International Journal of
Innovative Research

International Journal of Innovative Research, **10(3)**: 70–78, 2025
ISSN 2520-5919 (online)
www.irsbd.org

RESEARCH PAPER

Current contamination situation of surface water of Rajshahi Metropolitan city

Anupam Mozumder[1], Keya Karmokar[2], A. F. M. Shahabuddin[3]

[1]Department of environmental science, Bangladesh Agricultural University, Mymensingh, Bangladesh.
[2]Senior Scientific Officer, Soil Resource Development Institute, Dhaka, Bangladesh.
[3]Department of Agricultural Extension, Ministry of Agriculture, Bangladesh.

ARTICLE HISTORY

Received: October 10, 2025
Revised: November 20, 2025
Accepted: December 17, 2025
Published: December 31, 2025

*Corresponding author:
keyasau20@gmail.com

ABSTRACT

Rapid urbanization and unregulated discharge of municipal and agricultural effluents have raised concerns regarding the suitability of surface water for irrigation and aquaculture in Rajshahi, Bangladesh, necessitating a comprehensive assessment of its quality. This study was conducted to evaluate the physicochemical properties and selected elemental concentrations of river, canal, pond, and drain water in the Rajshahi metropolitan area. Water samples were collected from 20 locations and analyzed for pH, electrical conductivity (EC), potassium (K), sulphur (S), phosphorus (P), sodium (Na), and arsenic (As) using standard laboratory procedures. The results showed that mean pH values (7.38–7.54) indicated slightly alkaline conditions but remained within the acceptable range (6.5–8.5) recommended for irrigation water. Electrical conductivity values (342.80–616.00 µS/cm) were below the threshold limit of 750 µS/cm, suggesting no salinity hazard for irrigation. Sodium concentrations (14.38–29.60 ppm) were within permissible limits for irrigation use. Arsenic concentrations (0.0020–0.0052 ppm) were far below the maximum allowable limit of 0.01 ppm for irrigation water, indicating no immediate arsenic toxicity risk. However, potassium concentrations in most samples exceeded the recommended level for aquaculture, with only one sampling site (Kumerpara) falling within the suitable range. Overall, the studied water bodies were suitable for irrigation based on pH, EC, Na, and As concentrations, although limitations exist for aquaculture due to elevated potassium levels in most sites. Continuous monitoring and effective regulatory measures are recommended to ensure sustainable water quality management in the metropolitan area.

Keywords: Water, nutrient, pH, EC, pollution.

Introduction

Water quality deterioration occurs through physical, chemical, and biological alterations, often resulting from the discharge of untreated municipal sewage, industrial effluents, agricultural runoff, and solid wastes (Vörösmarty et al., 2010; Zhang et al., 2015; Stewart et al., 2016). In developing countries, inadequate sanitation and waste management systems further accelerate contamination of natural water bodies (Levy et al., 2016; Agyeman et al., 2020).

Natural water typically contains dissolved major and minor constituents (e.g., Ca^{2+}, Mg^{2+}, Na^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}) and trace elements such as As, Cd, Cr, Cu, Mn, P, and Zn due to geological and environmental factors (Appelo & Postma, 2010; Srinivasamoorthy et al., 2012). While many of these elements are essential in small amounts, elevated concentrations can reduce irrigation suitability, lower crop productivity, cause ionic toxicity, and pose health risks to humans and aquatic organisms (Ayers & Westcot, 2015; Tchounwou et al., 2012). Seasonal variation also significantly influences macro- and micronutrient concentrations in surface and groundwater (Al-Fughum & Al-Anzy, 2015; Iqbal et al., 2017). Therefore, systematic monitoring of physicochemical parameters is essential to evaluate water suitability for irrigation, aquaculture and domestic use.

Rajshahi is one of the rapidly expanding metropolitan cities in northwestern Bangladesh. Accelerated urban growth, increasing population density, expanding agricultural activities, and inadequate waste management systems have raised concerns regarding the deterioration of surface water quality in rivers, canals, ponds, and urban drains within the metropolitan area. These water bodies are extensively used for irrigation, fish culture, and other domestic and agricultural purposes. However, comprehensive and updated information on their physicochemical and elemental status remains limited.

Considering the increasing anthropogenic pressure and the dependence of local communities on these water resources, a detailed assessment of water quality is necessary. Therefore, the present study was undertaken to determine key physicochemical parameters pH and electrical conductivity (EC) and to quantify selected macro and trace elements, namely potassium (K), sulphur (S), phosphorus (P), sodium (Na), and arsenic (As), in river, canal, pond, and drain water of Rajshahi metropolitan city. The findings of this study will provide scientific evidence regarding the suitability of these water sources for irrigation and aquaculture and will contribute to sustainable water resource management in the region.

Materials and Method

The study was conducted in Rajshahi, a rapidly urbanizing metropolitan city located in the northwestern region of Bangladesh along the bank of the Padma River. The city includes mixed land-use areas comprising residential zones, commercial centers, agricultural fields, and drainage networks, which potentially influence surface water quality through municipal, agricultural, and urban runoff.

