical parameters such as pH, TDS, EC, chloride, total hardness, alkalinity, fluoride, turbidity and arsenic concentrations represent the chemical purity of water in terms of mineral contents.

The microbiological issues include such traditional parameters as total bacterial count (CFU/mL) and indicator organisms (E. coli, fecal coliforms, Salmonella, Shigella), which indicate the presence of fecal contamination and pathogen risk. These parameters have well-established links to water safety: for example, high turbidity or microbial counts indicate potential treatment failures, while excessive fluoride or arsenic pose specific long-term health hazards (Talpur et al., 2024). By comparing measured values against WHO and national standards, this study will determine whether the drinking water in these localities is fit for consumption and to identify any urgent problem.

Materials and Methods

Study Area

Water samples were collected from three locations in the Rawalpindi/Islamabad region: PWD Colony, Gulberg Green Town and Korang River (Fig. 1). Rawalpindi is in the Pothohar region of Punjab province and is the fourth largest city in Pakistan. Korang River flows from the Margalla Hills to Rawal Dam and is an outlet stream that later joins the Soan River (Ahmad et al., 2014). Sampling points within each locality included groundwater sources, filtration plant outlets and river tributaries.

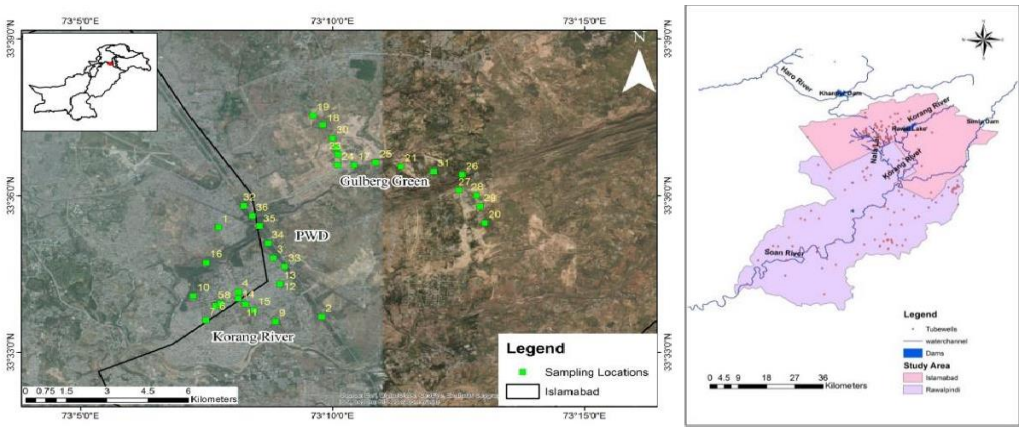

Fig. 1 Study area map with sampling points of PWD Colony, Gulberg Green, Korang River. After (Shabbir and Ahmad, 2015).

Sample Collection

A total of 36 water samples were collected from three locations during April–May. Samples were taken on different days and at different times, most frequently between 12:00 and 15:00 hours. For microbiological analyses, sterile 100 mL polypropylene bottles were used and for physicochemical analyses, 500 mL polyethylene bottles were used. Prior to sampling, bottles were rinsed with distilled water and then with site water. At each sampling point water was allowed to flow for 2–3 minutes prior to collection to obtain representative samples. The bottles were filled without entrapping air bubbles, labelled and transported to the laboratory under recommended conditions. Microbiological samples were processed within 24 hours, if immediate transport was not possible, samples were stored at ≤10°C and delivered to the laboratory within 24 hours. Sampling locations were selected randomly in the study area. Field observations (date, time, temperature and sample numbers) were recorded at the time of collection.

Physicochemical Parameters Analysis

All parameters (pH, EC and TDS) were measured using the Multi-Parameter Device (PC ST Estr) by pouring the sample into a distilled-water-rinsed beaker and sequentially recording each reading. The probe was rinsed before use, dipped into the sample, and readings were obtained by pressing *mode ENT* to switch between pH, EC and TDS.

Turbidity was measured using a turbidity meter supplied with the turbidity kit. Ten milliliters of well-mixed sample were placed in the cuvette supplied with the kit. The instrument was set to Test/CAL and the turbidity reading recorded after the optical measurement stabilized.

Chloride: Chloride concentrations were determined by argentometric titration (Mohr's method). Ten milliliters of sample were transferred to a conical flask, 4–5 drops of potassium chromate (K_2CrO_4) indicator were added, and the sample was titrated with standardized $AgNO_3$ solution until an orange-yellow endpoint was reached. Reagents and glassware were rinsed with distilled water prior to use. Each sample was titrated in triplicate and a reagent blank was run to correct results. The chemical reactions are summarized as:

$$AgNO_3 + NaCl \rightarrow AgCl\,(s) + NaNO_3$$

$$2\,AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4\,(\text{orange-red precipitate}) + 2\,KNO_3$$

Hardness (EDTA titration): Total hardness was determined by complexometric titration with 0.1 M EDTA. One milliliter of sample was placed in an Erlenmeyer flask, 2 mL of ammonium buffer (pH = 10) was added and two drops of Eriochrome Black T (EBT) indicator were added. Samples were titrated with 0.1 M EDTA until the color changed from red to blue. Each measurement was repeated three times and a blank determination using distilled water was performed.

Alkalinity: Alkalinity titrations were performed by titrating 50 mL of sample with standardized H_2SO_4 using methyl orange as an indicator. The initial pH was measured before titration. The volume of acid required to reach the endpoint (yellow to pink) was recorded, and three replicate titrations were performed for each sample.

Fluoride: Fluoride concentration was determined using the HI 96739 Fluoride High Range method (HI 96739 meter and reagents). The meter was zeroed using the manufacturer's buffer and indicator reagents according to the supplied protocol. Reagent volumes and mixing steps were followed exactly (2.00 mL buffer + indicator to 10 mL, then 1.00 mL sample added). After mixing and the specified reaction time, fluoride concentration was read directly from the instrument (mg/L). Measurements were performed in replicates and averaged.

Arsenic: For arsenic analysis, 50 mL of the water sample was added to the reaction bottle up to the marked line. One level pink spoon of the first reagent was added, and the bottle was capped securely with the red cap and shaken vigorously for 15 seconds while kept upright. The bottle was then uncapped, and one level red spoon of the second reagent was added, followed by capping and shaking again for 15 seconds. Next, one level white spoon of the third reagent was added, the bottle was recapped and shaken upright for 5 seconds. The red cap was then replaced with a dry white turret cap. An arsenic test strip was carefully removed from its container and inserted into the turret, ensuring that the test pad and red line faced the back of the white cap.

The strip was positioned so that the red line was level with the top of the turret, which was then closed to hold the strip securely in place. The reaction was allowed to occur in an undisturbed, well-ventilated area for 10 minutes. After this period (not exceeding 12 minutes), the turret was lifted, and the test strip was removed for immediate comparison with the color chart provided in the arsenic test kit. The color of the test pad was matched within 3 seconds to determine

the arsenic concentration, and the corresponding results were recorded.

