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Water quality and distribution of drug resistant bacteria in tap, well and surface water samples of randomly selected areas in Bangladesh

Abstract

Water quality measurement is an inevitable requisite to identify weaknesses of the supply system, prioritize opportunities, identify measures to drive improvement, and improve healthcare services. In our study, we evaluated 15 water samples corresponding to tap, pond, lake, island, river, and sea waters. We evaluated water quality in terms of physicochemical parameters, total heterotrophic count (THC), and total coliform count (TCC), moreover, detection of bacterial isolates and their antibiogram. In most of the cases, tap and tube well waters showed decreased value for total dissolved solids, turbidity and electrical conductivity but in some cases, those showed indifference when compared with other surface water sources. The highest HPC and TCC were observed in the Buriganga river water that were 7.7×10^7 cfu/ml and 2.3×10^4 cfu/100 ml, respectively. A total of 9 bacterial isolates were presumptively identified when compared their physiology, colony and biochemical characteristics to the Bergey's manual of systemic bacteriology. The most predominantly identified bacteria were *E. coli* and *Staphylococcus aureus*, and the less frequently identified was *Vibrio* spp. A degree of resistance to antibiotics was observed against most of the isolates. Among 9 of the isolates, 4 of the isolates showed complete resistance (100%) to amoxicillin and tetracycline antibiotics where, 4 of the isolates also showed complete sensitivity (100%) to only one antibiotic, azithromycin. It is needed to improve the quality of water sources as directly or indirectly, they are the major source of morbidity and mortality in a developing country like Bangladesh. It is also pivotal to knock the policy level to make or apply a mammoth regulation on antibiotic use and its release to the environment as there is no late to start a step ahead to seek for the betterment.

Keywords: antibiotic, antibiotic resistance, water quality, physicochemical parameters

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Introduction

Bangladesh is an overpopulated country and much of its urbanization is not well planned and is coupled to industrial development. The inappropriate handling and disposal of medical and industrial wastes as well as household waste are the direct source of water pollution in our freshwater bodies.[1] Water quality deterioration is a major risk for the environment because 80% of the diseases in developing countries are associated with polluted water.[2] Moreover, the drinking water as tube well and tap waters also become polluted due to ignoring proper hygiene practice and through the contaminated distribution process.[3,4]

Dhaka, the capital of Bangladesh, holds a population beyond its capacity and is the second polluted megacities in the world where the responsible authority to distribute water to the massive population is Dhaka Water Supply and Sewerage Authority (Dhaka WASA). It was estimated that around 87% of the supply water comes from groundwater and the rest of the water supply comes from treated surface water. But, the water table is lowering due to huge water consumption, and thus, it is high time to consider surface water as the primary source for supply after proper treatment.[5] Inadequate sewage and inefficient waste management impose a threat to the surface water results the parameters for water quality determination far above the critical limit.[6]

The persistence of microbes especially pathogens is accessible in surface water as well as in treated water sources.[7] Waterborne diseases are associated with pathogenic microbes that create an outbreak globally where wastewater act as a vehicle for transporting and spreading waterborne diseases.[8,9] Antibiotics are considered an emerging pollutant for more than 20 years, and it has recently been shown that antibiotic-resistant genes have adapted in the environment through pathogenic bacteria.[10,11] Contaminated water with feces contains pathogens is a great danger for human health that can cause cholera, diarrhea, dysentery, and enteric fever like typhoid fever.[12,13] *Salmonella* species, a group of bacteria from the Enterobacteriaceae family are pathogenic which can cause enteric diseases like gastroenteritis, diarrhea, and typhoid fever.[14] Besides, it has originated multiple antibiotic resistance ability.[15,16] Similarly, *Vibrio cholerae*, a water-borne disease that can be transmitted by person to person contact and can cause severe diarrhea and sometimes can be fatal if it is not treated.[17] About 2.9 million total cholera cases with 95,000 deaths were illustrated annually from 2008 to 2012.[18] On the other hand, four spices of *Shigella* (*S. dysenteriae*, *S. flexneri*, *S. boydii*, and *S. sonnei*) cause disease outbreak, and its' control is comparatively hard due to lower infectious doses.[19,20] Bacillary dysentery like shigellosis becomes epidemic globally that can cause disease and fatality especially in children who are under 5 years in a developing country like Bangladesh.[21,22] Therefore, a regular systemic survey is

required to have an eye on the quality of our drinking and surface water sources as well as to detect the intensity of microbial antibiotic resistance.

