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Trends of Research on Water Quality in Bangladesh: A Review

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ABSTRACT

Bangladesh's existing body of water is being gradually polluted every day and a continuous quality assessment procedure is required for evaluating physical, chemical and biological properties of water. Many researchers have performed their study based on water quality and other associated problems. The study investigated trends in water quality research over the decade from 2010 to 2020 under the keyword "water quality assessment". The classification of articles was achieved by rating four (4) levels: (1) the title, (2) the keywords, (3) the abstract, and (4) the whole text. The study looked through 74 domestic and global journals, symposium papers, and other relevant articles to provide a broad scenario of the present context of water quality. We found sixty-five articles for surface water, six on supply water, two for groundwater, and rest of the work discussed both ground and surface water quality. We found fourteen articles emphasised about the law, rules and regulation to protect the water quality. The current state of surface water, according to the study's conclusions, is unfit for human consumption and the environment, and it is deteriorating on a daily basis. Rivers often absorbed a substantial amount of untreated sewage and industrial waste, both directly and indirectly. Lake water poses a threat to aquatic life as well as human health. Preliminary treatment is required before using the ground to supply drinking water. The researchers also tried to figure out what causes water contamination and what may be done about it. Based on this overview, readers can easily understand the trends in water quality research in Bangladesh.

Key words: Ground water, surface water, supply water, trends of research, water quality.

INTRODUCTION

Bangladesh, which is 20°34' and 26°38'N latitude and 88°01' to 92°41' E longitude, is a developing country with a populace growing rate of 1.48 per year and an area of 1,47,570 square kilometres (Mokaddes et al., 2013). Water stays often overlooked in Bangladesh, despite its importance in the economic, social, and communication sectors (Hasan et al., 2014). Water quality suffers as a result of urbanization and industry (Islam and Azam, 2015). As a consequence of the rapid growth of the population, unplanned urbanization, industrialisation, and farming operations, Bangladesh's river systems have become polluted (Islam et al., 2015). Every day, a considerable amount of untreated sewage, industrial fluids, and municipal garbage is dumped into the rivers surrounding Dhaka City, contaminating the surface water (Rahman et al., 2013). A total of seventy-four journal papers and conference proceedings were read for this review study in order to extract significant information about water quality status, which was then organized and presented in a logical manner. In addition, the corrective actions have been thoroughly discussed. This evaluation may serve to raise public awareness and draw attention to the relevant issues,

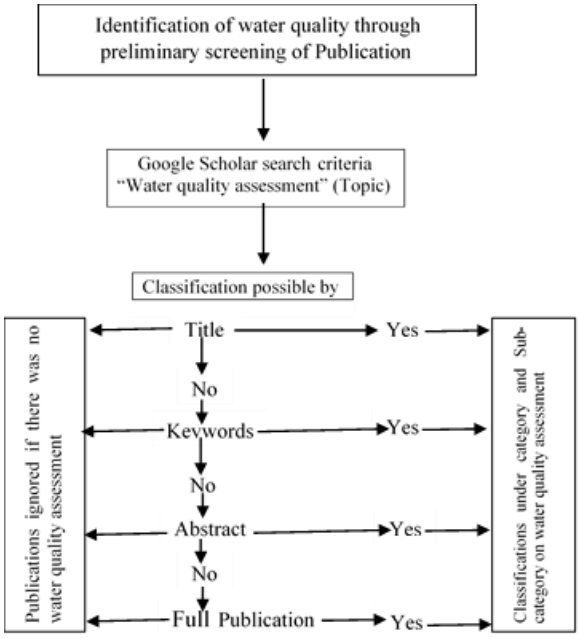

Figure 1 Research methodology flow diagram.

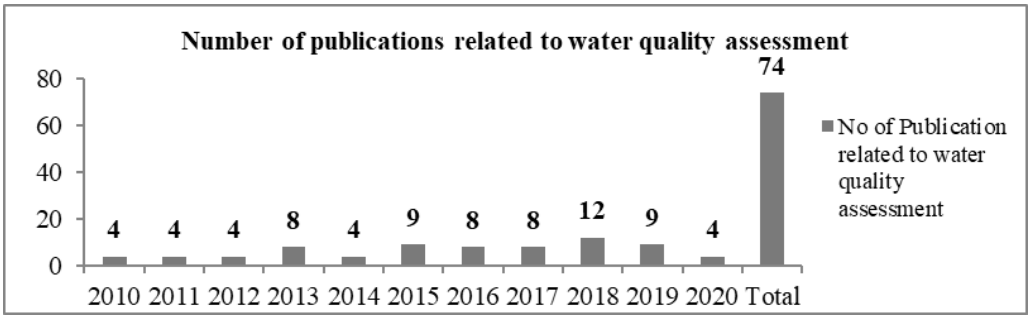

Figure 2: Academic publications on water quality assessment.

allowing them to take the required steps to improve water quality.

