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Comprehensive assessment of physicochemical quality, heavy metals, and ecological risks in the Someshwari river water, Netrokona, Bangladesh

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ABSTRACT

This study aimed to assess the physicochemical quality of water, the presence of toxic heavy metals, and the associated ecological risk in the trans-boundary of the Someshwari River as it enters Bangladesh through Netrokona District. Samples were collected over the period from June 2021 to May 2022 from five distinct locations. The investigation examined the current status of various physicochemical parameters of the water, including color, odor, temperature, dissolved oxygen (DO), biological oxygen demand (BOD), electric conductivity (EC), total dissolved solids (TDS), and alkalinity, as well as the concentrations of heavy metals (Pb, Cd, Cr, Cu, and Mn). The findings of the study revealed that temperature, pH, DO, BOD, TDS, EC, and total alkalinity were within established standard limits. The pH values across all water samples exhibited variation within the range of 7.60 to 7.80. Additionally, the concentrations of Pb, Cd, Cu and Mn were found to be within acceptable levels. Notably, no detectable levels of Cr were identified in the river water throughout the three seasons. The HPI values were within the acceptable range, with a range of 42.68 to 92.10 during the pre-monsoon, 26.60 to 48.71 during the monsoon, and 5.57 to 98.00 during the post-monsoon seasons, respectively. Similarly, the HEI values indicated a low level of contamination, with variations from 0.21 to 20.30 in the pre-monsoon, 0.63 to 22.27 in the monsoon, and 5.01 to 33.12 in the post-monsoon seasons, respectively. Mean CD values consistently indicated a lower level of pollution across all three seasons. In summary, the results of this investigation suggest that the water quality in the designated area is suitable for various uses. However, to maintain this water quality, it is strongly recommended that effective awareness programs be implemented to prevent water pollution.

Keywords: Water pollution, Someshwari River, Physiochemical parameter, Heavy metal

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Introduction

Water stands as a vital natural resource on our planet, serving as a life-sustaining element for all living organisms. Water bodies go beyond merely being sources of water; they provide resources like fish, shrimp, and other economically valuable aquatic creatures such as crabs, oysters, squids, and aquatic plants used in domestic and agro-industrial applications (Shamsuzzaman *et al.*, 2017). Additionally, these water bodies are integral components of natural ecosystems. Regrettably, water is often mismanaged on a global scale (Hofstra *et al.*, 2019). The monitoring of surface water is of utmost importance for the sustainable management of aquatic resources and the prediction of floods. Freshwater supplies face increasing pressure due to factors such as pollution, escalating demand, and inefficient water utilization (du Plessis, 2022). Bangladesh boasts an intricate network of 700 rivers, many of which are tributaries (Ahmed *et al.*, 2010). Since these river systems are of exceptional ecological significance, the destruction of aquatic ecosystems and loss of biodiversity are directly linked to river pollution (Uddin and Jeong, 2021; Das *et al.*, 2021). Unfortunately, the contamination of Bangladesh's river water is on the rise (Ahmed *et al.*, 2012). River pollution poses a significant challenge in developing nations, where industrial discharges harm a substantial portion of water bodies, while untreated sewage pollutes the remainder (Islam *et al.*, 2015). The levels of heavy metals in the environment continue to rise due to human activities, particularly in aquatic ecosystems. The pollution of aquatic ecosystems with heavy metals is escalating rapidly, fueled by factors like population growth, urbanization, industrialization, and agricultural practices (Baki *et al.*, 2011). Heavy metals can accumulate in the organs and tissues of aquatic organisms, making them some of the most hazardous pollutants (Shah *et al.*, 2021; Jaber *et al.*, 2021). Due to their non-biodegradable nature, they cause both acute and chronic effects on aquatic life (Jantawongsri *et al.*, 2021). Trace metals such as zinc, copper, and iron are essential for the biochemical processes of aquatic plants and animals, though only in trace amounts (Akan *et al.*, 2012).