Materials and methods

Study area and sample collection procedures

The study included fifteen water samples that were collected from randomly selected locations in Bangladesh and classified as Tap, Tube well, River, Lake, Sea, Island, and Pond waters. These were Sajek, Rangamati, and Cox's Bazar tap waters; Bogura and Magura tube well waters; Maniknagar and Kaptai lake waters; Jamalpur pond water; Gorai, Jamuna, Brahmaputra, Padma and Buriganga river waters; Cox's Bazar sea water and Swapnadeep island water. All water samples were collected in triplicates in autoclaved sterile sample bottles.

Tap water: The tap was cleaned by wiping with a clean cloth to remove dirt and then, turned on at maximum flow to run water for 1-2 min. The tap was turned off and sterilized for about one minute with the flame from a lighter. The tap was carefully turned on and water was allowed to flow for 1-2 min at a medium flow rate. The sample bottles were carefully opened, and immediately held under the water jet and filled. This was done by holding the protective cap of the bottle face down to prevent any entry of dust, which may contaminate the samples were immediately taken back to the laboratory for analysis.

Tube well water: The area surrounding the tube well head was cleaned with a sterile cloth to minimize the potential for contamination of samples. Sterilized sample bottles were used to fetch water from the tube well. The sample bottles were not opened until they were ready to be filled. Then, the handle of tube well was pressed to flow water at a maximum rate of 30 sec. Sample bottles were carefully opened, and immediately held under the flowing water and filled, and then, the samples were immediately taken to the laboratory for analysis. River, Pond, Lake, Sea, and Island waters**:** The sample bottles were held by the lower part, submerged, and collected in sterile bottles. To prevent leakage, the lid was screwed tightly.

Analysis of physicochemical parameters

Physicochemical parameters of the water samples were detected following the procedure recommended by the manufacturers of the equipment. Determination of pH of the samples was performed using a single electrode pH meter (Jenway pH meter, Model 3305). This was done by dipping the electrode of the pH meter into the water sample and then, the reading at the pH screen was recorded. EC of each water sample was measured with the help of EC meter (range 0-1999 µS/cm) (Hanna Instruments, HI 98303) which measures the resistance offered by the water between two platinized electrodes. The instrument was standardized with known values of conductance observed with standard KCl solution. TDSs of each water sample were measured with the help of TDS meter (HM digital TDS-3) with a range from 0-9990 ppm. Turbidity of each water sample was determined by using a turbidity meter (Apera Instruments, LLC-AI481). Each sample was poured in the sample holder and kept inside for a few minutes. After achieving the reading stability, the value was recorded. DO is one of the most important parameter as it correlates with water body directly and indirectly with the information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc.[23] DO value was measured by using DO meter (Apera Instruments, AI480). In this experiment, presence of chlorine was determined by chlorine meter (RCYAGO CL2 chlorine tester, PC102) and recorded.

Inoculation without enrichment

All the samples were inoculated, and cultured by spread plate technique to determine Heterotrophic Plate Counts (HPCs), and Total Coliform Counts (TCCs). Samples were serially diluted with normal saline and then, 100µl of the diluted water samples were spread onto nutrient agar media for HPC, and MacConckey agar media for TCC. Moreover, Mannitol Salt Agar (MSA) was also inoculated to detect the presence of *Staphylococcus aureus*. The plates were incubated at 37°C for 24 h. Following growth, the number of organisms was calculated by multiplying the number of colonies with dilution factor for HPCs, and TCCs. Different colonies from TCC plate were further inoculated on selective media to presumptively identify those colonies.

Inoculation after enrichment

All those 15 samples were inoculated by spread plate technique on some selective media after enrichment to detect the presence of some selective bacteria. Enrichment culture is an isolation technique designed to make conditions of growth favourable for an organism of interest while having an unfavourable environment for any competition. This enrichment was generally done by transferring 20ml of each water sample to 80ml of buffered peptone broth and incubated at 37°C for 8 h. Enrichment was performed to detect the presence of *Salmonella* spp. and *Shigella* spp. on XLD (Xylose Lysine Deoxycholate) media; as well as *Vibrio* spp. on TCBS (Thiosulfate Citrate Bile Salts Sucrose) media. The plates were incubated at 37°C for 24 hours. Following growth, their colony characteristics were noted.