METHODS

The study used Google Scholar to look into the trends in water quality studies during a ten-year period, from 2010 to 2020. The focus of this study was solely on water quality. The research method flow is depicted in Figure 1.There were number of research works carried out by different scholars from different institutions [Dhaka University (DU)-15 no's; Jahangirnagar University (JU)-09 no's; Bangladesh Agricultural University (BAU)-06 no's; BCSIR (Bangladesh Center for Scientific and Industrial Research) -06 no's; BUET (Bangladesh University of Engineering and Technology) -04 no's and others institution-34 no's.]. The goal was to learn about existing studies on the health consequences of poor water quality around the world in order to identify areas that needed more research. Between 2010 and 2020, the key phrase 'Water quality assessment' remained used to hunt for research publications. During this time, a total of 74 research were examined. The studies were classified using a four-tier system that included (1) the title, (2) the keywords, (3) the abstract, and (4) the complete publication. The title was taken into consideration initially from the publications. The final stage was to identify subcategories for each category.

Analysis of bibliographic information

The review was conducted to examine current literature from local, regional, and international research journals. Figure 2 shows the number of articles published on water quality assessmentfrom2010 to 2020. It's clear that

Table 1: The top eight writers are listed in order of the number of papers they have published on water quality.

SL	Name of the Author	Publication Number
1	Islam MS	4
2	Ahmad MK	2
3	Alom MM	2
4	Islam JB	2
5	Islam MM	2
6	Islam SMD	2
7	Mohiuddin KM	2
8	Nargis A	2

Table 2: The top four academic journals for water quality assessment sorted by the number of articles.

SL	Journal of Academic Research	Publication Count
1	Journal of environmental science and natural resources	4
2	Springer	3
3	IOSR Journal	2
4	Progressive agriculture	2

Table 3: For the classification of publications, categories and subcategories were chosen (Based on life cycle assessment).

Topic	Surface Water	Ground Water	Supply Water	Both Ground and Surface
Sub Topic	**River**			
	1. Water quality	1. Water quality	1. Water quality	1. Water quality
	2. Toxic metal	2. Physicochemical analysis	2. Physicochemical analysis	2. Physicochemical analysis
	3. Heavy metal	3. Microbiological analysis	3. Microbiological analysis	3. Microbiological analysis
	4. Trace metal	4. Trace metals	4. Toxic metal	4. Hydrological parameters
	5. Water pollution	5. Water pollution	5. Heavy metal	
	6. law, rules and regulation for protect the water quality	6. Law, rules and regulation for protect the water quality	6. Distribution line	
	7. Lake		7. Law, rules and regulation for protect the water quality	
	8. Water quality			
	9. Heavy metal			
	10. Physicochemical analysis			
	11. Microbiological analysis			
	12. Water pollution			
	13. Law, rules and regulation for protect the water quality			

research interest in water quality evaluation has risen consistently. Among the selected articles, the highest number (12 articles) was found in the year of 2018, and the second highest is 9 articles on 2015 and 2019. Table 1 summarizes the articles published by authors, whereas Table 2 summarizes the papers published by academic publications. The screening technique yielded the following categories (Table 3): (1) Water source, (2) research

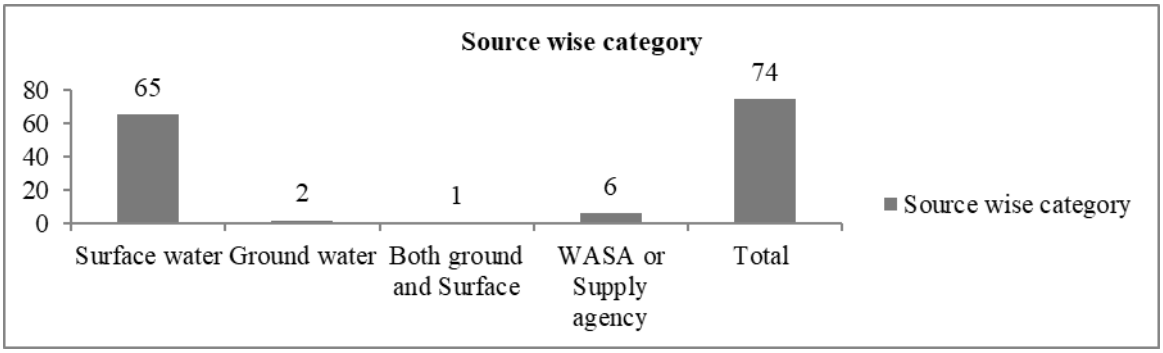

Figure 3: The number of articles related to various water sources.

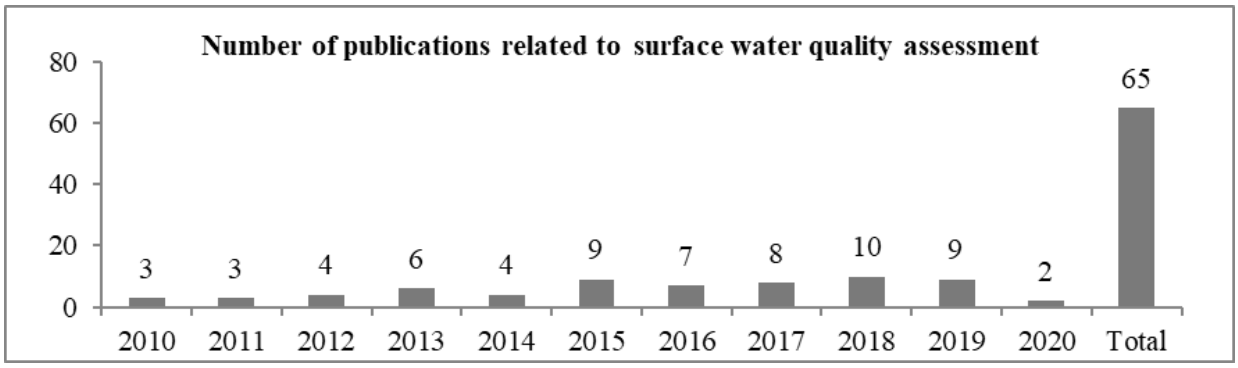

Figure 4: Year wise publications on surface water.