Microbiological analysis: Water samples were collected in sterilized bottles of 100 ml for bacteriological analysis. Every sample bottle was clearly marked with the location and date of sampling. Precautions were taken during storage and shipping of samples to avoid quality loss. For accuracy, the bottles were transported to the testing lab within an hour of being collected. Samples were held without delay for transport or stored at ≤ 10°C and then sent to laboratories within 24 hours.

Since it is required to compare and enumerate bacteria, 3 types of agar media namely, Nutrient Agar (NA), Salmonella Shigella (SS) Agar and Eosin Methylene Blue (EMB) Agar were prepared. The bacterial analysis of the water samples was conducted using the plate count method, where aliquots of each sample were spread on the respective agar media to assess the presence and quantity of total bacteria, total coliforms, *E. coli*, *Salmonella*, and *Shigella*.

The inoculated plates were incubated at 37°C for 24 to 36 hours. After incubation, bacterial growth on Nutrient Agar indicated the total bacterial load, while colonies on EMB Agar confirmed the presence of *E. coli*, and those on SS Agar showed the occurrence of *Salmonella* and *Shigella* species in the tested water samples. Total bacterial load was expressed as colony-forming units (CFU) per milliliter.

Results and Discussion

All the samples were analyzed for pH, TDS, EC, turbidity, alkalinity, hardness, arsenic, chloride and fluoride. These samples were also analyzed for bacterial contamination.

Physicochemical Characteristics

pH: The pH of drinking water is a key indicator of water quality, with the WHO recommending a permissible range up to 8.5. In this study, the pH of collected samples ranged from 5.8 to 8.5, with an average of 7.4 (Fig. 2). Groundwater from Rawalpindi showed lower pH values (5.8–6.0) due to limited carbonate minerals such as limestone and dolomite. These findings are consistent with the study of Shabbir and Ahmad (2015), who also reported low pH in Rawalpindi water sources. Although pH has no major direct health effects, very low or high values can irritate skin and eyes, reduce disinfection efficiency, and increase metal corrosion.

Electrical conductivity: The electrical conductivity depends by the presence of various salts in the water, and it varies in the study area in PWD bore-well samples, EC values ranged from 465 to 957 µS/cm, with the highest value (957 µS/cm) recorded at a filter plant. In Gulberg Green, EC varied widely, from a low of 326 µS/cm at a property dealer's office to a high of 1501 µS/cm at a construction site. This large variation reflects differences in water sources and local activities.

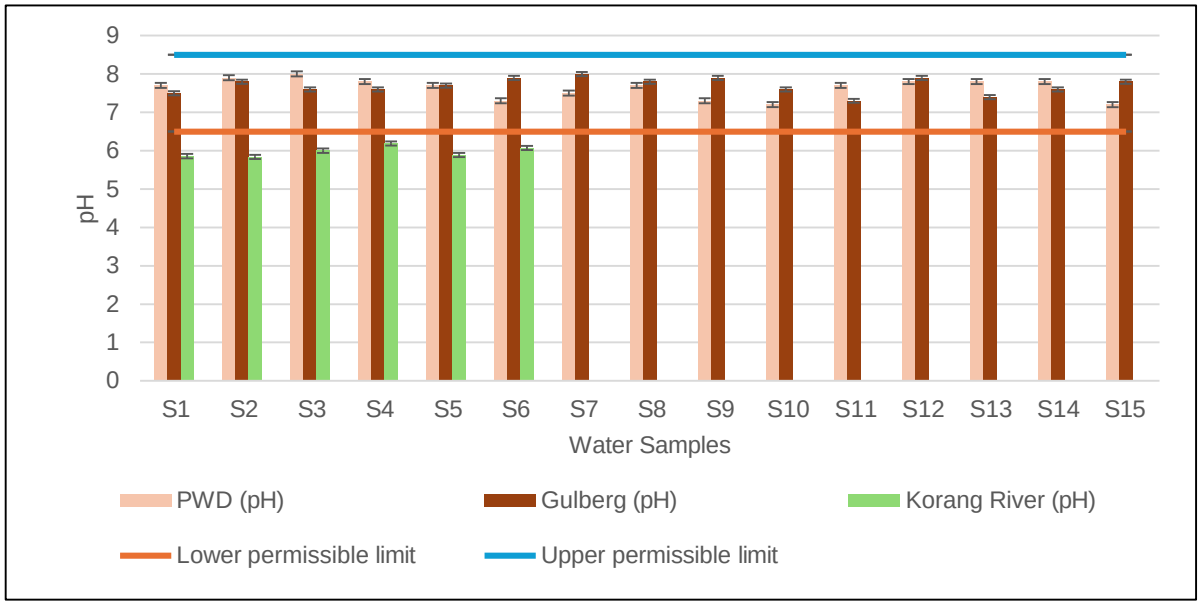

Fig. 2 pH value in study area.

For Korang River samples, two sites (S4 and S6) showed the lowest EC values of 1090–1091 µS/cm, while all other samples (S1, S2, S3, S5) had values above 1159 µS/cm (Fig. 3). Similar results have been reported in a study conducted in India, with comparable landscape and possible contaminations (Chaudhari et al., 2014, Ozlu and Kumar, 2018).

Total dissolved solids: Generally, inorganic salts like calcium, magnesium, potassium, chlorides, bicarbonates and sulphates along with the dissolved organic compounds are included in TDS. Therefore, the TDS levels vary considerably depending upon the solubility of minerals and geographical location of the water sample (Corwin and Yemoto, 2020).

In the study the TDS values range from 230 mg/L to 858 mg/L, with an average of 544 mg/L (Fig. 4) and these results are in accordance with the previous studies based on collected samples from the community sources (Hussain et al., 2016, Aleem et al., 2018). TDS levels in PWD and Gulberg Green bore-well samples ranged between 330–750 mg/L and 230–840 mg/L, respectively.

The lowest value (231 mg/L) was from a site with a water supply connection, while the highest (839 mg/L) came from a construction site. Korang River samples showed higher TDS levels (771–858 mg/L). Overall, the TDS values of water samples from all sites (PWD, Gulberg, and Korang River) were lower than the WHO guideline of 1000 mg/L.