Identification of bacterial isolates

All the isolates were presumptively identified by microscopic observation, colony characteristics, and biochemical properties. Biochemical tests that were performed includes Triple Sugar Iron (TSI), Indole, Nitrate reduction, Citrate, Catalase, Oxidase, Methyl Red (MR), Urease, Motility, and Voges-Proskauer (VP). The test results were noted and compared with the Bergey's manual of systemic bacteriology.

Antibiogram of bacterial isolates

Antibiogram test was performed to determine the resistance patterns of identified organisms. For this purpose, disk diffusion method was employed. Here, commercially available filter paper disks, each contained a defined concentration of a specific antibiotic, was used. This procedure was generally done by a filter disk impregnated with an antibiotic was applied to the surface of an agar plate. The latter was cultured with the organism to be tested and then, the plate was incubated at 37°C for 24-48 h. This procedure was done for each isolate, and following incubation, the zone of inhibitions (ZOIs) were recorded, and compared with the Clinical and Laboratory Standards Institute (CLSI) guideline.

Result

The main objective of this study was to evaluate the quality of water from different sources in Bangladesh and to observe the drug resistance pattern of the isolated bacteria.

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Physicochemical data analyses

The physicochemical parameters as pH, TDS, Turbidity, DO, EC, and Cl of collected water samples are presented in Table 1. Cox's Bazar water sample exceeded the capacity of the instrument (9990 ppm) to measure the TDS value while the Rangamati tap water had the lowest TDS value that was 55 ppm. The pH of the water samples ranged from the lowest 6.8 (Swapnadeep island water) to the highest 8.2 (Jamuna river water) while the turbidity of the water samples ranged from the lowest 0.19 NTU (Sajek tap water) to the highest 40.0 NTU (Brahmaputra river water). However, Cox's Bazar water also has exceeded the capacity of the instrument (1999 µS/cm) to measure the EC while the Rangamati tap water has the lowest 110 µS/cm.

Table 1 Physicochemical properties of water samples

Sample No.	Type of sample water	Source	pH	TDS (ppm)	Turbidity (NTU)	DO (mg/l)	EC (µS/cm)	Cl (ppm)
1.		Sajek	7.4	82	0.19	5.8	170	1.5
2.	Tap	Rangamati	7.3	55	0.3	4.3	110	2
3.		Cox's Bazar	7.8	199	0.59	3.7	404	1.5
4.		Bogura	7.3	108	2.22	3.7	220	<0.5
5.	Tube well	Magura	7.7	103	1.9	4.4	208	<0.5
6.		Kaptai	7.3	61	0.3	4.1	122	2.5
7.	Lake	Maniknagar	7.2	157	5.14	3.8	312	>2.5
8.	Pond	Jamalpur	6.9	204	11.93	3.8	408	1.5
9.		Gorai	7.5	171	4.18	4.1	340	1.5
10.		Jamuna	8.2	112	2.24	4.1	224	>2.5
11.	River	Bhramaputra	7.1	173	40	3.7	344	2.25
12.		Padma	7.2	325	0.87	3.4	650	>1.5
13.		Buriganga	7.9	280	30.9	4.8	540	<2.5
14.	Sea	Cox's Bazar	7.8	Out of range	2.36	5.9	Out of range	<0.5
15.	Island	Sopnodeep	6.8	282	25.3	4.8	564	1.5

Note: TDSs, Total dissolved solids; DO, dissolved oxygen; EC, electrical conductivity; Cl, chlorine

HPC and TCC counts

The HPCs for all the water samples were quite high ranging from the lowest, 7.6×10^3 cfu/ml in tube well water at Magura to the highest, 7.7×10^7 cfu/ml in Buriganga river water. Among the three tap water samples from Sajek, Rangamati, and Cox,s Bazar, the latter contain the maximum count that was 3.3×10^4 cfu/ml. We had two tube well water samples from Bogura and Magura, and we got a higher count from Bogura that was 8.0×10^3 cfu/ml. Furthermore, higher HPC was detected in Kaptai lake water (1.1×10^5 cfu/ml) than Maniknagar lake water (1.6×10^4 cfu/ml). There were 5 river water samples from Gorai, Jamuna, Brahmaputra, Padma, and Buriganga rivers where the river Buriganga showed the maximum count that was 7.7×10^7 cfu/ml. The rest of the samples were collected from a pond in Jamalpur, Cox's Bazar sea, and Swapnadeep island where HPCs were 3.2×10^6, 6.9×10^4, and 9.2×10^5 cfu/ml, respectively (Table 2). Comparative to HPCs, TCCs also showed the highest counts in the same water samples except for tube well water where the highest TCC was found in Magura with 7.6×10^3 cfu/100 ml. The range of TCC started from 8.0×10^1 cfu/100 ml in Cox's Bazar sea water to 2.3×10^4 cfu/100 ml in Buriganga river water (Table 2).