Sampling Design and Justification

To represent the overall contamination status of surface water within the metropolitan area, four major categories of surface water bodies were selected: river, canal, pond, and drain water. These sources reflect the principal water bodies used for irrigation, aquaculture, and urban discharge in the study area. A total of 20 sampling sites were selected using a stratified approach, with five samples collected from each water category (River: R_1–R_5; Canal: C_1–C_5; Pond: P_1–P_5; Drain: D_1–D_5). Sampling locations were distributed across different functional zones of the city, including residential, commercial, institutional, and wastewater-affected areas, to capture spatial variability and anthropogenic influence. This distribution ensured representative coverage of major surface water systems and potential pollution gradients within the metropolitan area.

Samples were collected during the period of August to October 2011, representing the post-monsoon season when surface runoff and dilution effects stabilize and allow assessment of prevailing contamination levels.

Collection of water samples

20 samples of water taken from different places covering 5 from each of Padma River and ponds, canal and different drain of Rajshahi urban region within August - October 2011. Samples represented as River water (R_1-R_5), Canal water (C_1-C_5), Pond water (P_1-P_5), and Drain water (D_1-D_5) and they are outlined in Table1. Water sampling sources and collected sample information for analysis was mentioned in Table 1.

Type of water collected	Sampling sites	Sample code
River water	Kumarpara	R_1
	Durgapara	R_2
	Laxmipur	R_3
	I-damn	R_4
	T-damn	R_5
Pond water	Salbon petrol pump	P_1
	D.C office	P_2
	Rajshahi college	P_3
	Rajshahi court	P_4
	Ram Chandrapur	P_5
Canal water	Under the Binodpur bridge	C_1
	Dackmari	C_2
	Katakhali	C_3
	Harian	C_4
	Beside the Binodpur bridge	C_5
Drain water	Near Rajshahi central jail	D_1
	New market	D_2
	Rail station	D_3
	Shamokdum majar	D_4
	Saheb bazer	D_5

Water samples were taken into 100 ml of plastic bottles and cleaned with diluted hydrochloric acid (1:1) and washed with distilled water. The bottles were re -sagged 3 to 4 times with water to first remove. The samples containing a bottle immediately sealed to prevent air exposure. Samples were taken from several centimeters below the surface. To provide the necessary information for each sample, such as collected data, location, etc., they were recorded in the notebook and each sample collected in the plastic bottle marked with a separate identification number. End of collection, all samples were filtered with Whatman No. 1 filter paper to remove undesirable solid and suspended material before analysis. 90 ml of samples were transferred to another 100 ml bottle, which contained 10 ml of 2m of hydrochloric acid solution. The hydrochloric acid solution protected water samples from any fungal and other pathogenic attack. Collected water samples were for chemically analyzed carrying to Humvold Soil Testing Laboratory, Bangladesh Agricultural University, Mymensingh. After being brought to the laboratory, the bottles were held in a clean, cool and dry place. The mentioned analysis on collected samples was hydrogen ion concentration (pH), Electrical conductivity, K, S, P, Na and As).

Hydrogen ion concentration

The concentration of hydrogen ion (pH) of water determined electrometrically by taking 100 ml sample in 200 ml of beaker immersing electrode pH of the meter (model WTW pH 522) to water (Apha, 1995).

Electrical Conductivity (EC)

Electrical conductivity (EC) of the water samples was measured electrometrically using a conductivity meter (Model WPACM 35) following the standard procedure described by Tandon, 1995. Approximately 100 mL of water sample was placed in a 200 mL beaker, and the electrode of the conductivity meter was immersed directly into the sample to record the EC value.

Potassium

Designed potassium (K) using water independently using the emission spectrophotometer of the flame (model Jenway PEP3) with suitable filters. About 50 ml of filtered samples were poured into 100 ml beaker aspired in the flame of light emitted by potassium at 768 nm, which directly proportional to the concentration of these ions presented in water samples. The current emissions for both elements were recorded according to the procedures designed by Golterman, 1971 and Ghosh et *al.*, 1983.

Sulphur

Sulphur (S) determined turbidimatrically using barium chloride ($BaCl_2.2H_2O$) as turbidimatric agent. Exactly 25ml water samples were taken within a volumetric flask followed by addition of 10 ml sodium acetate acetic acid buffer solution, 1 ml gun acatia 1g barium chloride ($BaCl_2$) crystal. After proper mixing, the turbidity was measured at λmax of 425 nm using spectrophometer of Model Seectronic 21D (Wolf, 1982 and Tandon, 1995).

Phosphorus

Phosphorus (P) determined from waters separately using flame emission spectrophometer (Model Jenway PEP3) by appropriate filters. About 50 ml filtered samples were taken into a 100 ml beaker aspirated in a natural gas flame of light emitted by Calcium at 422.7 nm which directly proportional to the concentration of ions presented within sample, respectively. The presented emission for both elements was recorded maintaining procedures suggested Golterman 1971 and Ghosh *et al*., 1983.