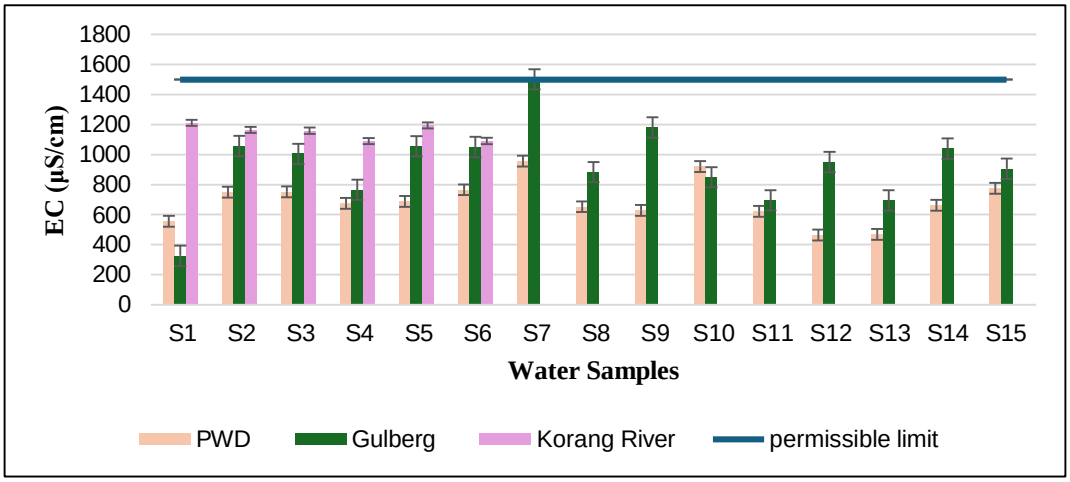

Fig. 3 Electrical conductivity values in study area

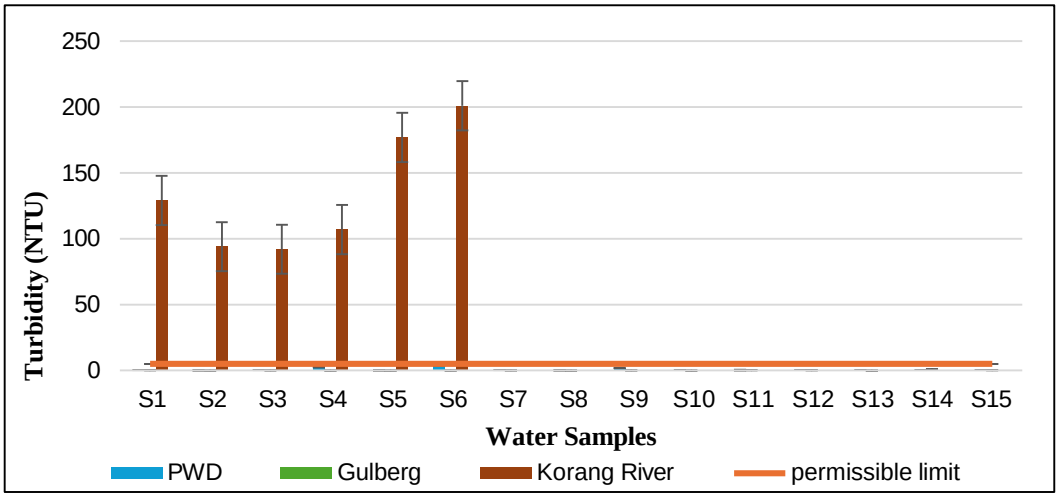

Fig. 4 Concentration of TDS the in study area.

Hardness: The hardness of water is the indication for the presence of cations such as magnesium and calcium and anions for instance sulphate, chloride, carbonate and bicarbonate (Dalmieda and Kruse, 2019). WHO's Guidelines for Drinking-Water Quality do not propose health-based limits but Pakistan's National Standards for Drinking Water Quality specify total hardness (as $CaCO_3$) ≤ 500 mg/L (Environment, 2010). In PWD, water hardness in Table 1 ranged from 8.7 mg/L (sample 12) to 14.2 mg/L (sample 7), with moderate variations in other samples. In Gulberg Green (Table 2), hardness varied from 8.2 mg/L(sample 1) to 17.1 mg/L (sample 15), with other samples showing intermediate values. Korang River samples had hardness between 10.8 mg/L (samples 2 and 3) and 12.5 mg/L (sample 4), indicating relatively lower variation (Fig. 6). Our study has found similar results as that of Batool et al. (2018) and ,Masood et al. (2015). The water reservoirs of Islamabad and Rawalpindi show negligible hardness.

Alkalinity: In Gulberg Green, alkalinity levels ranged from 1.7 mg/L in sample 1 to 5.8 mg/L in sample 15, with a sharp rise to 5.2 mg/L in sample 2. In PWD, concentrations varied from 3 mg/L in a mosque (sample 1) to 6.3 mg/L in a shop (sample 15), while a roadside water filter (sample 14) had 3.8 mg/L and most other samples stayed below 5.2 mg/L. Korang River showed higher alkali levels overall, with sample 4 at 8.3 mg/L, sample 6 at 7.3 mg/L, and the remaining samples values were below 6.8 mg/L (Table 3).

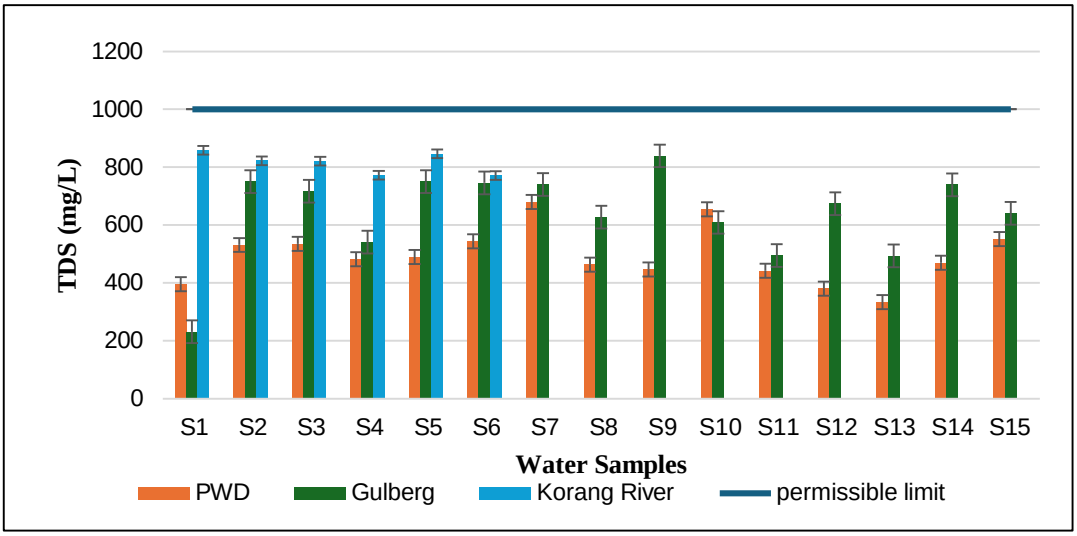

Fig. 5 Turbidity values in the study area.