category. Remarkably, the body of scholars accompanied experiential studies on water quality assessment is large and diverse with a total of 317 different writers publishing in 74 diverse journals. The Journal of Environmental Science and Natural Resources has published the highest number of journals and Islam MS has the highest number of publications.

RESULTS AND DISCUSSION

The articles were classified into source categories: surface water has 65 articles, ground water has two articles, both ground and surface have one item, and WASA or supply agency has six articles (Figure 3).

Publications on surface water quality

65 articles related to surface water were divided in year wise category. Among the selected articles, highest is 10 that were published in 2018. Lowest number of publications was found in the year 2020. Year wise publications on surface water within 2010-2020 are shown in Figure 4.

River water

The capital city Dhaka is surrounded by a chain of rivers Buriganga, Turag, Balu, Shitalakkhya and Dhaleshwari. So, most of the research articles were published based on various issues of river water pollution and the category wise breakdown of these publications have been shown in Table4.As we can see from Table 4, the highest number of publications (20) were based on the river Buriganga followed by second highest with river Turag (12 publications) and the least number of research was done in Dhaleshwari river.Except water pollution, in all other categories, more research was carried out in Buriganga river. Only on the Turag river, maximum research was conducted based on water pollution. A comprehensive breakdown of year wise publication on each river has been shown in Figures 5-10.

The Buriganga river

A total 20 articles discussed about various pollution aspects of the river Buriganga (Figure 11). Among which, 6 articles were related to the assessment of the present condition of water quality and the potential reasons behind it. According

Table 4: Number of publications on river water based-on subcategory (water quality, toxic metal, heavy metal and water pollution)

Name of the River	No. of articles	Water quality	Toxic metal	Heavy metal	Trace metal	Water pollution
The Buriganga river	20	6	1	9	3	1
The Turag river	12	5	0	2	0	5
Combined	08	1	1	3	0	3
The Balu river	07	3	1	1	1	1
The Bangshi river	05	1	0	4	0	0
The Shitalakkhya river	04	1	1	2	0	0
The Dhaleshwari river	03	1	0	2	0	0
Total	59	18	4	23	4	10

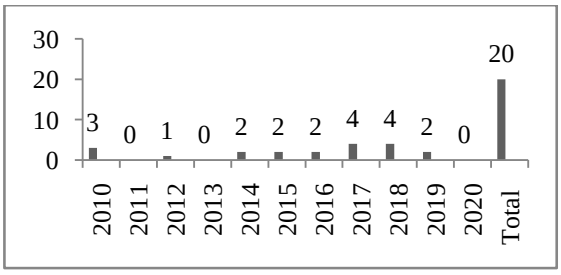

Figure 5: Publications on Buriganga River

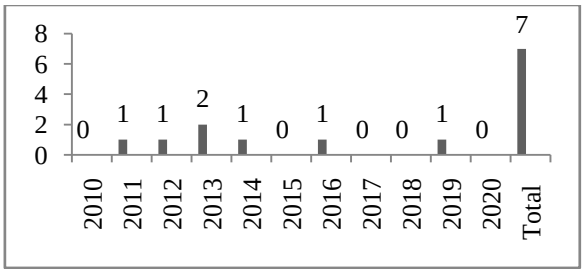

Figure 6: Publications on Balu River

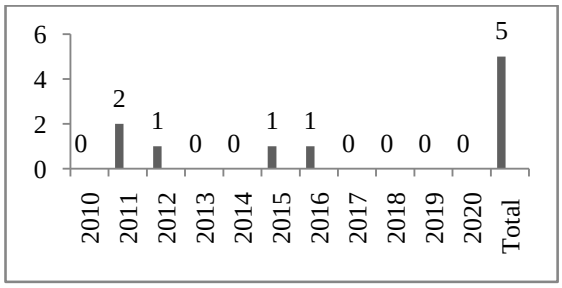

Figure 7: Publications on Bangshi River

to their findings, river water was polluted both by point and non-point sources (Ahmed et al., 2016).Furthermore, fish accumulated the most metals, followed by soil, plants, and water (Realet al., 2019). In Sadarghat, Hazaribagh and Zinzira, the concentration of trace metals (Cr, Cd and Fe) in water surpassed the supreme allowable perimeter for irrigation and drinking water during the dry season (Moniruzzaman et al., 2012). The Buriganga river