Presumptive identification of isolates

Results of the bacteriological analysis of the water samples are presented in Table 3. All the selective organisms were presumptively detected by their growth on selective media from both enriched and not enriched water samples followed by examining their physiology by microscopy, colony morphology on selective growth media, and biochemical characteristics. Their presumptive identification was performed according to Bergey's manual of systemic bacteriology. The bacteria which were isolated from water samples include *Escherichia coli*, *Enterobacter* spp., *Staphylococcus aureus*, *Salmonella* spp., *Shigella* spp., *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Proteus* spp., and *Klebsiella* spp.

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Table 2 Quantification of microbial load from different water samples

Sample No.	Types	Source	HPC (cfu/ml)	TCC (cfu/100ml)
1.	Tap	Sajek	8.4×10^3	2.2×10^2
2.		Rangamati	8.4×10^3	3.0×10^2
3.		Cox's Bazar	3.3×10^4	5.5×10^3
4.	Tube well	Bogura	8.0×10^3	3.2×10^2
5.		Magura	7.6×10^3	7.6×10^3
6.	Lake	Kaptaii	1.1×10^5	3.4×10^3
7.		Maniknagar	1.6×10^4	2.0×10^3
8.	Pond	Jamalpur	3.2×10^6	1.7×10^4
9.	River	Gorai	8.8×10^5	2.7×10^2
10.		Jamuna	2.7×10^6	2.8×10^3
11.		Bhramaputra	2.2×10^6	1.4×10^4
12.		Padma	1.3×10^6	1.0×10^3
13.		Buriganga	7.7×10^7	2.3×10^4
14.	Sea	Cox's Bazar	6.9×10^4	8.0×10^1
15.	Island	Sopnodeep	9.2×10^5	3.2×10^2

Note: HPC, heterotrophic plate count; TCC, Total coliform count; cfu, colony forming unit

Table 3 Presumptive isolation of bacteria following microscopy, colony morphology and biochemical properties

Characterization properties																
Isolate No.	Microscopy	Media	Colony morphology	TSI (slunt/butt)	Gas	H2S	Indole	Nitrate reduction	Citrate	Oxidase	Catalase	Methyl Red	Urease	Motility	Voges-Proskauer	Presumptively Identified Bacteria
1	Gram -ve, Rod	Mac	Mucoid, pink, large	A/A	+	-	-	+	+	-	+	-	-	+	+	*Enterobacter* spp.
2	Gram -ve, Rod	Mac	Mucoid, pink, large	A/A	+	-	-	+	+	-	+	-	+	-	+	*Klebsiella* spp.
3	Gram -ve, rod	Mac	Gummy pink with precipitated bile zone, small	A/A	+	-	+	+	-	-	+	+	-	+	-	*E. coli*
4	Gram +ve, cocci, cluster	MSA	Golden Yellow with yellow zone	A/A	-	-	-	+	+	-	+	+	+	-	+	*Staphylococcus aureus*
5	Gram -ve, curved rod	TCBS	Mucoid green, black center, small, slightly flattened	K/A	-	+	+	+	+	+	+	+	-	+	+	*Vibrio parahaemolyticus*
6	Gram -ve, comma shaped	TCBS	Yellow, Large, slightly flattened	A/A	-	-	+	+	+	+	+	-	-	+	+	*Vibrio cholerae*
7	Gram -ve, rod	TCBS	Yellow, small	K/A	+	-	-	+	+	-	+	+	+	+	-	*Proteus* spp.
8	Gram -ve, rod	XLD	Red, small, Flattened	K/A	+	-	-	+	-	-	+	+	-	-	-	*Shigella* spp.
9	Gram -ve, Rod	XLD	Red with black centers, small	K/A	-	+	-	+	-	-	+	+	-	+	-	*Salmonella* spp.