The Someshwari River, also recognized as the Simsang River in the Indian state of Meghalaya, is a significant watercourse spanning Meghalaya's Agro Hills and Bangladesh's Netrokona District. As it flows into Bangladesh, it becomes a trans-boundary river (Rahman *et al.*, 2015). The primary aim of this research was to examine the levels of heavy metals in the water as it moves from upstream to downstream in the Someshwari River, which enters Bangladesh. In the Netrokona district of Bangladesh, the Someshwari River holds a pivotal role as the largest and most crucial source of freshwater for both agricultural and residential purposes as well as plays a crucial role in shaping the climatic conditions. Although once the Someshwari river was rich in aquatic biodiversity (native wild fishes, crabs and reptiles), the breeding grounds have been reported to have reduced drastically due to various anthropogenic interventions including sand extraction, soil erosion, siltation, and pollution (Chakraborty and Mirza, 2010). Remarkably, no prior scientific research has been conducted on the physicochemical quality of water or the presence of toxic heavy metals in the Someshwari River. Subsequently, it is imperative to initiate comprehensive studies to assess pollution levels, particularly regarding heavy metals, as elevated concentrations beyond permissible limits could pose significant environmental and health-related concerns. For that reason, understanding the potential sources and ecological consequences of metal toxicity in Someshwari River water is crucial for developing effective policies to safeguard and manage this watershed. The study set out with the following objectives: i) to examine various water quality parameters (pH, EC, TDS, DO, BOD, alkalinity), ii) to assess the concentrations of heavy metals (Pb, Cd, Cr, Cu, Mn) and iii) to evaluate the extent of heavy metal pollution and the associated ecological risks stemming from heavy metal contamination in the Someshwari River's water.

Materials and Methods

Study area

The study area is positioned at the Someshwari River in Netrokona District of Bangladesh (Fig. 1). The Someshwari River serves as a prominent river in the Agro Hills region of Meghalaya. Upon entering Bangladesh, it traverses through Susang-Durgapur and other locales of Netrokona District before merging into the Kangsha River (Rahman *et al.*, 2015).

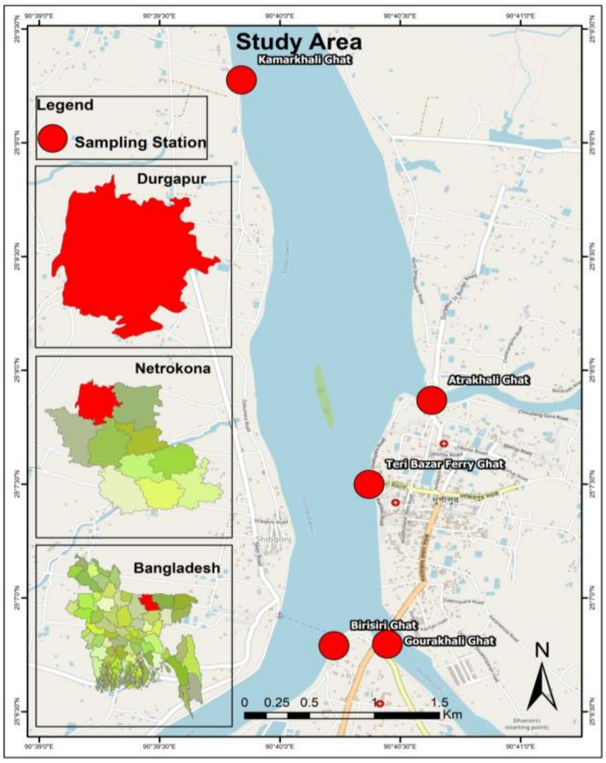

Fig. 1. Map showing the study area in the Someshwari River at Netrokona, Bangladesh.