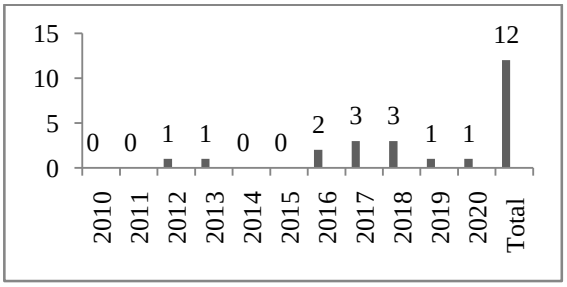

Figure 8: Publications on Turag River

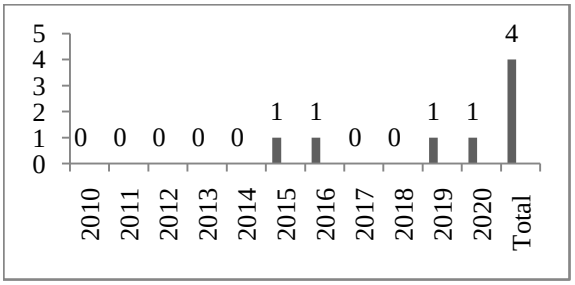

Figure 9: Publications on Shitalakhya River

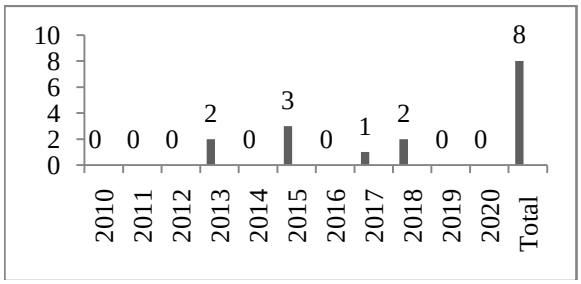

Figure 10: Publications on Combined River

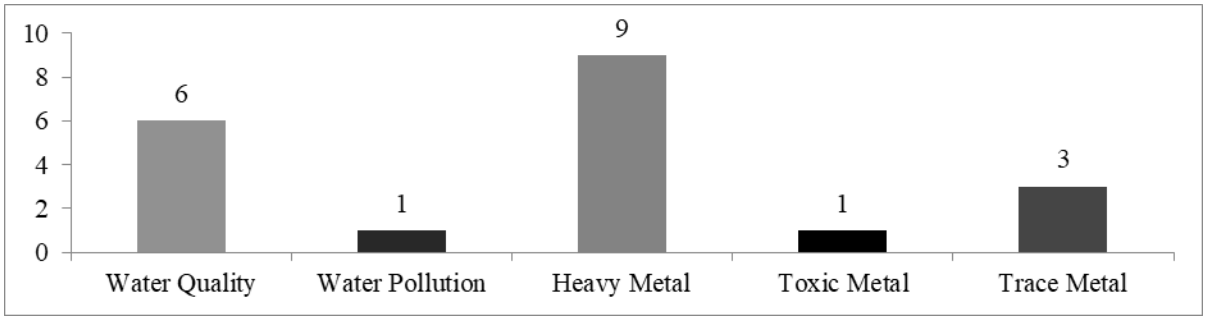

Figure 11: Category wise Publications on Buriganga River.

sediments had several times higher mean total trace metal concentrations than the Turag, Padma, and Korotoa river sediments (Mohiuddinet al., 2015).They also emphasized the potential health jeopardizes connected with ingesting fish from the Buriganga River, especially during the winter (Nargis et al., 2018)and stated that the current state of

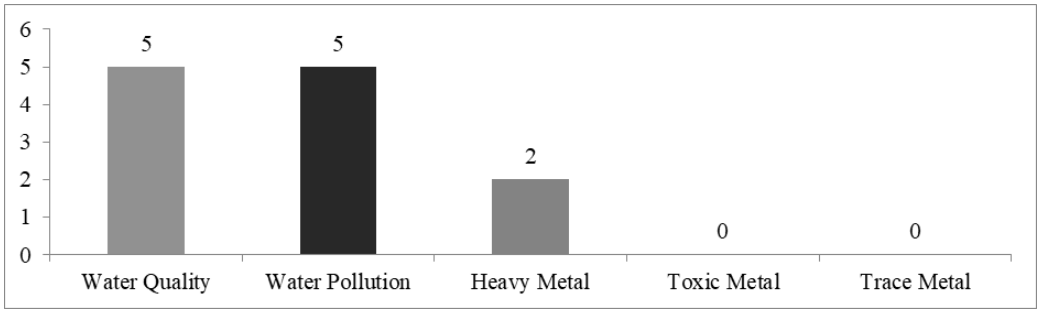

Figure 12: Category wise publication on Turag River.

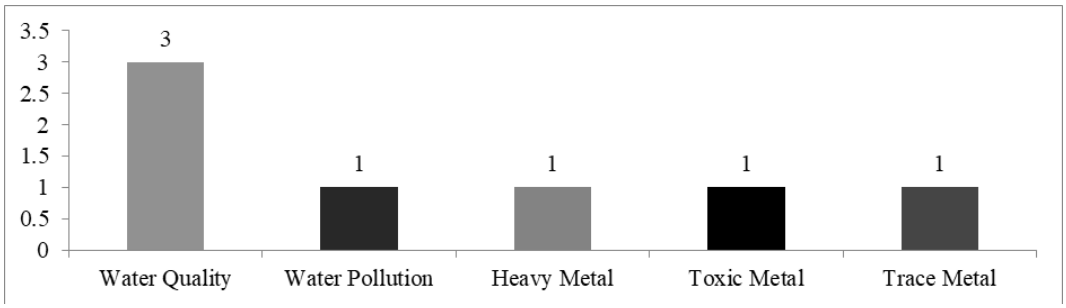

Figure 13: Category wise publication on Balu River

water is unsuitable for humans and the environment (Rahman and Bakri 2010).