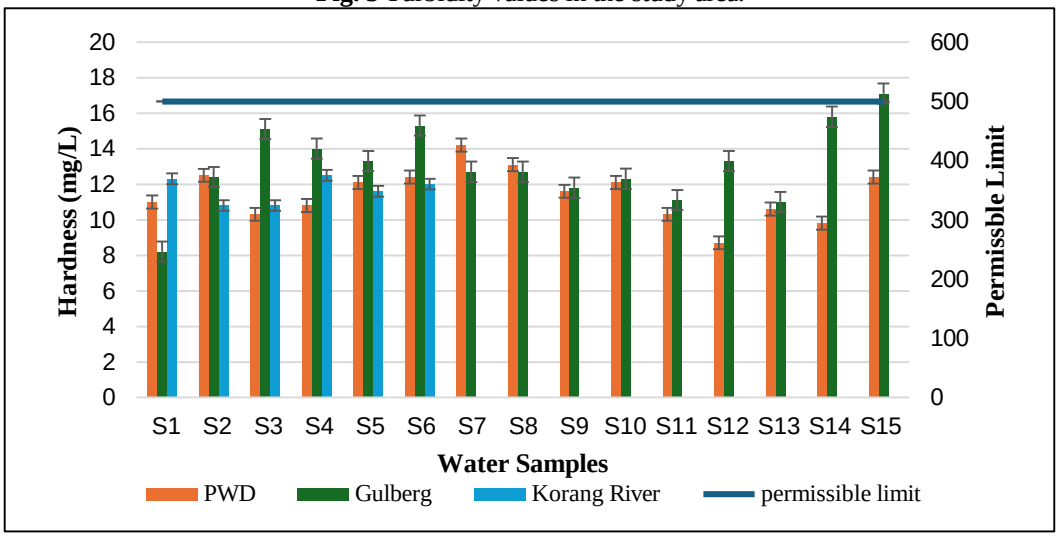

Fig. 6 Value of Hardness values in the study area.

The alkalinity of drinking water in Islamabad and Rawalpindi ranged between 1.7mg/L to 8.3mg/L with a mean value of 5mg/L. The Canadian Water Rules have proposed the alkalinity limit of less than 250mg/L (Kachroud et al., 2019). All water samples collected in the study area have alkalinity values within safe limits (Fig. 7). The alkalinity values of the collected samples suggested that there is no industrial water release without proper treatment near the studied locations. Our results are consistent with the previous studies conducted in Rawalpindi and Islamabad (Sohail et al., 2020).

Chloride: Chloride concentrations in PWD bore wells ranged from 4.9 mg/L (sample 6) to 17.8 mg/L (sample 2), with 13.6 mg/L in sample 7. In Gulberg Green, levels varied from 4.1 mg/L (sample 11) to 13.3 mg/L (sample 6), with 11.1 mg/L in sample 15. Korang River water showed higher chloride, ranging from 15.4 mg/L (sample 5) to 22 mg/L (sample 2). Overall, the studied samples had lower levels of chloride as compared to WHO recommended guidelines (Fig. 8). Previous studies conducted on the same geographical areas also confirmed this trend (Shehzadi et al., 2015).

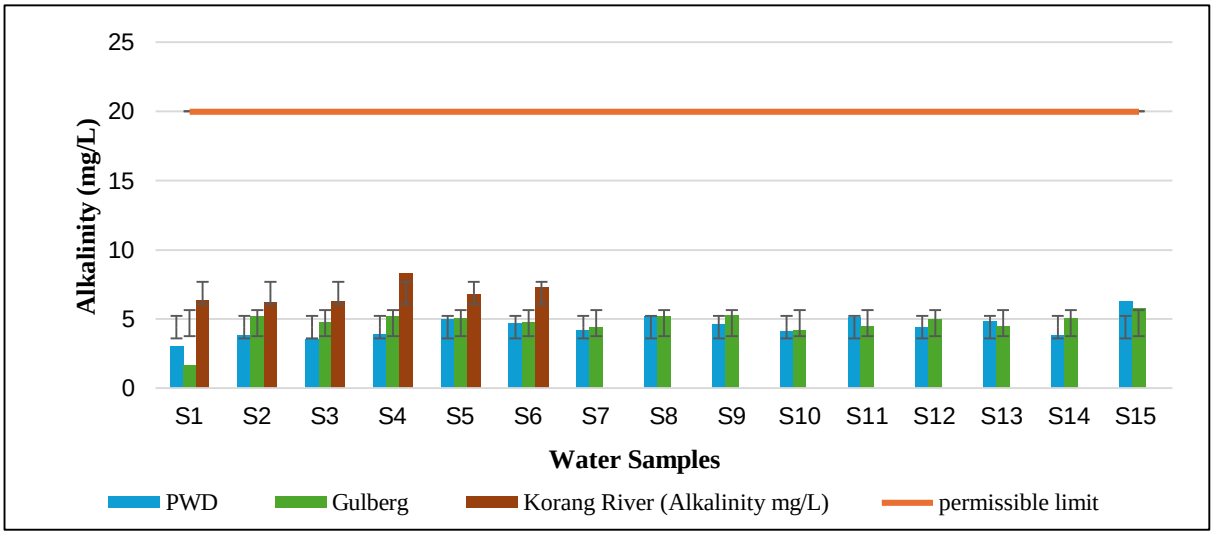

Fig. 7 Alkalinity values in the study area.

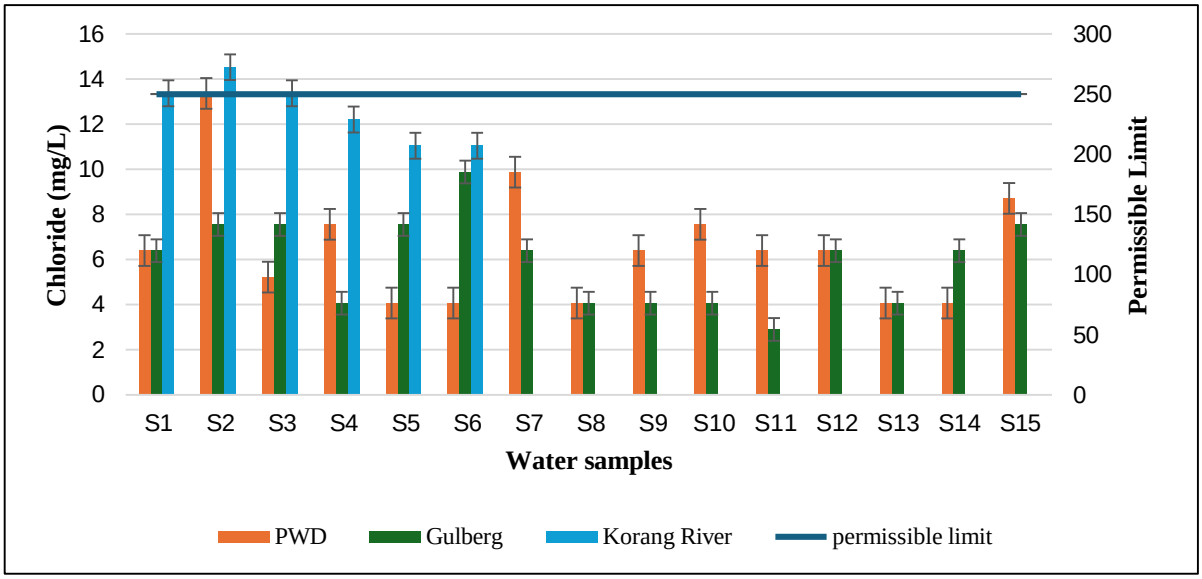

Fig. 8 Concentration of chloride in study area.