Sample collection

Sample collection occurred from June 2021 to May 2022, categorized into monsoon (June-September), post-monsoon (October-January), and pre-monsoon (February-May) seasons. Five sampling stations-Gourakhali Ghat (St-1), Birisiri Ghat (St-2), Teri Bazar Ferry Ghat (St-3), Atrakhali Ghat (St-4), and Kamarkhali Ghat (St-5)-were utilized. For physicochemical and heavy metal analysis, 500 ml water samples were collected in double-stoppered plastic bottles from each station. Bottles were pre-treated with detergent, 5% nitric acid (HNO_3), and rinsed with deionized water before sampling. They were submerged approximately 10 cm below the water surface. Post-collection, bottles were sealed carefully, labelled with respective identification numbers, and stored for analysis (Nahian *et al.*, 2018; Latif *et al.*, 2022).

Sample analysis

Physicochemical parameters were analyzed in the Environmental Science and Resource Management lab at Mawlana Bhashani Science and Technology University. Temperature and pH were measured with a thermometer and a calibrated digital pH meter. Dissolved oxygen (DO) was determined with a digital meter, while electrical conductivity (EC) and total dissolved solids (TDS) were assessed using digital meters. Total alkalinity (TA) was measured via titration. For heavy metal analysis, 100 ml water samples were digested with concentrated HNO_3, diluted to 100 ml with distilled water, filtered, and preserved. Heavy metals (Pb, Cd, Cr, Cu, and Mn) were analyzed using an atomic absorption spectrophotometer (Model AA-6800, Shimadzu Corporation, Japan) at the Wazed Miah Science Research Centre lab, Jahangirnagar University.

Analysis of environmental and ecological risk of heavy metals

In calculating the HPI, Prasad and Bose (2001) assigned unit weights (Wi) inversely proportional to the recommended standard (Si) for each parameter, as suggested by Reddy (1995).

The HPI model (Mohan *et al.*, 1996) is given by:

$$HPI = \frac{\sum_{i=1}^{n} Wi\, Qi}{\sum_{i=1}^{n} Wi}$$

Where Q_i = sub-index of the ith parameter. W_i = the unit weightage of the ith parameter and n = the number of parameters considered.

The heavy metal evaluation index (HEI) method gives an overall quality of the water with respect to heavy metals (Edet and Offiong, 2002) and is computed as:

$$HEI = \sum_{i=1}^{n} \frac{Hc}{Hmac}$$

Where, H_c = the monitored value of the ith parameter and Hmac = the maximum admissible concentration of the ith parameter.

The contamination index (CD) summarizes the combined effects of several quality parameters considered harmful to domestic water (Backman *et al.*, 1998) and the contamination index is calculated from the equation below,

$$C_{fi} = \frac{Cai}{Cni} - 1$$

Where, C_{fi}, C_{ai} and C_{ni} = the contamination factor, the analytical value, and the upper permissible concentration of the ith component, respectively.

Statistical analysis

The data was carefully organized and tabulated, followed by thorough statistical analysis using Microsoft Excel and SPSS version 20.0 for presentation and interpretation. The results were communicated through graphs and tables.

Results and Discussion

Physicochemical water qualities

Temperature profiles displayed significant fluctuations, ranging from 18.27 to 20.10°C during the pre-monsoon season, 19.25 to 22.10°C during the monsoon season, and 16.07 to 17.07°C during the post-monsoon season. The highest water temperature 22.10°C and was recorded at St-5 during the monsoon season, while the lowest, 16.07°C, was observed at the same location in the post-monsoon season (Table 1). It's worth noting that lower river water temperature often indicate purification of the water. Surface water temperature can be influenced by various factors, including geographical location, seasonal changes, and daily fluctuations. For context, Yasmeen *et al.* (2012) reported a water temperature range of approximately 31 to 33°C for the Buriganga River during the wet season and 21.9 to 22.4°C during the dry season. Hoque *et al.* (2012) observed water temperatures of around 30.9°C for the Buriganga River during the monsoon season and 21.5°C during the winter season for the Bangshi River. Uddin *et al.* (2014) found mean water temperatures of 32.59°C during the dry season and 35.93°C during the wet season in the Jamuna River. Moreover, Mobin *et al.* (2014) and Meghla *et al.* (2013) recorded average water temperatures for the Turag River, which were 28.39 and 32.5°C, respectively.