The Turag river

About 12 articles discussed about different categories of pollution aspect of Turag River was discussed (Figure 12). The water pollution of the Turag river was mentioned in 5 publications. Coliforms and other disease-causing bacteria were found in the Turag river water, according to research (Rabbi et al., 2016). According to another article, most industrial effluents are dumped explicitly or implicitly into the Turag River without appropriate management, resulting in surface water contamination (Majed and Chowdhury, 2018). Only 2 articles were identified for this river where the pollution caused by the heavy metals was discussed (Banu et al., 2013; Mohiuddin et al., 2016). The study looked into the possibility of heavy metal contamination being a threat to the environment (Banu et al., 2013) and frightening situation for city people and the Turag rivers aquatic ecology due to sediment contamination (Mohiuddin et al., 2016).

The Balu river

A total of 7 articles were evaluated in relation to this river (Figure 13), with the most commonly cited category being the river's water quality. The water feature of the Balu River was examined in three research works. The sorts of heavy metals discovered in this river were explored in an article (Rahman et al., 2016). Only one article has given importance about the toxicity of the water (Islam et al., 2013).In his study, pollution caused by the trace metals were discussed (Islam et al., 2012).Their study found that, in December and March seasons, most of the location had high concentration of different metals (Islamet al., 2012). The levels of Cr, Pb, Cd, and Fe in Balu river water remained ominously upper than Bangladesh Department of Environment (DOE) guidelines, indicating that pollutants from a variety of sources were present, including residential sewage, agricultural runoff, industrial effluents, municipal sewage and so on (Sultana et al., 2019). The quantities of Cd, Ni, Pb, and Cr in irrigation, drinking, aquaculture, and surface water for the dry season exceeded the WHO, GOB, USEPA, DOE, and FWPCA guidelines (Islam et al., 2013). According to another research, if pollutants are released at the same time, heavy metal bio-accumulation in fish rises (Rahman et al., 2016). The EC and PO4 measurements, as well as the hue of the water, were all over the permitted levels for drinking and irrigation water (Hasan et al., 2013).

The Bangshi river

We looked at five articles in which the pollution

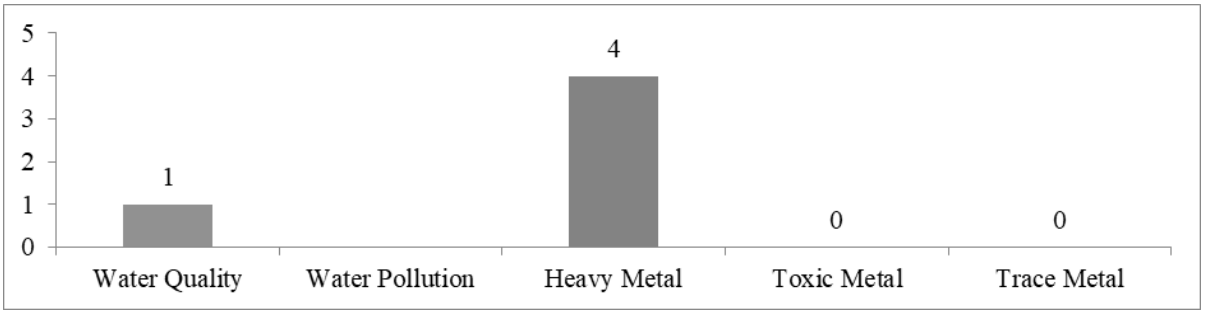

Figure 14: Category wise publication on Bangshi River.

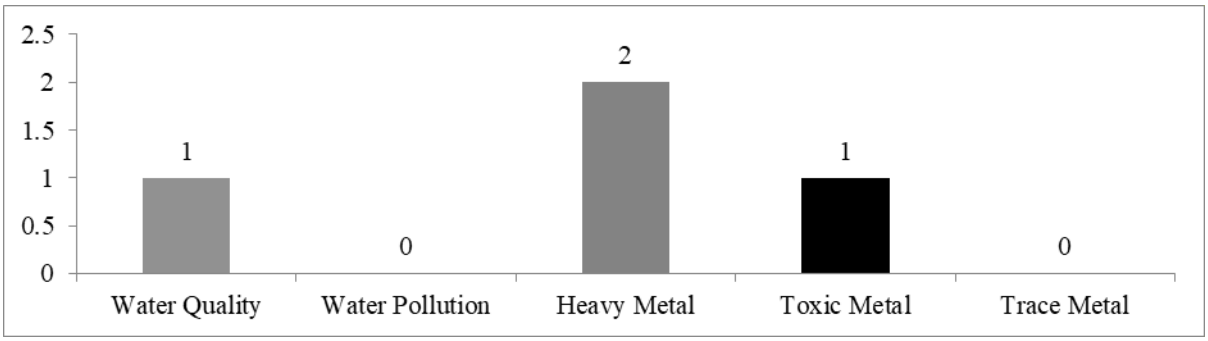

Figure 15: Category wise publication on Shitalakkhya River.

characteristics of the Bangshi River were described (Figure 14). The effects of heavy metal contamination were examined in four studies. The pH and Dissolved Oxygen (DO) readings of all sampling stations exceeded the DOE's regulatory limit, according to a research (Hossain et al., 2012).In another study, heavy metal absorptions in diverse fish species of the Bangshi river were found to differ significantly (Rahman et al., 2012). According to the study, harmful heavy metals such for example Cu, Pb, Cr, Ni, and Zn were found in the water, which might lead to a rise in different health problems or diseases in the surrounding communities (Khanam et al.,2011).