Note: Mac, MacConkey agar; MSA, Mannitol Salt Agar; TCBS, Thiosulfate Citrate Bile Salts Sucrose agar; XLD, Xylose Lysine Deoxycholate agar; A, Acidic; K, Alkaline; TSI, Triple Sugar Iron test

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Frequency of isolates among different water bodies

Among the isolates, *E. coli* and *Staphylococcus aureus* were predominantly found in all the water samples collected except for Cox's Bazar sea water that lacked *E. coli*, and Buriganga river water that lacked *Staphylococcus aureus* species. The maximum number of bacterial isolates was found in both Jamalpur pond and Padma river waters. Interestingly, *Vibrio* spp. that are typically found in sea water, were also found in some freshwater samples. We identified *V. cholerae* from Jamalpur pond, Padma and Buriganga river water samples, and *V. parahaemolyticus* from Jamalpur pond, Buriganga river, and Cox's bazar sea water samples. The frequency of bacteria identified among the varieties of water samples was distributed in Table 4.

Table 4 Frequency of occurrence of bacteria in water samples

Isolates	Tap			Tube well		Lake		Pond	River					Sea	Island
	Sajek	Rangamati	Cox's Bazar	Bogura	Magura	Kaptai	Maniknagar	Jamalpur	Gorai	Jamuna	Brahmaputra	Padma	Buriganga	Cox's Bazar	Swapnadeep
Enterobacter spp.	√	√				√						√			√
Klebsiella spp.	√			√			√	√		√		√	√	√	√
Salmonella spp.	√				√	√		√	√	√	√	√		√	
Staphylococcus aureus	√	√	√	√	√	√	√	√	√	√	√	√		√	√
E. coli	√	√	√	√	√	√	√	√	√	√	√	√	√		√
Shigella spp.			√		√	√	√	√		√	√		√	√	
Proteus spp.			√						√					√	√
Vibrio cholerae								√				√	√		
Vibrio parahaemolyticus								√					√	√	

Antimicrobial resistance analysis

The resistance of isolated bacteria to antimicrobial compounds is presented in Table 5. All the isolates showed a degree of resistance against most of the antibiotics. *Enterobacter* spp., *Klebsiella* spp., *E. coli*, and *Proteus* spp. showed complete resistance (100%) against Amoxycillin while, absolute resistance for tetracycline was found among *E. coli*, *Proteus* spp., *V. cholerae* and *V. parahaemolyticus*. Overall, the highest sensitivity or the lowest resistance was found for the antibiotic Azithromycin that showed 100% sensitivity for *Enterobacter* spp., *Klebsiella* spp., *V. cholerae* and *V. parahaemolyticus*. Furthermore, Cotrimoxazole and Gentamicin showed an extent of resistance among the isolates except for *Staphylococcus aureus* that showed 100% sensitivity against Cotrimoxazole, where, *Salmonella* spp., and *Shigella* spp. also showed 100% sensitivity against Gentamicin.

Table 5 Antibiogram of isolates identified from various water samples

Isolates	Nalidixic acid (NA-30 µg)	Amoxycillin (AMX-30 µg)	Gentamicin (GEN-10 µg)	Tetracycline (TE-30 µg)	Cotrimoxazole (COT-25 µg)	Azithromycin (AZM-30 µg)
Enterobacter spp.	R (75%)	R (100%)	R (25%)	R (25%)	R (50%)	R (0%)
Klebsiella spp.	R (50%)	R (100%)	R (25%)	R (0%)	R(25%)	R (0%)
Salmonella spp.	R (50%)	R (25%)	R (0%)	R (25%)	R (25%)	R (25 %)
Staphylococcus aureus	R (25%)	R (50%)	R (75%)	R (25%)	R (0%)	R (25%)
E. coli	R (100%)	R (100%)	R (25%)	R (100%)	R (25%)	R (50%)
Shigella spp.	R (75%)	R (75%)	R (0%)	R (75%)	R (50%)	R (25%)
Proteus spp.	R (50%)	R (100%)	R (25%)	R (100%)	R (50%)	R (25%)
Vibrio cholerae	R (25%)	R (75%)	R (75%)	R (100%)	R (50%)	R (0%)
V. parahaemolyticus	R (25%)	R (75%)	R (75%)	R (100%)	R (25%)	R (0%)