Sodium

Determined Sodium (Na) separately by flame emission spectrophometer (Model Jenway PEP3) using appropriate filters. About 50 ml of filtered samples collected in 100 ml beaker aspired in the flame of light emitted by sodium at 589 nm, which directly proportional to the concentration of ions listed in the sample. The present emission for both elements recorded maintaining guideline suggested by Golterman 1971 and Ghosh *et al*., 1983.

Arsenic

Designed arsenic (As), atomic absorption spectrophotometer (AAS, Unicam969) according to the Clesceri et *al.*, 1989. The wave lengths of Mn and As were 279.5 nm and 193.7 nm, respectively.

Statistical analysis

Statistical analysis of generated data was carried out by using the methods of Gomez and Gomez 1984 correlation studies were also calculated according to procedure described by the author.

Results and Discussion

The water samples of selected sites of Rajshahi Metropolitan Area were analyzed for the major ionic constituents such as pH, EC, K, S, P, Na, As and the results have been presented in Table (2-3).

Hydrogen ion concentration (pH)

The pH values of the 20 water samples collected from river, canal, pond, and drain sources in Rajshahi ranged from 7.22 to 7.66, indicating slightly alkaline conditions. None of the samples were acidic (pH < 7.0). The overall mean pH value was 7.46. The highest pH value (7.66) was recorded in sample R_3 (Laxmipur), while the lowest value (7.22) was observed in sample R_2 (Durgapur) (Table 2). The average pH values for river, canal, pond, and drain water were 7.44, 7.38, 7.47, and 7.54, respectively (Table 3).

The pH values of the studied water samples (7.22–7.66) indicate slightly alkaline conditions, with an overall mean of 7.46. These values fall within the recommended range of 6.0–8.5 for irrigation water (FAO, 2015), suggesting no pH-related limitation for agricultural use. Similarly, the observed pH values lie within the optimal range (6.5–8.5) for freshwater aquaculture indicating suitability for fish culture (Boyd, 2015; Bhatnagar and Devi, 2013). The slightly alkaline nature of the water bodies is consistent with recent studies conducted in Bangladesh, where river and surface waters commonly exhibit pH values between 7.0 and 8.0 (Islam et al., 2015; Rahman et al., 2017; Uddin et al., 2021). These similarities suggest that the present findings reflect the typical Hydrochemical characteristics of surface waters in the region.

Electrical conductivity (EC)

The EC of water samples collected from the different location of Padma River, Canal, Drain and pond of Rajshahi Metropolitan Area in the range of 340 to 619 μScm^{-1} with the mean value of 430 μScm^{-1}. EC of water samples taken from various locations of the Padma, Canal, Drain and Metropolitan Rajshahi pond in the range of 340 to 619 μScm^{-1} with a mean 430 μScm^{-1}.

Of the 20 samples, 15 samples (75%) showed lower than the mean value and the rest 5 showed higher than the average value. The highest EC value 619 μScm^{-1} was obtained from P_3 (Rajshahi college), whereas the lowest value 340 μScm^{-1} was observed in C_3 (Katakhali), (Table 2). On the other hand, The EC of Padma River of Rajshahi Metropolitan Area in the range of 371 to 375 µScm^{-1} with the mean value of 373.20 µScm^{-1} (Table 2). The EC of Pond in the range of 615 to 619 µScm^{-1} with the mean value of 616 µScm^{-1}, Canal within range of 340 to 346 µScm^{-1} and mean value was 342.80 µScm^{-1} and EC of drain water range of 386 to 390 µScm^{-1} with mean value was 388 µScm^{-1} (Table 2). The average Electrical conductivity (EC) in river pond canal and drain was 373.20, 616.00 342.80, 388.00 µScm^{-1} (Table. 3).

The EC values of the studied water samples ranged from 340 to 619 µS/cm, with a mean value of 430 µS/cm, indicating moderate ionic concentration. According to FAO guidelines, irrigation water with EC between 0.25 and 0.75 mS/cm falls under the medium salinity category (FAO, 2015). The EC values recorded in the present study (0.34–0.62 mS/cm) therefore indicate medium salinity water, which is generally suitable for irrigation of most crops under proper soil and water management practices.

The observed EC values are comparable with recent studies conducted in Bangladesh. EC values ranging from approximately 300–700 µS/cm in the Buriganga River (Islam et al., 2015), while documented EC levels between 350–650 µS/cm in the Turag River (Rahman et al., 2017). Similarly, many Bangladeshi rivers exhibit EC values within 300–800 µS/cm depending on seasonal variation (Uddin et al., 2021). These similarities suggest that the present findings reflect the typical Hydrochemical characteristics of surface waters in Bangladesh.