The Shitalakkhya river

Figure 15 depicts the review of approximately four research articles on various aspects of pollution in the Shitalakkhya river. Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), and Electrical Conductivity (EC) of the Shitalakkhya river water are all above the national standard, rendering it unfit for drinking, domestic, irrigation, or industrial use, as well as dangerous to aquatic life and human health, according to Islam et al. (2015).In two studies, the presence of heavy metals was discussed. They discovered that the pH values were within acceptable ranges, but that the DO level was in a stressful state for the aquatic ecosystem and that BOD levels were exceptionally high at all sampling stations (Jolly et al., 2019). Al, Fe, As, Cu, Co, Cr, and Zn pollute sediments because their quantities exceed the Toxicity Reference Value (TRV) set through the USEPA (United States Environmental Protection Agency) (Islam et al.,2016).

The Dhaleshwari river

The heavy metal composition of the Dhaleshwari river was explored in two articles (Figure 16). They deliberated about water quality and agreed that proper testing and treatment for microbiological contamination should be done in the water body before it is used for human consumption (Ahsan et al., 2018; Akter et al.,2019). Another study exposed that tanneries contaminate the Dhaleshwari river in Savar through removal of raw effluents straight into the river, with Pb, Cd, Cr, and other heavy metal absorptions in the fish species, sediment, and water beyondFAO, WHO, and EPA standard parameters(Mohanta et al.,2019).

Lake or inland surface water

Total of 6 articles were found to have discussed about the lake or inland surface water quality. Both in 2015 and 2019,

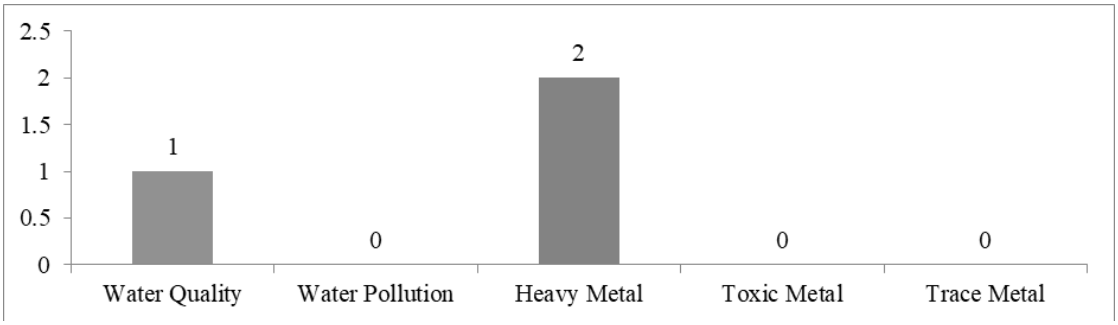

Figure 16: Category wise publication on Dhaleshwari River.

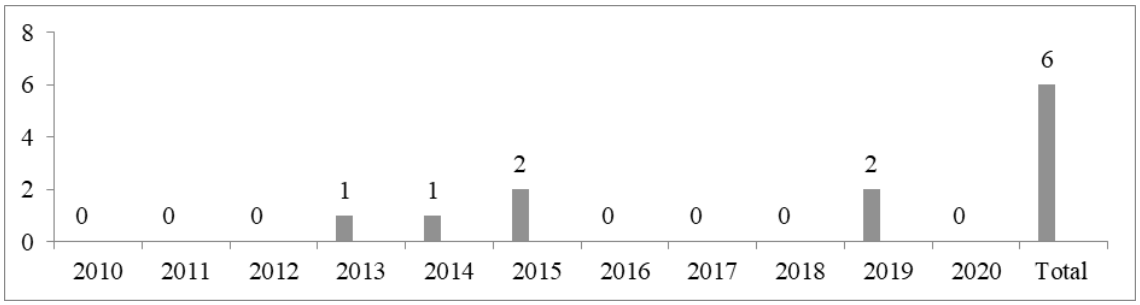

Figure 17: Year wise publications on lake or inland surface water.

two research works were published regarding lake or inland surface water quality. Year wise publication on Lake or Inland surface water within 2010-2020 is shown in Figure 17.According to their findings, BOD contents in all samples from Gulshan and Ramna Lake surpassed drinking water quality guidelines by GOB (Razzak et al., 2013). Another study, determined the water quality (the criteria for drinking) of Hatirjheel lake. 100% of the samples met the standard (ECR 97) value for pH, however 100% of the samples failed to meet the standard for color, turbidity, carbon dioxide (CO2), and chloride (Alam, 2014). The water feature of two main water bodies in Dhaka city, 'Shahidullah Hall pond of Dhaka University' and, Ramna Lake surpassed the Bangladesh standard, and the study determined that the inland water feature of Dhaka city is not decent enough to uphold public health and that appropriate management is required to preserve water quality (Sarker et al., 2019). Conductivity, temperature, transparency, pH, free CO2, hardness, soluble O2, total alkalinity, and further water quality limits of three lakes on the Jahangirnagar university grounds showed negligible physico-chemical parameter disparity from the usual range, with prominent exceptions (Rahman et al., 2015).