Table 1. Physico-chemical results of PWD.

Serial no.	pH	EC	TDS	Hardness	Turbidity	Alkalinity	Chloride	Flouride	As
Sample 1	7.7	557	395	11.0	0.0	3.0	9.2	0.53	0.0
Sample 2	7.9	750	531	12.5	0.12	3.8	17.8	0.8	0.0
Sample 3	8.0	752	535	10.3	0.00	3.5	8.1	1.4	0.0
Sample 4	7.8	676	482	10.8	2.48	3.9	11.5	1.4	0.0
Sample 5	7.7	689	489	12.1	0.10	5.0	5.2	0.93	0.0
Sample 6	7.3	766	544	12.4	3.68	4.7	4.9	1.03	0.0
Sample 7	7.5	957	680	14.2	0.0	4.2	13.6	0.8	0.0
Sample 8	7.7	653	463	13.1	0.04	5.2	5.2	1.1	0.0
Sample 9	7.3	629	446	11.6	1.78	4.6	9.1	3.4	0.0
Sample 10	7.2	920	654	12.1	0.0	4.1	10.5	0.56	0.0
Sample 11	7.7	623	442	10.3	0.19	5.1	8.3	0.5	0.0
Sample 12	7.8	465	380	8.7	0.0	4.4	8.7	0.3	0.0
Sample 13	7.8	468	334	10.6	0.0	4.8	6.9	0.3	0.0
Sample 14	7.8	662	470	9.8	0.0	3.8	7.06	0.46	0.0
Sample 15	7.2	776	552	12.4	0.0	6.3	12.9	0.53	0.0
Pak-EPA	8.5			<500			250		
WHO	6.5	1500	1000		<5	20	250	0.5-1.5	0.01

Table 2. Physico chemical results of Gulberg Green.

Serial no.	Ph	EC	TDS	Hardness	Turbidity	Alkalinity	Chloride	Fluoride	As
Sample 1	7.5	326	231	8.2	0.19	1.7	8.5	0.6	0.0
Sample 2	7.8	1057	750	12.4	0.00	5.2	10.5	1.0	0.0
Sample 3	7.6	1005	717	15.1	0.1	4.8	9.8	1.0	0.0
Sample 4	7.6	766	541	14.0	0.02	5.2	6.8	0.7	0.0
Sample 5	7.7	1056	750	13.3	0.01	5.1	10.4	1.7	0.0
Sample 6	7.9	1051	746	15.3	0.03	4.8	13.3	0.6	0.0
Sample 7	8.0	1501	740	12.7	0.13	4.4	9.1	1.2	0.0
Sample 8	7.8	883	627	12.7	0.00	5.2	7.1	0.6	0.0
Sample 9	7.9	1180	839	11.8	0.08	5.3	6.2	1.6	0.0
Sample 10	7.6	849	609	12.3	0.02	4.2	6.4	1.1	0.0
Sample 11	7.3	696	494	11.1	0.2	4.5	4.1	1.4	0.0
Sample 12	7.9	950	674	13.3	0.16	5.0	8.3	0.8	0.0
Sample 13	7.4	695	493	11	0.00	4.5	4.8	0.3	0.0
Sample 14	7.6	1040	739	15.8	1.0	5.1	8.4	0.8	0.0
Sample 15	7.8	905	641	17.1	0.18	5.8	11.1	1.1	0.0
WHO	6-8	1500	1000		<5	20	250	0.1-1.5	0.01

Table 3. Physico chemical results of Korang River.

Serial no.	pH	EC	TDS	Hardness	Turbidity	Alkalinity	Chloride	Fluoride	As
Sample 1	5.86	1211	858	12.3	129	6.4	20	0.03	0.1
Sample 2	5.84	1164	822	10.8	94	6.2	22	0.13	0.05
Sample 3	6.0	1159	821	10.8	92	6.3	19.2	0.5	0.01
Sample 4	6.19	1090	772	12.5	107	8.3	18.4	0.3	0.05
Sample 5	5.89	1194	846	11.6	177	6.8	15.4	0.03	0.0
Sample 6	6.07	1091	771	12	201	7.3	16.3	0.3	0.0
WHO	6-8	1500	1000		<5	20	250	0.1-1.5	0.01

Table 4. Total Bacteria, coliform, *E. coli*, *Salmonella* and *Shigella* found in water samples of PWD.

Sample #	**Total Bacteria Count (CFU/ml)**	***Escherichia coli* (CFU/ml)**	***Fecal coliform* (CFU/ml)**	***Salmonella&Shigella.* (CFU/ml)**
Sample 1	12	0	2	0
Sample 2	8	1	4	0
Sample 3	22	0	2	8
Sample 4	23	4	5	0
Sample 5	20	0	5	0
Sample 6	13	0	13	0
Sample 7	14	0	0	0
Sample 8	78	0	0	0
Sample 9	166	0	0	5
Sample 10	85	0	107	3
Sample 11	23	0	7	1
Sample 12	21	0	11	0
Sample 13	100	0	17	1
Sample 14	131	27	0	0
Sample 15	21	3	5	0

Table 5. Total Bacteria, coliform, *E. coli*, *Salmonella* and *Shigella* found in water samples of Gulberg.

Sample #	***Total Bacteria Count* (CFU/ml)**	***Escherichia coli* (CFU/ml)**	***Fecal coliform* (CFU/ml)**	***Salmonella* & *Shigella*. (CFU/ml)**
Sample 1	TNTC	0	0	0
Sample 2	333	224	0	0
Sample 3	53	32	0	0
Sample 4	39	TNTC	0	10
Sample 5	83	TNTC	10	0
Sample 6	2	0	TNTC	1
Sample 7	3	0	TNTC	0
Sample 8	16	10	TNTC	0
Sample 9	TNTC	1	252	0
Sample 10	TNTC	3	10	TNTC
Sample 11	4	0	4	0
Sample 12	6	45	0	0
Sample 13	76	1	0	0
Sample 14	12	3	0	0
Sample 15	106	96	6	2

*****TNTC=Too numerous to count

Fluoride: In PWD bore wells, fluoride ranged from 0.3 mg/L to 3.4 mg/L (sample 9), with sample 1 showing notable variation (Fig. 9). In Gulberg Green, the highest levels were 1.7 mg/L (sample 5) and 1.6 mg/L (sample 9), while the lowest was 0.3 mg/L (sample 13, construction site) as shown in Table 2. Korang River samples showed lower fluoride, ranging from 0.03 mg/L (samples 1 and 5) to 0.5 mg/L (sample 3). The higher levels of fluoride may be due to the fertilizers or sewage contamination in the water reservoirs. The WHO permissible limit for the fluoride in drinking water is 1.5mg/L and the higher levels of fluoride in the drinking water may accelerate the risk of fluorosis, which initiates the hip joint fractures in women, as fluoride may be associated with the gender-dependent mechanisms. Besides, previous studies have confirmed the higher concentrations of fluoride in the portable water of Pakistan (Chandio et al., 2015, Rasool et al., 2018).