The analysis revealed that the TDS concentrations exhibited variations in different seasons. Specifically, during the pre-monsoon season, TDS levels ranged from 30 to 36 ppm. In the monsoon season, they varied from 25 to 31 ppm, while during the post-monsoon season; they extended from 37 to 48 ppm. It's noteworthy that St-2 had the highest TDS concentration, recording 48 ppm during the post-monsoon season, whereas St-1 and St-5 had the lowest TDS concentrations, at 25 ppm, during the monsoon season. Water with low TDS levels is generally considered safe for human consumption. However, it's not advisable to consume water with TDS levels as low as 50 ppm because it might lack the essential minerals necessary for optimal bodily functions. Typically, TDS concentrations ranging from 50 to 150 ppm are considered ideal for drinking water. To provide some context, Islam *et al.* (2012) reported TDS levels for Dhaleshwari River water ranging from 69 to 131 ppm in the monsoon season, 95 to 299 ppm in the post-monsoon season, and 190 to 224 ppm in the pre-monsoon season. Hoque *et al.* (2012) recorded TDS levels for Bangshi River water at 306.3 ppm during the monsoon season and 496.0 ppm during the winter season. Saifullah *et al.* (2012) found TDS levels for the Buriganga River ranging from 471 to 692 ppm in the dry season and 324 to 170 ppm in the wet season. In the case of the Someshwari River, EC demonstrated varying values across different seasons. Specifically, during the pre-monsoon season, EC ranged from 70 to 97 µS/cm, during the monsoon season it fluctuated between 65 to 77 µS/cm, and during the post-monsoon season, it spanned from 75 to 103 µS/cm. Notably, the monsoon season typically exhibited lower EC values, while the post-monsoon season displayed higher conductivity, mainly due to the dilution effect caused by rainwater and surface runoff. Comparing this with other studies, Yasmeen *et al.* (2012) observed that during the dry season, the mean EC of the Buriganga River ranged from approximately 763 to 1206 µS/cm, exceeding the standard level of 700 µS/cm (EQS, 1997), which can have harmful effects on aquatic organisms. In terms of pH values, they followed a consistent pattern across all seasons, falling within the range of 7.66 to 7.80. The mean concentration of pH exhibited slight fluctuations within the range of 4.9 to 5.1. For reference, Hoque *et al.* (2012) recorded pH values of 7.6 during the monsoon season and 8.5 during the winter season for the Bangshi River. Saifullah *et al.* (2012) noted that the pH of all sampling sites in the Buriganga River was higher in the dry season compared to the wet season. Rahman *et al.* (2012) found pH values varying from 6.60 to 7.85 at different locations in the Turag River.

The concentration of DO notably decreased during the post-monsoon season. Among the different sampling stations, St-5 exhibited the highest DO concentration of 5.7 ppm during the monsoon season, while St-2 had the lowest concentration of 4.9 ppm in the post-monsoon season. This seasonal variation was primarily attributed to the discharge of waste into the relatively low-flow bodies of water during the post-monsoon season. Across all three seasons, including pre-monsoon, monsoon, and post-monsoon, the DO values, including the average concentrations, remained within the standard limits established for fisheries and irrigation purposes as provided by ECR (1997). For reference, Islam *et al.* (2012) reported DO levels ranging from 1.22 to 3.66 ppm in various sampling locations within the Turag River water. Hoque *et al.* (2012) documented DO levels in the water of the Bangshi River, noting a concentration of 4.7 ppm during the monsoon season and 3.2 ppm during the winter season. According to Saifullah *et al.* (2012), the DO levels in the Buriganga River fluctuated between 3.6 ppm during the dry season and 4.9 ppm during the wet season. Regarding BOD, due to the higher concentration of organic waste in the river water, the study identified higher BOD levels during the post-monsoon season compared to the pre-monsoon and monsoon seasons. St-5 had the lowest BOD concentration at 1.2 ppm, while St-3 exhibited the highest BOD concentration at 2.5 ppm. However, these BOD values did not exceed the standard levels established for fisheries and irrigation. The presence of lower BOD values in all sampling stations during two seasons indicates a relatively lower amount of microorganisms. Khondker and Abed (2013) recorded BOD levels ranging from 0.78 to 2.04 ppm in the Turag River. In contrast, Meghla *et al.* (2013) recorded higher BOD concentrations in all seasons, attributable to the presence of comparatively more organic waste in the Turag River. Regarding alkalinity in the Someshwari River water, it ranged from 35 to 42 ppm in the pre-monsoon season, 25 to 33 ppm in the monsoon season, and 45 to 60 ppm in the post-monsoon season. These values did not exceed the standard level for surface water (as shown in Table 1). In comparison, Yasmeen *et al.* (2012) reported mean alkalinity levels for the Buriganga River water ranging from 168 to 248 ppm during the dry season and 158 to 240 ppm during the wet season. Ahmed *et al.* (2012) found alkalinity values ranging from 5.64 ppm in the pre-monsoon season to 121.0 ppm in the post-monsoon season in the Dhaleshwari River.