Publications on ground water quality

Two articles highlighted the condition of ground water and one article acknowledged the pollution caused by trace metals (Prosun et al., 2018; Bodrud-Doza et al., 2020). Their study initiates that, the water assessments nearly all the Noakhali areas were sullied by microbial defilement and the physicochemical limits remained not appropriate for drinking and they also conferred government in addition to NGOs must come accelerative to supply safe and acceptable drinking water in this seaside area (Prosun et al., 2018). Another study determined groundwater of Dhaka is faintly acidic to alkaline and in certain samples Fe and Mn concentrations surpass the usual tolerable parameters and they also discussed about the possibility of occurrence of child health hazard owing to ingesting of groundwater for extensive periods, deprived of added remedy (Bodrud-Doza et al., 2020).

Publications on both ground and surface water quality

A study on ground and surface water quality assessment found that arsenic, total hardness, extreme manganese, iron concentrations, and coliform bacteria contamination are the main restraints for drinking water source in Rajshahi City Corporation, Bangladesh.

Publications on water and sanitation authority (WASA) or supply agency water quality

We reviewed six articles where supply water quality

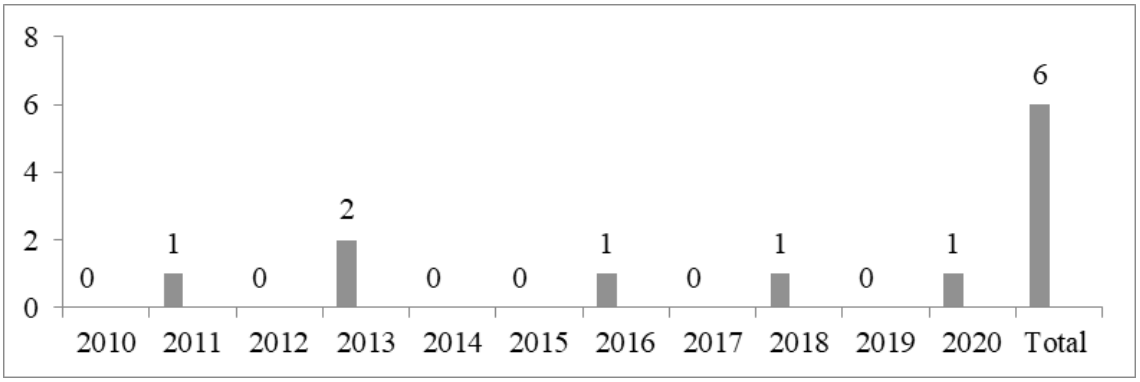

Figure 18: Year wise publications on WASA or supply agency water quality.

feature remained discussed (Mahbub et al., 2011; Alom and Habib, 2016; Sabrina et al., 2013; Sultana et al., 2013; Roy et al., 2018; Jamal et al., 2020). Among the six articles, four were on supply water of Dhaka city (Mahbub et al., 2011; Alom and Habib, 2016; Sabrina et al., 2013; Jamal et al., 2020) and two were about the supply water of Tangail municipality (Sultana et al., 2013) and Rajshahi area (Roy et al., 2018). Year wise publication on supply water within 2010-2020 is shown in Figure 18.In their study, they recorded identical trace quantity of Arsenic (0.0071ppm) in five educational institutes of Tangail town (Sultana et al., 2013). Another study looked at Rajshahi WASA (RWASA) water parameters (pH, turbidity, iron, hardness, and odor) and discovered that all but the pH varied from the standard value (Roy et al., 2018). The microbiological quality of Dhaka city's supply water was tested, and 25 out of 45 samples met BDS and WHO standards (Mahbub et al., 2011). They came to the conclusion that the distribution lines were the most likely cause of microbial contamination in drinking water (Mahbub et al., 2011). In their study, they discovered that 36% of DWASA customers boil their water for consumption (Alom and Habib, 2016). Another investigation discovered that DWASA's water quality is good and meets the drinking water criterionsECR-1997 and BDS 1240:2001(Jamal et al., 2020).

Sources of pollution

According to the study, industrial effluent discharge, municipal wastewater and sewage discharge, population explosion, encroachment and land grabbing, solid and residential waste disposal, agricultural waste, sewage, and industrial waste are all potential sources of contamination (Ullah and Ghosh, 2011; Sultana et al., 2019; Hasan et al., 2013; Hasan et al., 2014; Rahman et al., 2016).Agricultural run-off, as well as the release of wastewater from nearby industries and municipalities that has not been properly treated (Ullah and Ghosh, 2011) and dumping waste beside the riverbank pollutes the water (Tahmina et al., 2018). In Dhaka metropolitan, more than 5,000 tons of solid waste is generated each year, with 63% of it being thrown in the river (Mohiuddin et al., 2015).Water bodies are severely polluted as a result of improper garbage disposal and discharge methods (Real et al., 2019). WASA water is contaminated by bacteria in the supply system and/or domestic reservoirs or tanks (Mahbub et al., 2011). Various trace elements resulting from wastewater discharges, agricultural operations, and leakage into groundwater supplies from extremely contaminated areas have also contaminated groundwater (Bodrud-Doza et al., 2020).