Arsenic: Analysis of As results presented in Table 1 and 2 in the PWD and Gulberg show that all the locations were free of As content. As for the Korang River, it was found to have concentration of As ranging from 0.1 to 0.5 mg/L in some samples. Arsenic contents were compared with the WHO guideline value of 0.01 mg/L (Organization, 2022). Arsenic levels are elevated mainly in the Korang River samples (S1–S4), with some samples exceeding the WHO limit, while in the remaining samples arsenic was not detected or found below the permissible limit. Previous studies conducted in other parts of Punjab, Pakistan have reported comparatively higher concentrations of As in the drinking water sources (Javed et al., 2020).

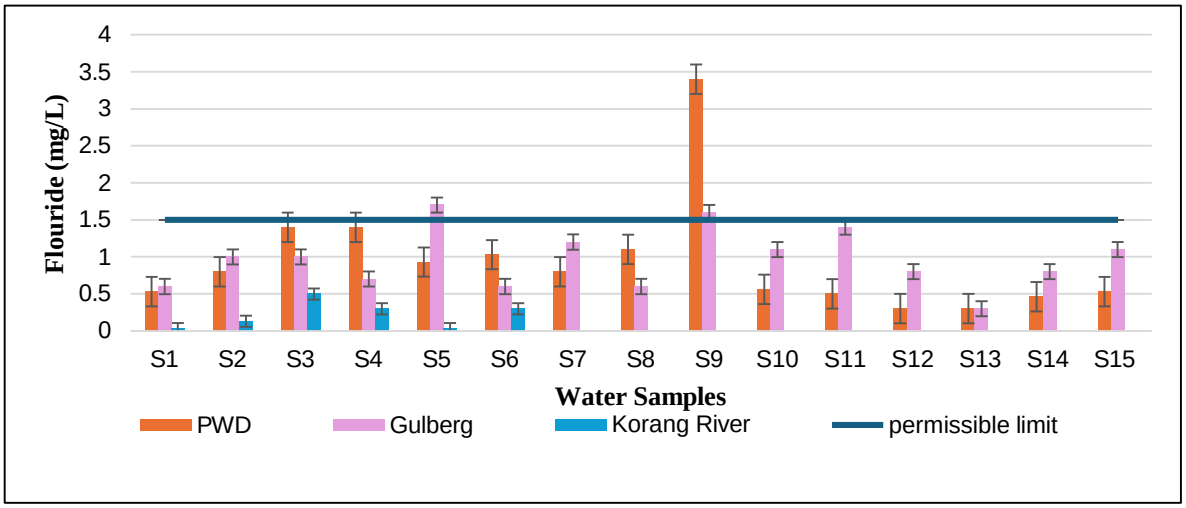

Fig. 9 Concentration of fluoride in study area.

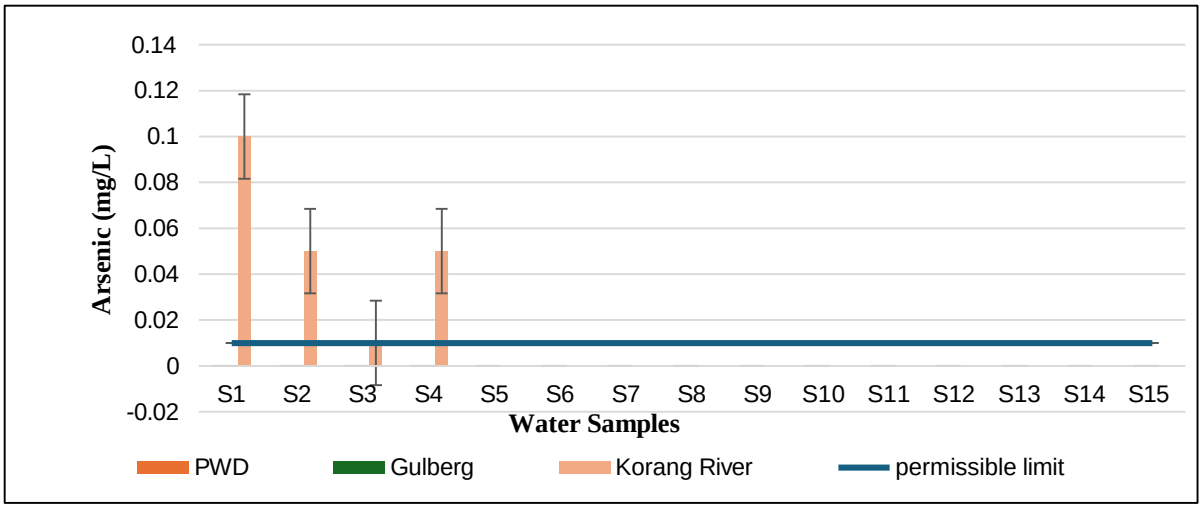

Fig. 10 Concentration of arsenic in the study area.

Microbial Analysis

Table 4 shows microbial analysis for the samples collected from the Bore wells of PWD. In the analysis, all the samples showed growth of Bacteria. *Total Coliform* was found in eleven samples (S1, S2, S3, S4, S5, S6, S10, S11, S12, S13 and S15). These samples were collected from mosque, D Watson, Poor women's house, another house, car wash station, filter plant, house and shop, respectively. The rest of the four samples showed negative results (S7, S8, S9, S14) which were collected from filter plant, filter plant of a house, another house and water filter at the side of a road, respectively. *E. coli* was found in eight samples (S1, S2, S4, S6, S11, S13, S14, and S15) and the rest of the samples showed negative results (S3, S5, S7, S8, S9, S10, and S12). Five samples (S3, S9, S10, S11, and S13) were found contaminated with *Salmonella* and *Shigella*.

Table 5 shows microbial analysis for the samples collected from the pumping wells of Green Gulberg Town. All the samples showed growth of Bacteria. Total Coliform was found in eight samples (S5, S6, S7, S8, S9, S10, S11, and S15), collected from a house, another house, construction site, a store, construction site, house, and mosque and the construction site, respectively. Rest of the samples showed negative results (S1, S2, S3, S4, S12, S13, and S14) which were collected from property dealer office with water supply connection, labor resting area, water tank, mosque, house, and two construction sites, respectively. E. coli was found in eleven samples (S2, S3, S4, S5, S8, S9, S10, S12, S13, S14, and S15). The

remaining samples showed negative results (S1, S6, S7, and S11). Only four samples (S4, S6, S10, and S15) were found contaminated with *Salmonella* and *Shigella*.