Note: R, resistant

Discussion

Physicochemical properties of water samples from different places in Bangladesh revealed substantial differences. The samples were collected from the end of January to the middle of February. The highest pH value was found in Jamuna river water (8.2), and the lowest in Sopnodeep water (6.8), and all the samples are safe according to the Bangladeshi standard of pH for drinking water range from 6.2 to 8.5.[24] TDS of Cox's Bazar sea water, on the other hand, surpassed the highest limit in the measuring instrument where Tap water from Rangamati showed the lowest 55 ppm only that is acceptable for drinking according to world health organization (WHO) as the palatability of water with a TDS value less than 600 ppm is considered as good.[25] The massive TDS value of sea water

might be the result of higher salinity of sea water than processed water as tap water. As a result of higher water pollution in Brahmaputra and Buriganga, a vast amount of turbidity was noticed (40 NTU and 30.90 NTU, respectively) while a small amount was found in tap water from Sajak (0.19 NTU) that represents minimum pollution. Moreover, the turbidity of tap water in Sajak complies with the drinking water standard by WHO which is ideally less than 1 NTU.[25] However, the higher the DO value, the better the aquatic life quality is considered and healthy water is considered to have DO above 6.5 to 8 mg/l. The lowest DO value (3.4 mg/l) was found in the water of the Padma river that might be due to the building up of organic materials because of human activities. In contrast, sea water of Cox's Bazar represented the lowest water pollution by showing the highest amount of DO (5.9 mg/l). DO does not have any direct effect on public health but very low DO value makes drinking water unpalatable, and the maximum allowable limit for drinking water by Bangladeshi Standard is stated as 6 mg/l (Bhuiyan *et al*., 2010).[26] EC is the measure of the dissolved ionic components in the water and thus, it relates to electrical characteristics that serve as a tool to measure the purity of water. The World Health Organization (WHO) guidelines describe that EC value should not exceed 400 µS/cm.[27] But, water samples from Swapnadeep island, Cox's Bazar sea, Cox's Bazar tap, Jamalpur pond, Padma river, and Buriganga river exceeded the value that indicates substantial ionization. The TDS and EC values generally correlate with each other, and the same was observed in our study.

The isolates we detected were mostly facultative anaerobic and the most frequently identified bacteria were *Escherichia Coli* and *Staphylococcus aureus* where the less frequently isolated was *Vibrio* spp. The water samples carried a substantial number of indicator organisms and the presence of pathogens that is precarious for human consumption. All of our water samples exceeded the maximum safety limit for drinking water that is 5 cfu/100 ml for TCC, and 100 cfu/ml for HPC.[28] Even, the Tap and Tube well water samples might create high risk as they exceeded the safety limit for drinking water. Except for the tap and tube well waters, other water sources are not usually used for drinking purpose but they are used in recreational purposes as cleaning utensils, washing clothes or taking bath, etc. In 1975, the European Economic Community Council adopted a directive for bathing water where it is indicated that TCC should be 500 cfu/100 ml but, the maximum permissible count is 10,000 CFU/100 ml, and no *Salmonella* is admissible (Directive 76/160). The water quality standards for both drinking and recreational purposes made the quality of the water bodies very unsatisfactory. Among the 15 water samples, the river Buriganga showed the highest counts in terms of HPC and TCC that correlates with previous studies where significant pollution of the river Buriganga was observed due to organic, chemical, and bacterial pollution.[29,30]

Most of the isolates showed a degree of resistance to the antibiotics that is alarming. *Enterobacter* spp., *Klebsiella* spp., *E. coli*, and *Proteus* spp. showed complete resistance (100%) against Amoxycillin where, Azithromycin showed complete sensitivity (100%) for *Enterobacter* spp., *Klebsiella* spp., *V. cholerae* and *V. parahaemolyticus*. The resistance might be due to the over exposure of those antibiotics or the dissemination of resistant bacteria in the natural water bodies. The latter is frequently used for irrigation, aquaculture, or recreation activities that can directly or indirectly harm and infect the human population with antibiotic-resistant pathogens.

Conclusion

Water quality in both drinking and recreational waters is a critical issue for high morbidity and mortality in developing countries like Bangladesh. In association with it, drug resistance is a serious concern worldwide and most of the studies on antibiotic resistance are done in aquatic environments to observe how far the resistance is distributed. However, the presence and distribution of antibiotic resistance in nature has always been ignored in a country like Bangladesh. To improve the quality of life, it is indispensable to take proper actions to improve the eminence of both drinking and natural body waters and keep away their dissemination from antibiotic-resistant microorganisms through proper legislation and public awareness.

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None.

Conflicts of interest

Authors declare that there is no conflict of interest.

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