Concentration of Potassium (K)

Water samples containing potassium (K) taken from different locations of the Metropolitan Rajshahi area in the range of 4.70 to 10.75 ppm with a mean value of 22.7.68 ppm (Table 2). Of the 20 samples, 10 samples (50.00%) showed lower than the mean value and the rest of 10 (50.00%) showed higher than the average value. The presence of higher P content (10.75 ppm) was found at P_3 (Rajshahi Collage) and the lowest P content (4.70ppm) at R_1 (kumerpara) (Table 2). The Potassium (K) of River in the range of 4.70 to 4.78 ppm with the mean value of 4.74 ppm, In Canal the range was 5.15 to 5.16ppm and mean value was 5.15 ppm and in drain water the range was 10.10 to 10.12 ppm with mean value was 10.11ppm (Table 2). The average Potassium (K) in river pond canal and drain were 4.74, 10.73 5.15, 10.11 ppm (Table 3). K content in monsoon season was higher than the winter season (in case of pond water). This may be due to the K fertilizer escape to the neighboring field of the crop, leaching of domestic outflow and decomposition of organic matter that contaminated water with the pond.

The potassium (K) concentration of the studied water samples ranged from 4.70 to 10.75 ppm, which falls within low to moderate levels commonly observed in surface waters. Elevated K concentrations in some locations may be attributed to agricultural runoff, domestic wastewater discharge, and decomposition of organic matter, particularly during the monsoon season. Similar sources of potassium enrichment in surface waters have been reported in recent studies conducted in Bangladesh (Islam et al., 2015; Rahman et al., 2017; Uddin et al., 2021). Seasonal increases in nutrient concentrations due to rainfall-induced runoff have also been documented (Bhuiyan et al., 2016; Hasan et al., 2019).

Potassium in natural waters may also originate from mineral weathering processes involving potash-bearing minerals such as sylvite and feldspar (Srinivasamoorthy et al., 2014). However, the detected K concentrations in the present study (3.83–16.16 ppm) are within acceptable limits for irrigation water and are not expected to pose any significant hazard to crop production (FAO, 2015). These findings are consistent with recent Hydrochemical studies in Bangladesh, indicating that potassium levels in surface waters generally remain within safe limits for agricultural use.

Concentration of Sulphur(S)

S concentration of collected water samples varied 2.40 - 3.44 ppm where the mean value was 2.95 ppm. Among 20 samples, 20 showed lower Sulphur than the mean value (2.95 ppm) and the rest gave more the mean. The highest value 3.44 was recorded at D_2 (New market) and lowest (2.40 ppm) at P_2 (DC office). The calculated mean value was 2.95 ppm, (Table 2). In the river water concentration of S were varied from 2.75 to 2.76ppm and mean value was 2.755 ppm. In the pond water it was varied from 2.40 to 2.46 and mean value was 2.43. The concentration in the cannel was varied from 3.18 to 3.22 ppm and mean value was 3.20. In the drain water it was varied from 3040 to 3.44 ppm whereas the mean value of 2.95ppm, (Table 2). The average concentration Sulphur(S) in river pond canal and drain were 2.76, 2.43, 3.20, 3.42 ppm (Table 3). From the experimental location S concentration was 2.40 to 3.44 ppm.

Concentration of Phosphorus (P)

The condition of phosphorus (P) of the tested water samples was in the range of 0.279 - 0.488 ppm with a mean value (0.366). Out of 20 samples in 5 (about 75%) K concentration was higher than mean value (0.366) and in the remaining 15 samples (about 75%) P statuses were higher than that of mean value (0.366 ppm). Presence of higher P content (0.488 ppm) was found at R_4 (I-damn) and the lowest P content (0.279 ppm) at C_3 (Katakhali) (Table 2). In the river water concentration of P were varied from 0.446 to 0.488 ppm and mean value was 0.464 ppm. In the pond water it was varied from 0.361to 0.365 ppm and mean value was 0.363.

The concentration in the channel changed from 0.279 to 0.300 ppm and the average value was 0.295. In drain water it was varied from 0.340 to 0.342 ppm, mean value was 0.341ppm. Average concentration Phosphorus (P) in river, pond, canal and drain were 0.464, 0.363, 0.295, 0.341, ppm (Table 3).

Similar ranges of phosphorus in surface waters have been reported in Bangladesh and other South Asian regions. For instance, World Health Organization (2017) reported that surface waters in developing countries often contain elevated nutrient concentrations due to anthropogenic inputs. Moreover, Food and Agriculture Organization (2011) emphasized that nutrient enrichment in irrigation water is frequently associated with fertilizer runoff and urban effluents. A study conducted by Department of Environment Bangladesh (DoE, 2018) also documented comparable phosphorus concentrations in urban surface waters of Bangladesh, indicating moderate nutrient loading influenced by municipal and agricultural activities. According to Food and Agriculture Organization (2015), irrigation water containing moderate nutrient levels, including phosphorus, can contribute positively to crop production when concentrations remain below thresholds causing eutrophication or soil imbalance. The phosphorus levels observed in the present study fall within acceptable ranges for irrigation use and are unlikely to pose immediate toxicity risks to crops.

For aquaculture, nutrient concentrations are critical for maintaining balanced productivity. Food and Agriculture Organization (2014) noted that moderate phosphorus concentrations in aquaculture water bodies support primary productivity but excessive accumulation may cause algal blooms. The phosphorus concentrations recorded in this study are within ranges commonly observed in productive freshwater aquaculture systems. Regarding sodium (Na), recent guidelines by World Health Organization (2017) and Food and Agriculture Organization (2011, 2015) confirm that irrigation water containing sodium below critical thresholds does not significantly impair soil structure or crop yield under proper management. The tested water samples, containing sodium concentrations within acceptable limits, are therefore suitable for long-term irrigation and aquaculture practices in the studied area.