Table 1. Physicochemical parameters of Someshwari River water with standard.

Parameters	Sampling Site	Pre- Monsoon Avg. (N= 5)	Monsoon Avg. (N= 5)	Post- Monsoon Avg. (N= 5)	Standard
Temperature (°C)	St-1	17.10	19.25	17.01	20-30 (EQS, 1997)
	St-2	17.23	20.41	17.07	
	St-3	17.22	21.07	17.03	
	St-4	16.27	21.31	16.07	
	St-5	16.20	22.10	16.30	
	Mean±SD	16.80±0.52	20.83±1.07	16.70±0.47	
TDS (ppm)	St-1	33	25	38	<400 (Fisheries) 2000 (Irrigation) (ADB,1994)
	St-2	36	30	48	
	St-3	35	31	42	
	St-4	32	28	38	
	St-5	30	25	37	
	Mean±SD	33.2±2.39	27.8±2.77	40.6±4.56	
EC (µS/cm)	St-1	82	75	87	1000 (Fisheries) 750 (Irrigation) (ADB,1994)
	St-2	97	77	103	
	St-3	80	71	85	
	St-4	71	66	76	
	St-5	70	65	75	
	Mean±SD	80±10.89	70.8±5.31	85.2±11.28	
pH	St-1	7.65	7.66	7.71	Irrigation 6.5-8.5 (ECR, 1997)
	St-2	7.61	7.63	7.68	
	St-3	7.60	7.64	7.66	
	St-4	7.71	7.70	7.80	
	St-5	7.70	7.72	7.74	
	Mean±SD	7.65±0.05	7.67±0.04	7.72±0.05	
DO (ppm)	St-1	5.4	5.5	5.1	5 or more (Fisheries and Irrigation) (ECR, 1997)
	St-2	5.2	5.4	4.9	
	St-3	5.3	5.5	5.0	
	St-4	5.5	5.6	5.1	
	St-5	5.4	5.7	5.0	
	Mean±SD	5.36±0.11	5.54±0.11	5.02±0.08	
BOD (ppm)	St-1	2.0	1.9	2.3	6 or less and 10 or less (Fisheries and Irrigation) (ECR, 1997)
	St-2	1.9	1.5	2.2	
	St-3	1.8	1.3	2.1	
	St-4	2.1	2	2.5	
	St-5	1.6	1.2	2.1	
	Mean±SD	1.88±0.19	1.58±0.36	2.24±0.17	
Alkalinity (ppm)	St-1	35	25	45	100 (Surface water) (ECR, 1997)
	St-2	40	31	50	
	St-3	42	32	55	
	St-4	38	30	56	
	St-5	42	33	60	
	Mean±SD	39.4±2.97	30.2±3.11	53.2±5.81	