Microbiological results were interpreted according to WHO drinking-water guidelines, which require E. coli to be absent (0 per 100 mL) in water used for drinking. Accordingly, any detection of E. coli and/or fecal coliforms was considered unsafe for direct consumption. E. coli was identified in 4/15 PWD samples (S2, S4, S14, S15) and 11/15 Gulberg samples and fecal coliforms were also commonly present, thus making these waters unsuitable for consumption without proper treatment and protection of the water sources. Similar contamination patterns have been reported in Islamabad and Punjab, respectively (Rasheed et al., 2016, Ahmed et al., 2020).

Salmonella and *Shigella* are common in areas with poor sanitation because they originate from human and animal waste, and both can cause serious illnesses such as typhoid, shigellosis, and gastroenteritis (Mahagamage et al., 2020).

These pathogens, along with *E. coli*, are known to survive well in water, and their presence usually reflects contamination from sewage or human activities (Ahmed et al., 2020). In this study, the detection of *Salmonella*, *Shigella*, and E. coli indicates sewage intrusion into water bodies of Islamabad and Rawalpindi due to poorly managed pipelines, drainage leakage, and pollution in the densely populated Korang River basin. Overall, about 10 samples were tested positive for Salmonella and Shigella, 16 for coliforms, and 20% contained all major pathogens, highlighting a significant water safety concern even during the dry season.

Effective management of water reservoirs requires protecting water sources and minimizing reliance on treatment methods. Korang River and Rawal Lake, major water sources for Islamabad and Rawalpindi, face significant contamination from both point and non-point sources. To prevent outbreaks of enteric pathogens, these reservoirs must be safeguarded from fecal contamination, and a reliable sewage disposal system should be implemented and maintained (Anser et al., 2020).

Conclusion

The study of 36 water samples (PWD Colony, Gulberg Green and Korang River) collected during months of April–May were found highly variable and, in places, unsafe water quality. The pH ranged between 5.8–8.5 (mean = 7.4), TDS 230–858 mg/L (mean = 544 mg/L), extreme turbidity in Korang (92–201 NTU), fluoride up to 3.4 mg/L and a peak arsenic reading of 0.10 mg/L.

The presence of E. coli/fecal indicators and Salmonella/Shigella indicates fecal intrusion and non-compliance with WHO guidelines, making these waters unsafe for drinking, and posing serious health risks, if measures for effective treatment and protection of sources are not taken. The results point to urgent, integrated actions: protect the Korang catchment from sewage and waste discharge, repair water supply lines to prevent cross-contamination, apply turbidity control (coagulation/filtration) prior to disinfection, implement targeted de-fluoridation and arsenic removal where needed, and promote household-level safeguards (boiling, point-of-use filtration) while system upgrades proceed.

Noting the study's limitations (single dry-season sampling, modest sample size and some field/kit methods), we recommend expanded seasonal monitoring with higher-precision laboratory assays (including arsenic speciation), molecular pathogen testing and quantitative risk assessment to better target interventions, and protect public health in the Islamabad–Rawalpindi water supply network.

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References

PCRWR (2021). Drinking water quality in Pakistan: Current status and challenges. Pakistan Council of Research in Water Resources, Islamabad.

Ahmad, S. S., Murtaza, R., Shabir, R., Ahmed, M. N., Shah, T. (2014). Environmental diversification and spatial variations in riparian vegetation: A case study of Korang River, Islamabad. *Pak. J. Bot*, **46,** 1203-1210.

Ahmed, J., Wong, L. P., Chua, Y. P., Channa, N., Mahar, R. B., Yasmin, A., Vanderslice, J. A., Garn, J. V. (2020). Quantitative microbial risk assessment of drinking water quality to predict the risk of waterborne diseases in primary-school children. *International Journal of Environmental Research and Public Health*, **17,** 2774.

Aleem, M., Shun, C. J., Li, C., Aslam, A. M., Yang, W., Nawaz, M. I., Ahmed, W. S., Buttar, N. A. (2018). Evaluation of groundwater quality in the vicinity of Khurrianwala Industrial Zone, Pakistan. *Water,* **10,** 1321.

Ali, A., Shahzad, S., Hashim, I. (2015). Assessment of surface water quality of River Korang. *The Holistic Approach to Environment,* **5,** 191-209.

Altaf, A. (2018). Final orders: Korang River getting polluted [Online]. Available: Https://Tribune.Com.Pk/Story/1818564/Final-Orders-Korang-River-Getting-Polluted [Accessed 26 February 2026].

Anser, M. K., Yousaf, Z., Usman, B., Nassani, A. A., Abro, M. M. Q., Zaman, K. (2020). Management of water, energy, and food resources: Go for green policies. *Journal of Cleaner Production,* **251,** 119662.

Bashir, S., Aslam, Z., Niazi, N. K., Khan, M. I., Chen, Z. (2021). Impacts of water quality on human health in Pakistan. *Water Resources Of Pakistan: Issues And Impacts.* Springer.

Batool, A., Samad, N., Kazmi, S. S., Ghufran, M. A., Imad, S., Shafqat, M., Mahmood, T. (2018). Spring water quality and human health: An assessment of natural springs of Margalla Hills Islamabad Zone—Iii. *International Journal Of Hydrology,* **2,** 41-46.

Brief, A. (2017). Water quality and health-review of turbidity: Information for regulators and water suppliers. *Who/Fwc/Wsh,* **17,** 1-10.

Butt, M., Khair, S. (2014). Cost of illness of water-borne diseases: A case study of Quetta. *Journal of Applied and Emerging Sciences (Pakistan),* **5,** 133-143.

Chandio, T. A., Khan, M. N., Sarwar, A. (2015). Fluoride estimation and its correlation with other physicochemical parameters in drinking water of some areas of Balochistan, Pakistan. *Environmental Monitoring and Assessment,* **187,** 531.

Chaudhari, P. R., Ahire, D. V., Chkravarty, M., Maity, S. (2014). Electrical conductivity as a tool for determining the physical properties of Indian Soils. *International Journal of Scientific and Research Publications,* **4,** 1-4.

Corwin, D. L., Yemoto, K. (2020). Salinity: Electrical conductivity and total dissolved solids. *Soil Science Society of America Journal,* **84,** 1442-1461.

Dalmieda, J., Kruse, P. (2019). Metal cation detection in drinking water. *Sensors,* **19,** 5134.

Daud, M., Nafees, M., Ali, S., Rizwan, M., Bajwa, R. A., Shakoor, M. B., Arshad, M. U., Chatha, S. A. S., Deeba, F., Murad, W. (2017). Drinking water quality status and contamination in Pakistan. *Biomed Research International,* **2017,** 7908183.

Environment, G. O. P. M. O. (2010). National environmental quality standards (neqs) for ambient air, national standards for drinking water quality, and national environmental quality standards for noise. Islamabad: Government Of Pakistan, Ministry Of Environment.