In respect of sodium (Na) concentration, the surface waters of the study area showed values comparable to those reported for other rivers and groundwater sources in Bangladesh. Additionally, studies on ground and surface waters in southern Bangladesh found that river water and groundwater exhibit sodium levels within ranges considered acceptable for irrigation and other uses when evaluated using sodium-related indices such as sodium adsorption ratio (SAR) and soluble sodium percentage (SSP) (Roy *et al.*, 2025). Moreover, broader assessments of coastal and inland water quality in Bangladesh indicate that Na^+ concentrations and associated indicators of salinity vary with geography and season but generally remain below thresholds that would render water unusable for irrigation, although localized salinity intrusion can elevate levels in coastal aquifers (Meem *et al.*, 2025).

Although the measured Na concentrations in the present study were within acceptable limits for irrigation and aquaculture, surface water cannot be considered safe for direct drinking purposes without treatment. Evaporative concentration, sediment interaction, sewage discharge, and industrial effluents are major contributors to elevated sodium levels in surface waters (Stumm & Morgan, 2012; Kaushal & Belt, 2012; Wang & Wang, 2015).

Moreover, drinking water suitability depends not only on sodium concentration but also on microbiological quality and the presence of other chemical contaminants, which were not evaluated in this study. Therefore, proper treatment and disinfection are required before using these water sources for drinking and household consumption. For irrigation purposes, sodium concentration is a critical parameter influencing soil permeability and crop productivity. Irrigation water containing sodium below the permissible threshold does not pose significant sodicity hazards (Qadir et al., 2021; Sharma & Singh, 2022; Martínez-Ballester & Gómez-Larrea, 2023). The sodium levels observed in the present study were well within acceptable limits, indicating that the sampled waters are suitable for long-term irrigation use.

Similarly, for aquaculture and other commercial water uses, sodium concentrations remained within the recommended range suggesting that the water bodies can be utilized for fish culture and related activities, provided that other water quality parameters are properly managed (FAO, 2017).

Concentration of Sodium (Na)

Na content in water sample detected with the limit of 14.37 - 29.60 ppm with mean value of 19.62 ppm. Out of 20 samples, 10 samples (50%) gave below the mean value and the rest 10 (50%) showed above the mean value (19.62 ppm). Among samples, averaged highest value 29.67 ppm found in P_3 (Rajshahi college) while lowest value (14.37 ppm) was found in R_2 (Durgapur), (Table 2). The average concentration of Sodium (Na) in river, pond, canal and drain was 14.38, 29.60, 14.79, 19.72 ppm (Table 3).

The concentration of sodium (Na) in the surface water samples ranged from 14.37 to 29.60 ppm, with an arithmetic mean of 19.62 ppm. This spatial variation, where half the samples lay above and half below the mean, reflects natural Hydrochemical variability widely documented in surface waters (Hem, 2013; Wetzel, 2001). Elevated Na levels in specific sites like P3 (Rajshahi College) may also reflect local hydroclimatic and anthropogenic influences on water chemistry (Kaushal & Belt, 2012).

The Ca concentrations in the present study (2.01 to 7.29 ppm) fall within the range typical of freshwater systems where Ca is largely controlled by mineral dissolution (Appelo & Postma, 2005). Natural dissolution of calcium carbonate and sulfate minerals is a common source of Ca in both surface and groundwaters (Freeze & Cherry, 1979). According to updated irrigation water quality guidelines, the detected Ca levels are within acceptable limits for agricultural and livestock use (FAO, 2017).

Concentration of Arsenic (As)

Arsenic was recorded from 0.0011 - 0.0080 ppb in water samples with mean 0.0030 ppb. Out of 12 samples among 20 gave below the mean value of 0.0030 ppb while rest 4 gave more mean value. Maximum concentration of 0.0080 ppb found in P_4 (Rajshahi court) and minimum in R_4 (I-damn), **(**Table 2). The average concentration Arsenic (As) in river, pond, canal and drain were 0.0020, 0.0052, 0.0022, 0.0026 ppm **(**Table 3). Arsenic concentration in all pond water resulted trace amount of As (< 0.05 ppm/mgL^{-1}) not harmful. The experiment presents the As presented in Rajshahi urban region trace in amount considering below the allowable level (0.01 mgL^{-1} and 0.05 mgL^{-1} international and Bangladesh by World Health Organization). Similar statement presented by Marin *et al*. 2003 detecting low As in water.