Heavy metal concentrations in water

The findings indicated that the concentration of lead (Pb) in the river water was below the detection limit, reaching up to 0.0214 ppm during the pre-monsoon season, remained below the detection limit in the monsoon season, and was below the detection limit to 0.0378 ppm in the post-monsoon season. Notably, during the post-monsoon season, St-3 displayed the highest Pb concentration, measuring at 0.0378 ppm (Table 2). All these recorded values were considerably lower than the established domestic, irrigation, fishing, and surface water standards outlined by De (2005), ADB (1994), Ayers and Westcot (1976) and ECR (1997), respectively. This outcome underscores the absence of Pb in the Someshwari River water during the pre-monsoon and monsoon seasons, with only a minimal presence in the post-monsoon season, slightly exceeding the standard level. Hence, the water in this river remains at a low level of lead pollution. For context, Afrin *et al.* (2014) reported Pb concentrations in the Turag River water ranging from 0.002 to 0.005 ppm. In another study (Yasmeen *et al.* 2012), the Pb concentration in the Buriganga River water during the wet season fluctuated between 0.01, 0.011, and 0.0403 ppm. Interestingly, the Pb concentration in Baim fish in the Turag River water was reported to vary from 0.03 to 0.1 ppm by Sultana *et al.* (2014), which is higher than the results obtained in the present study. Throughout the pre-monsoon, monsoon, and post-monsoon seasons, the concentration of cadmium (Cd) in the river water ranged from below the detection limit to 0.0439 ppm, below the detection limit to 0.0159 ppm, and below the detection limit to 0.0993 ppm, respectively. The highest Cd concentration of 0.0993 ppm was observed at St-5 during the post-monsoon season (Table 2). This difference, with lower Cd levels during the monsoon compared to the pre-monsoon and post-monsoon seasons, can be attributed to dilution by rainwater and runoff. For comparison, Afrin *et al.* (2014) reported Cd levels in the Turag River water ranging from Below Detection Level (BDL) to 0.03 ppm. Ahmed *et al.* (2010) noted Cd concentrations ranging from 0.007 ppm during the pre-monsoon to 0.012 ppm during the monsoon in the Buriganga River. These findings differ from the results of the present study. In contrast, the concentration of chromium (Cr) in the Someshwari River water was below the detection limit during the pre-monsoon, monsoon, and post-monsoon seasons, indicating the absence of Cr. Additionally, Ahmed *et al.* (2010) reported Cr concentrations varying seasonally and spatially from 489.27 to 645.26 ppm, respectively. These results also differ from the findings in the present study.

The post-monsoon season saw St-5 with the highest concentration of copper (Cu), measuring at 0.3037 ppm (Table 2). However, during the pre-monsoon, monsoon, and post-monsoon seasons, the recorded levels of Cu at St-1, St-2, St-3 and St-4 were below the detection limit. The concentration of manganese (Mn) in the river water ranged from below the detection limit to 0.2994 ppm in the pre-monsoon season, below the detection limit to 0.0214 ppm in the monsoon season, and from 0.0194 to 0.3104 ppm in the post-monsoon season (Table 2). St-4 exhibited the highest concentration of Mn (0.3104 ppm) following the monsoon season. Across the pre-monsoon, monsoon, and post-monsoon seasons, the mean Mn concentration along the river was 0.08736, 0.0176, and 0.10072 ppm, respectively, which was slightly higher than the domestic, irrigation, and surface water standard levels established by De (2005), ADB (1994) and ECR (1997). For reference, Mondol *et al.* (2011) observed Mn concentrations in the water of the Tejgaon industrial area during the dry season, ranging from 0.019 to 0.34 ppm. Mokaddes *et al.* (2013) recorded Mn concentrations in river water within the Dhaka Metropolitan City, measuring 0.075 ppm. Faisal *et al.* (2014) reported the average Mn concentration in the river water of the Savar industrial area to be 37.65 ppm. These results differ from those of the present study.

Table 2. Concentration (ppm) of heavy metals in water of the Someshwari River.