Hussain, S. A., Hussain, A., Fatima, U., Ali, W., Hussain, A., Hussain, N. (2016). Evaluation of drinking water quality in urban areas of Pakistan, A case study of Gulshan-e-Iqbal Karachi, Pakistan. *Journal of Biological and Environmental Science,* **8,** 64-76.

Iqbal, J., Javed, H., Sajjad, M. T. (2024). An assessment of the drinking water supply system in Islamabad, Pakistan. *Engineering Proceedings,* **75,** 6.

Jalees, M. I., Farooq, M. U., Anis, M., Hussain, G., Iqbal, A., Saleem, S. (2021). Hydrochemistry modelling: Evaluation of groundwater quality deterioration due to anthropogenic activities in Lahore, Pakistan. *Environment, Development & Sustainability,* **23,** 3062–3076.

Javed, A., Amjad, H., Hashmi, I. (2022). Drinking water quality monitoring of centralized water storage reservoirs in various zones of the National University. *Nust Journal Of Engineering Sciences,* **15,** 44-52.

Javed, A., Farooqi, A., Baig, Z. U., Ellis, T., Van Geen, A. (2020). Soil arsenic but not rice arsenic increasing with arsenic in irrigation water in the punjab plains of Pakistan. *Plant and Soil,* **450,** 601-611.

Ji, Y., Wu, J., Wang, Y., Elumalai, V., Subramani, T. (2020). Seasonal variation of drinking water quality and human health risk assessment in Hancheng city of Guanzhong Plain, China. *Exposure And Health,* **12,** 469-485.

Kachroud, M., Trolard, F., Kefi, M., Jebari, S., Bourrié, G. (2019). Water quality indices:

Challenges and application limits in the literature. *Water*, **11,** 361.

Kashiwase, H. F., Tony. (2023). World water day: Two billion people still lack access to safely managed water [Online]. Washington, Dc: World Bank. Available: Https://Blogs.Worldbank.Org/En/Opendata/World-Water-Day-Two-Billion-People-Still-Lack-Access-Safely-Managed-Water [Accessed 28 February 2026].

Khalid, R., Jamil, A., Younas, K., Rasheed, S., Ghaffour, N., Nawaz, M. S. (2025). Removal of pesticide lambda–cyhalothrin from aqueous medium by parthenium hysterophorus biochar with non–linear adsorption modeling. *Desalination and Water Treatment,* 101480.

Mahagamage, M., Pathirage, M., Manage, P. M. (2020). Contamination status of salmonella spp., shigella spp. and campylobacter spp. In surface and groundwater of the Kelani River Basin, Sri Lanka. *Water*, **12,** 2187.

Masood, Z., Rehman, H. U., Baloch, A., Akbar, N. U., Zakir, M., Gul, I., Gul, N., Jamil, N., Din, N., Ambreen, B. (2015). Analysis of physicochemical parameters of water and sediments collected from Rawal Dam Islamabad. *American-Eurasian Journal Of Toxicological Sciences*, **7,** 123-128.

Nadeem, N., Nadeem, M., Bostan, N., Sattar, S., Simm, R. & Javed, S. (2025). Assessment Of water quality and occurrence of multidrug-resistant clinically relevant bacteria in drinking water in the twin cities of Pakistan. *Environmental Monitoring And Assessment*, **197,** 1-12.

Organization, W. H. (2017). Water quality and health: review of turbidity: Information for regulators and water suppliers [Online]. Geneva: World Health Organization. Available: Https://Www.Who.Int/Publications/I/Item/Who-Fwc-Wsh-17.01 [Accessed 02 March 2026].

Organization, W. H. (2022). Arsenic [Online]. Available: Https://Www.Who.Int/News-Room/Fact-Sheets/Detail/Arsenic [Accessed 1 March 2026].

Ozlu, E. Kumar, S. (2018). Response of soil organic carbon, ph, electrical conductivity, and water stable aggregates to long-term annual manure and inorganic fertilizer. *Soil Science Society of America Journal*, **82,** 1243-1251.

Rasheed, S., Hashmi, I., Campos, L. 2016. Inactivation of escherichia coli and salmonella with chlorine in drinking waters at various ph and temperature levels: Chlorine inactivation of e. coli and salmonella. *Proceedings of The Pakistan Academy of Sciences: B. Life and Environmental Sciences*, **53,** 83-92.

Rasool, A., Farooqi, A., Xiao, T., Ali, W., Noor, S., Abiola, O., Ali, S., Nasim, W. (2018). A review of global outlook on fluoride contamination in groundwater with prominence on the Pakistan current situation. *Environmental Geochemistry and Health*, **40,** 1265-1281.

Shabbir, R., Ahmad, S. S. (2015). Use of geographic information system and water quality index to assess groundwater quality in Rawalpindi And Islamabad. *Arabian Journal for Science and Engineering*, **40,** 2033-2047.

Shahid, N., Zia, Z., Shahid, M., Faiq Bakhat, H., Anwar, S., Mustafa Shah, G., Rizwan Ashraf, M. (2015). Assessing drinking water quality in Punjab, Pakistan. *Polish Journal of Environmental Studies*, **24,** 2597-2606.

Shahzad, S., Ali, N., Hussain, J., Ali, A., Ali, S. (2019). Prevalence of water-borne diseases and perception of quality of drinking water in the low socioeconomic area of Islamabad, Pakistan: A cross-sectional study. *South Asian Journal Of Emergency Medicine*, **2,** 29-36.

Shehzadi, R., Rafique, H., Abbas, I., Sohl, M. A., Ramay, S. M., Mahmood, A., Sohl, M. N. (2015). Assessment of drinking water quality of Tehsil Alipur, Pakistan. *Desalination and Water Treatment*, **55,** 2253-2264.

Sohail, M. T., Mahfooz, Y., Aftab, R., Yen, Y., Talib, M. A., Rasool, A. (2020). Water quality and health risk of public drinking water sources: a study of filtration plants installed in Rawalpindi and Islamabad, Pakistan. *Desalination And Water Treatment*, **181,** 239-250.

Talpur, H. A., Talpur, S. A., Mahar, A., Rosatelli, G., Baloch, M. Y. J., Ahmed, A., Khan, A. H. A. (2024). Investigating drinking water quality, microbial pollution, and potential health risks in selected schools of Badin city, Pakistan. *Hydroresearch*, **7,** 248-256.

Tauseef Azam, M., Ahmad, A., Ahmed, A., Khalid, A. Saleem, S. (2024). Health risk assessment of arsenic

and lead contamination in drinking water: a study of Islamabad And Rawalpindi, Pakistan. *Water Supply*, **24,** 2055-2065.

Zeb, H., Yaqub, A., Ajab, H., Zeb, I. Khan, I. (2023). Effect of climate change and human activities on surface and ground water quality in major cities of Pakistan. *Water*, **15,** 2693.