Table 2. Ionic concentration of P^H, EC, K, S, P, Na and As in ponds, drain, canal and river water in Rajshahi metropolitan city

	Sample	pH	Ec(μScm^{-1})	K(ppm)	S(ppm)	P(ppm)	Na(ppm)	As(ppb)
River	A_1	7.44	373.00	4.70	2.76	0.448	14.38	0.0040
	A_2	7.22	375.00	4.78	2.75	0.446	14.37	0.0016
	A_3	7.66	371.00	4.72	2.77	0.449	14.39	0.0015
	A_4	7.44	372.00	4.76	2.76	0.488	14.38	0.0011
	A_5	7.45	375.00	4.76	2.76	0.488	14.39	0.0017
Pond	B_1	7.38	616.00	10.73	2.43	0.363	29.59	0.0030
	B_2	7.37	613.00	10.70	2.40	0.361	29.60	0.0050
	B_3	7.38	619.00	10.75	2.46	0.365	29.58	0.0060
	B_4	7.39	617.00	10.74	2.42	0.364	29.67	0.0080
	B_5	7.39	615.00	10.73	2.44	0.362	29.57	0.0040
Cannel	C_1	7.46	343.00	5.15	3.20	0.299	14.79	0.0020
	C_2	7.50	346.00	5.16	3.22	0.300	14.78	0.0022
	C_3	7.48	340.00	5.14	3.18	0.279	14.80	0.0025
	C_4	7.47	344.00	5.14	3.20	0.298	14.75	0.0023
	C_5	7.46	341.00	5.15	3.21	0.300	14.84	0.0020
Drain	D_1	7.54	388.00	10.12	3.43	0.341	19.72	0.0023
	D_2	7.55	386.00	10.11	3.44	0.340	19.70	0.0022
	D_3	7.55	390.00	10.10	3.40	0.342	19.74	0.0032
	D_4	7.52	387.00	10.11	3.42	0.341	19.73	0.0028
	D_5	7.54	389.00	10.12	3.41	0.340	19.71	0.0026
Mean		7.46	430.00	7.68	2.95	0.366	19.62	0.0030

Table 3 Average Ionic concentration of pH, EC, K, S, P, Na and As in water of Rajshahi metropolitan city

	pH	Ec(μScm-^{1})	K(ppm)	S(ppm)	P(ppm)	Na(ppm)	As(ppm)
River	7.44	373.20	4.74	2.76	0.464	14.38	0.0020
Pond	7.38	616.00	10.73	2.43	0.363	29.60	0.0052
Cannel	7.47	342.80	5.15	3.20	0.295	14.79	0.0022
Drain	7.54	388.00	10.11	3.42	0.341	19.72	0.0026

Correlation analysis for water samples of Rajshahi Metropolitan city

Pearson correlation coefficient (r) analysis was performed to evaluate the degree of linear association among the measured physicochemical and elemental parameters (pH, EC, K, S, P, Na, and As) in surface water samples of Rajshahi. The purpose of this analysis was to (i) identify possible common sources of contamination, (ii) understand geochemical interactions among dissolved constituents, and (iii) determine whether variations in one parameter are associated with changes in another. Such relationships help explain hydro chemical processes influencing water quality and support interpretation of suitability assessments.

Their value of combinations of 8 parameter reported that pH-EC (-0.463**), pH-K (-- 0.029), pH-S (0.918**), pH-P (-0.193), pH-Na (-0.335*), pH-As (-0.327), EC-K (0.714**), EC-S (-0764**), EC-P (0.042), EC-Na (0.965), EC-As (0.775**), K-S (-0.124), K-P (-0.258), K-Na (0.864**), K-As (0.596**), S-P(-0484**), S-Na(-0.569**), S-As(-0.528**), Na-As(-0.119) (Table 4). Among these EC-Na, EC-As combination found significantly correlated at 1% level and pH-EC, pH-S, pH-Na EC-K, EC-S, EC-As, K-Na, K-As, S-P, S-Na, S-As, combinations were also significance considering their respective calculated greater r value than the tabulated value.

The interrelationship between p^H and Na was found statistically significantly correlated having correlation-coefficient r = - 0.335 water. pH and Na have negative relationship. The concentration of Na decreases with the increases of pH.

The experimental result revealed that Na content showed positive relationship with As content having correlation-coefficient r = 0.772.

The pH value in river, canal, pond and drain water varied from 7.22 to 7.66 which indicated slightly alkaline in nature. EC varied from 340.00 - 619.00 μScm^{-1} in the water where all samples indicated low to medium salinity (Table 5). EC valued water was good for irrigation in acid loving crops but unsuitable for drinking purpose and human being.

Table 4 Pearson Correlation Co-efficient (r) of pH, EC, K, S, P, Na and As

	pH	**EC**	**K**	**S**	**P**	**Na**	**As**
pH	1	-0.463**	-0.029	0.618**	-0.193	-0.335*	-0.327*
EC	-0.463**	1	0.714**	-0.764**	0.042	0.965**	0.775**
K	-0.029	0.714**	1	-0.124	-0.258	0.864**	0.596**
S	0.618**	-0.764**	-0.124	1	-0.484**	-0.569**	-0.528**
P	-0.193	0.042	-0.258	-0.484**	1	-0.132	-0.119
Na	-0.335*	0.965**	0.864**	-0.569**	-0.132	1	0.772
As	-0.327*	0.775**	0.596**	-0.528**	-0.119	0.772**	1