Heavy Metals		Pre- Monsoon		Monsoon		Post- Monsoon	
		Avg. (N= 5)	Range	Avg. (N= 5)	Range	Avg. (N= 5)	Range
Pb	St-1	BDL	BDL-0.0214	BDL	-	BDL	BDL-0.0378
	St-2	BDL		BDL		BDL	
	St-3	0.0214		BDL		0.0378	
	St-4	BDL		BDL		BDL	
	St-5	BDL		BDL		BDL	
	Mean±SD	0.00428± 0. 01		BDL (0.02)		0.016733 ± 0.02	
Cd	St-1	BDL	BDL-0.0439	BDL	BDL-0.0159	BDL	BDL-0.0993
	St-2	BDL		BDL		BDL	
	St-3	BDL		BDL		0.0247	
	St-4	0.0201		0.0151		0.0223	
	St-5	0.0439		0.0159		0.0993	
	Mean±SD	0.0128±0.02		0.0155±0.006		0.02926 ± 0.04	
Cr	St-1	BDL	-	BDL	-	BDL	-
	St-2	BDL		BDL		BDL	
	St-3	BDL		BDL		BDL	
	St-4	BDL		BDL		BDL	
	St-5	BDL		BDL		BDL	
	Mean±SD	BDL (0.02)		BDL (0.02)		BDL ± (0.02)	
Cu	St-1	BDL	BDL-0.0537	BDL	BDL-0.0163	BDL	BDL-0.3037
	St-2	BDL		BDL		BDL	
	St-3	BDL		BDL		BDL	
	St-4	BDL		BDL		BDL	
	St-5	0.0537		0.0163		0.3037	
	Mean±SD	0.01074±0.02		0.0089±0.01		0.6074±0.14	
Mn	St-1	0.0169	BDL-0.2994	0.0151	BDL-0.0214	0.0283	0.0194-0.3104
	St-2	BDL		BDL		0.0194	
	St-3	0.0269		0.0159		0.0290	
	St-4	0.2994		0.0214		0.3104	
	St-5	0.0936		0.0179		0.1165	
	Mean±SD	0.08736±0.12		0.0176±0.003		0.10072 ±0.12	

Note: BDL = Below Detection Level

Ecological risk assessment of heavy metal in water

The study shows that Hazard Potential Index (HPI) values for all metals across the three seasons remained below the critical pollution threshold of 100 for potable water, with ranges of 42.68 to 92.10 (mean = 71.61) in the pre-monsoon, 26.60 to 48.71 (mean = 37.67) during the monsoon, and 5.57 to 98.52 (mean = 56.78) in the post-monsoon.

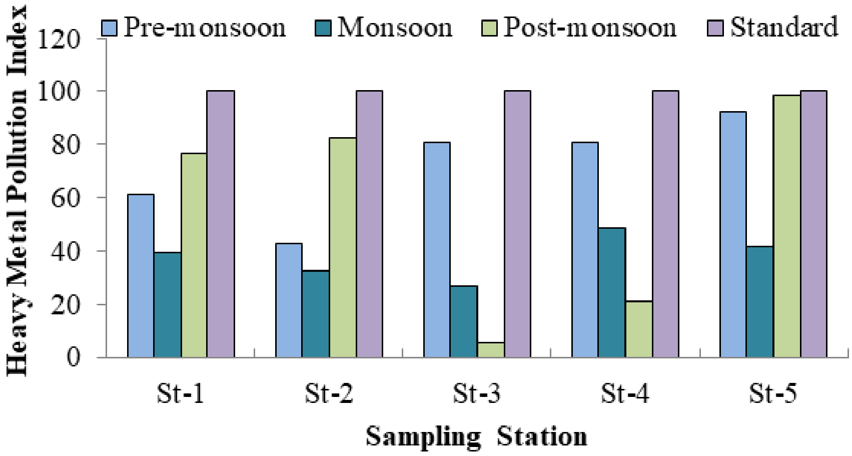

Fig. 2. Heavy metal pollution index at different sampling stations of Someshwari River.

The Heavy Metal Index (HEI) analysis for the Someshwari River showed seasonal variations, with HEI ranging from 0.21 to 20.30 (mean = 11.87) in the pre-monsoon, 0.63 to 22.27 (mean = 9.92) during the monsoon, and 5.01 to 33.12 (mean = 17.57) post-monsoon. These values indicate low heavy metal contamination across all stations, placing the river in the low pollution category based on Edet and Offiong (2002).