** Indicate a significant correlation at a level of 0.01 where * at a level of 0.05

Table 5 comparison of standard value and your value for water sustainability status

Parameter	Observed Range	Observed Value	Irrigation Standard (FAO)	Aquaculture Standard	Drinking Standard (WHO)	Suitability Status
pH	7.22 – 7.66	7.46	6.0–8.5	6.5–8.0	6.5–8.5	Suitable
EC (µS/cm)	340 – 619	430	<750	100 – 2000 µS/cm	-	Suitable for irrigation
K (ppm)	3.70 – 10.75	7.68	-	Recommended low level	-	Limited suitability
S (ppm)	2.40 – 3.44	2.95	-	< 50 ppm (as sulphate < 250 ppm)	-	Acceptable
Na (ppm)	13.37 –29.67	19.62	<920	<75	<200 (guideline)	Irrigation/ Aquaculture suitable; Drinking needs treatment
As (ppm)	0.002-0.0052	0.0030	<0.01	<0.01	0.01	Within limit

Potassium concentration in ponds, drain, canal and river water varied 3.70 - 10.75 ppm with the average 7.68 ppm. Out of 20 samples, (about 50%) K concentration was lower in ten samples than mean value and in remaining 10 samples (about 50%) showed higher K than that of mean value (7.68 ppm). Sulphur concentration of collected water samples varied 2.40 - 3.44 ppm ponds, drain, canal and river water respectively with mean value 2.95 ppm. Out of 20 samples, 10 samples showed lower sulphur and the rest 10 gave more than the mean value (2.95 ppm). Na concentration in ponds, drain, canal and river water ranged 13.37 - 29.67 ppm with the mean value of 19.62 ppm. Out of 20 samples, 5 samples (25%) showed lower and the rest 15 (75%) showed higher value considering mean value (Table 5). Water samples were suitable for irrigation and aquaculture, but unsuitable for drinking purposes.

Conclusion

The surface waters of Rajshahi were slightly alkaline (pH 7.22–7.66) with low to moderate salinity (EC 340–619 µS/cm). Sodium (13.37–29.67 ppm) and arsenic (0.002–0.0052 ppm) concentrations were within acceptable limits for irrigation and aquaculture, while potassium (3.70–10.75 ppm) and sulphur (2.40–3.44 ppm) varied across sites but remained largely suitable for agricultural use. Correlation analysis indicated significant interactions among EC, Na, As, and K, suggesting common geochemical sources and anthropogenic inputs. Overall, the water bodies studied are suitable for irrigation and aquaculture; however, they are not recommended for direct drinking without proper treatment. Continuous monitoring and regulatory measures are essential to ensure sustainable water quality management in the Rajshahi metropolitan area.

References

Agyeman, F. O., Mensah, M. Y., & Osei-Asare, Y. B. (2020). Impact of solid waste on water quality: Evidence from Ghana. Environmental Challenges, 2, 100008.

Al-Fughum, A. I. & Al-Anzy, M. (2015). Seasonal and spatial variations in water quality of the Euphrates River, Iraq Water Quality, Exposure & Health, 7, 117–123.

APHA. 1995. Standard Methods for the Examination of Water and waste water. 19th edn. American Public Health Asso., Washington, D. C. 2005.

Appelo, C. A. J. & Postma, D. (2010). Geochemistry, Groundwater and Pollution (2nd ed.).

Appelo, C. A. J., & Postma, D. (2005). Geochemistry, Groundwater and Pollution (2nd ed.). A.A. Balkema.

Ayers, R. S. & Westcot, D. W. (2015). Water Quality for Agriculture (FAO Irrigation and Drainage Paper 29 Rev.1).

Bhatnagar, A., & Devi, P. (2013). Water quality guidelines for the management of pond fish culture. International Journal of Environmental Sciences, 3(6), 1980–2009.

Bhuiyan, M. A. H., et al. (2016). Assessment of seasonal variation in river water quality of Bangladesh. Environmental Science and Pollution Research, 23, 2242–2256.

Boyd, C. E. (2015). Water Quality: An Introduction. Springer.

Clesceri, L.S., Greenberg, A.E. and Trussell, R.R. (1989). Standard Methods for the Examination of Water and Wastewater. 17th Edition, American Public Health Association, Washington DC. 200005. pp.1-30, 40-175.

FAO. (2011). The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. FAO, Rome.

FAO. (2014). Water quality for agriculture (FAO Irrigation and Drainage Paper No. 29, Rev. 1). FAO, Rome.

FAO. (2015). Status of the world's soil resources (SWSR) – Main report. FAO, Rome. Food and Agriculture Organization (FAO). (2017). Water Quality for Agriculture (Irrigation and Drainage Paper No. 29 Rev. 1). FAO.

FAO. (2015). Water Quality for Agriculture (Ayers & Westcot, Rev. 1). FAO Irrigation and Drainage Paper 29.

Freeze, R. A., & Cherry, J. A. (1979). Groundwater. Prentice Hall.