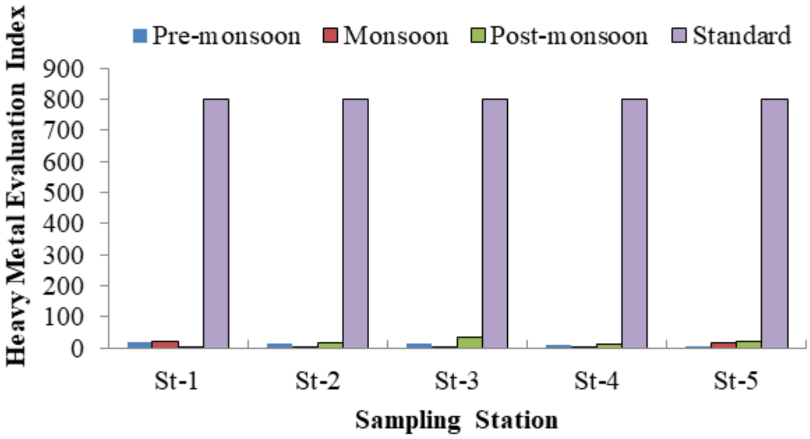

Fig. 3. Heavy metal evaluation index at different sampling stations of Someshwari River.

The Contamination Degree (CD) was used to assess metal pollution, categorized as low (CD < 1), medium (CD = 1-3), and high (CD > 3) (Brraich and Jangu, 2015). Mean CD values in the pre-monsoon (0.864) and post-monsoon (0.956) seasons indicated low pollution, while monsoon heavy metal detection was limited due to dilution by rainwater.

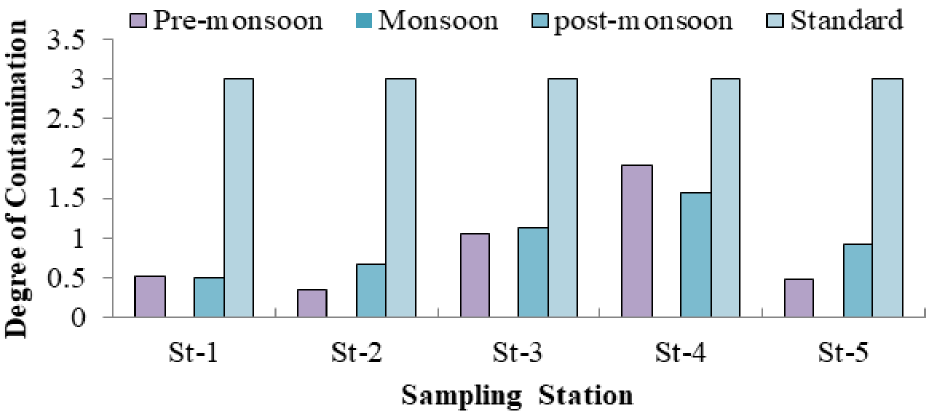

Fig. 4. Degree of contamination index at different sampling stations of Someshwari River.

Table 3. Standard used for the index's computation (Brraich and Jangu, 2015; Kabir *et al.*, 2020).

Metal	Unit	W_i	S_i	L_i	Mac
Pb	ppb	0.7	100	10	1.5
Cd	ppb	0.3	5	5	3
Cr	ppb	0.02	50	-	50
Cu	ppb	0.001	1000	2000	1000
Mn	ppb	0.0033	300	100	50

Conclusion

This study assessed heavy metal presence and environmental risks in Someshwari River water. The analysis showed low heavy metal concentrations, except for manganese, likely due to continuous river flow preventing metal accumulation. Ecological risk assessment categorized pollution levels as low to medium, influenced by seasonal variations. The absence of substantial industrial activity contributes to the river's cleanliness, but mechanical equipment usage for extraction poses potential future pollution risks. Legislative measures are needed to protect the river's pristine state and aquatic ecosystem.

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