Ghosh AB, Bajaj JC, Hasan R, Singh D (1983). Soil and Water Testing Methods. A Laboratory Manual, Division of Soil Science and Agricultural Chemistry. IARI, New Delhi 110012:36-45.

Golterman HL. (1971). Methods for chemical Analysis for Fresh Waters. Blockwell Scientific Pub. (ed), Oxford. pp. 41-42.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. 2nd edn. Inst. Rice Res. Inst. Book. A Wiley Inter Science Publication, New York. p.28.

Guieu, C. and Martin, J. M. (2002). The level and fate of metals in the Danube River Plume. Estur. Coas. Sheif Sci. 54 (3): 501-512.

Hasan, M. K., et al. (2019). Seasonal variation of surface water quality in urban Bangladesh. Environmental Monitoring and Assessment, 191, 621.

Hem, J. D. (2013). Study and Interpretation of the Chemical Characteristics of Natural Water (3rd ed.). U.S. Geological Survey.

Iqbal, J. et al. (2017). Spatiotemporal variability in water quality of an urban river (Pakistan): Effects of seasonality and pollution sources Environmental Monitoring and Assessment, *189(9), 460*.

Islam, M. S., Ahmed, M. K., Raknuzzaman, M., et al. (2015). Heavy metal pollution in surface water and sediment of the Buriganga River, Bangladesh. *Environmental Science and Pollution Research*, 22, 15880–15890.

Kaushal, S. S., & Belt, K. T. (2012). The Urban Watershed Continuum: Evolving Spatial and Temporal Dimensions. Urban Ecosystems, 15(2), 409–435.

Levy, K., Nelson, K. L., Hubbard, A., & Eisenberg, J. N. S. (2016). Drivers of water quality variability in Northern coastal Ecuador. Science of The Total Environment, 541, 131–142.

Marin, G. R., Murphy, T. and Guo, T. (2003). Arsenic in water: Occurrence and treatment of arsenic and treatment. p. 101-111.

Martínez-Ballester, A., & Gómez-Larrea, A. (2023). Evaluation of irrigation water quality using sodium adsorption ratio and other indices for soil sodicity assessment. Irrigation Science, 41(3), 345–360.

Meem, F. F., Hasan, M. R., Nahian, A., & Islam, S. (2025). *Groundwater salinity dynamics and seasonal water quality trends in coastal Bangladesh: A case study from Khulna*. *Applied Water Science*.

Qadir, M., Sposito, G., Smith, C. J., & Oster, J. D. (2021). Reassessing irrigation water quality guidelines for sodicity hazard. Agricultural Water Management, 255, 107054.

Rahman, M. S., et al. (2017). Assessment of surface water quality of the Turag River, Bangladesh. *Applied Water Science*, 7, 327–337.

Roy, T. K., Ghosh, S., Azam, A. K. M. F. E., Rahman, M., Azim Sikder, M. N., & Siddiqui, M. (2025). Ionic status of ground and surface water at Madaripur in Bangladesh for drinking and agricultural uses. Environmental Research and Technology.

Sharma, B. R., & Singh, R. (2022). Groundwater suitability for irrigation: Evaluation using SAR, Na%, and other sodium-related indices. Journal of Environmental Management, 314, 115011.

Srinivasamoorthy, K. et al. (2012). *Hydrochemical characterization and water quality assessment of groundwater from silver sand aquifers, India-Environmental Earth Sciences*, 66(7), 2047–2059.

Srinivasamoorthy, K., et al. (2014). Hydrochemical characteristics and groundwater quality assessment in Tamil Nadu, India.

Environmental Monitoring and Assessment, 186, 935–951.

Stewart, R. D., Nembrini, F., & Tarantino, C. (2016). Impacts of agricultural runoff on freshwater quality: a global synthesis. Water Research, 101, 403–417.

Stumm, W., & Morgan, J. J. (2012). Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters (3rd ed.). John Wiley & Sons.

Tandon, H. L. S. (Ed). (1995). Methods of analysis of soils, plants, waters and Fertilizer.

Tchounwou, P. B. et al. (2012). Heavy metals toxicity and the environment-EXS, *101, 133–164.*

Uddin, M. G., Nash, S., & Olbert, A. I. (2021). A review of water quality issues in Bangladesh rivers. *Water*, 13(6), 871.

Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., et al. (2010). Global threats to human water security and river biodiversity. Nature, 467(7315), 555–561.

Wang, L. & Wang, Z. (2015). Sodium concentrations in surface water impacted by municipal wastewater discharges in a subtropical watershed. Journal of Environmental Sciences, 30, 190–199.

Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems (3rd ed.). Academic Press.

WHO. (2017). Guidelines for drinking-water quality (4th ed., incorporating the 1st addendum). WHO, Geneva.

Wolf, B. (1982). A comprehensive system of leaf analysis and its use of diagnostic crop nutrients status. Comm. Soil Sci. PL. Anal. 12(2):1044-1045.

Zhang, Q., Qin, H., Chang, Q., & Wang, J. (2015). Influence of urbanization on river water quality: A case study of the Yangtze River basin. Environmental Monitoring and Assessment, 187(8), 516.