Remedial measures

Human activities such as urbanization, industrialization, and population growth are the primary drivers of today's water pollution. It is now more important than ever to take the required precautions to prevent further deterioration of water bodies and to take corrective measures to restore the quality of water that has already been polluted. This study looked at some remedial actions that, if implemented, could help the water quality recover from its current state, as indicated below and in Table 5. Appropriate rules and legislation on dumping industrial waste into the river should be implemented strictly (Arefin et al., 2016):

1. Industries such as tanneries, textiles, and brickfields should be moved away from riverbanks, and the government should compel these businesses to build effluent treatment plants (Ullah and Ghosh, 2011).
2. Polluting industries pose a serious threat to river water quality; thus, the government must enforce laws, environmental standards, and regulations against them (Khanam et al., 2011; Hasan et al., 2014).
3. Appropriate laws and regulations on industrial waste disposal in rivers should be enacted (Islam et al., 2012) and every industry must adhere to and implement the

Table 5: Practical application of the laws and some suggestions for potable water

SL	Law	Practical Application of Law	Suggestions
	ORDINANCE		
1	Water Pollution Control Ordinance,1970	Control and diminution of prevailing or prospective contamination of any waters, as well as the extension or modification of disposal systems, sewage systems, or treatment plants. Failure to comply with these rules could result in a fine and/or jail (Clemett, 2006; Arifuzzaman et al., 2019).	Legislation relating to drinking water should be enacted.
	POLICY		
3	The National Water Policy, 1999	Water resource protection, restoration, and augmentation; Water quality protection, including tightening rules on agrochemicals and industrial wastewater; Sanitation and safe drinking water (Clemett, 2006; Arifuzzaman et al., 2019).	Drinking water resources should be safeguarded, restored, and improved in a targeted manner.
4	National Policy for Arsenic Mitigation, 2004	Public awareness, arsenic-free drinking water, patient diagnosis and management, and capacity building are all priorities (EMF for RMIP, 2015).	The public should be made aware of the need of secure water supply.
	ACT		
2	Water Supply and Sewerage Authority Act, 1996	Improve and operate a water source and sanitation structure, as well as provide water, sewerage, and storm water drainage services (Arifuzzaman et al., 2019).	Water table monitoring, data gathering, database management, and continuing development for the justified practice and administration of water properties should all be included.
3	The Environmental Court Act, 2000	This act empowers the government to pursue legal action against anyone who poses a threat to the environment or causes harm to human society (Clemett, 2006).	There should be legal action taken against anyone who poses environmental dangers or damages the drinking water supply.
6	The Ground Water Management Act, 2018	This Act governs the management of groundwater resources for agricultural purposes (Arifuzzaman et al., 2019).	The Act should address commercial, industrial, and other water abstraction, groundwater fortification (e.g. restore, combined surface and groundwater use, rainwater harvesting, long-term planning, water mining penalties, and so on), a central monitoring/regulation mechanism, water pollution, and water safety issues.
	RULES		
1	The Environment Conservation Rules (ECR), 1997	Outline the steps for designating an ecologically significant region, obtaining an environmental clearance certificate, obtaining a pollution control certificate, defining environmental criteria, and so on (Clemett, 2006; Arifuzzaman et al., 2019).	Water contamination should be reduced by maintaining environmental standards.

Source: Prepared by authors

Department of the Environment's environmental regulations (Ullah and Ghosh, 2011).

4. To control pollution, a proper monitoring system, alternate drinking water sources, proper treatment systems, and groundwater management policies could be implemented (Bodrud-Doza et al., 2020).

5. Raising public awareness is critical to preventing major water quality degradation (Ullah and Ghosh, 2011; Arefin et al., 2016).

6. Government involvement, regular research, public alertness, and government legislation can all help to protect water (Ullah and Ghosh, 2011; Mokaddes et al., 2013).

Policy initiatives

A total of 14 articles were examined, all of which focused on the law, rules, and regulations that preserve water quality.

The government has given distinct devotion to the matter of river contamination by legislating rules such as the National Water Policy of 1999, the National Environmental Policy of 1992, the Industrial Policy of 1999, the Environmental Control Act of 1995, and the Environmental Control Regulations of 1997, but the majority of industries partake through little struggle to obey through environmental laws (Aktar and Moonajilin, 2017;Rahman and Bakri 2010). Appropriate regulations and policies on industrial waste disposal should be carefully enforced(Khanam et al., 2011; Islam et al., 2012; Arefin et al., 2016).Groundwater management policy (Bodrud-Doza et al., 2020), government regulations (Alam, 2014), enforcing environmental laws, regulations, and standards on polluting industries (Khanam et al., 2011; Hasan et al., 2014; Arefin et al., 2016), install effluent treatment plants (Ullah and Ghosh, 2011; Khanam et al., 2011); monitoring and enforcing current rules and regulations (Alam, 2014, Khanam et al., 2011; Mokaddes et al., 2013; Islam et al., 2015) and maintenance remain needed to prevent further deterioration of water quality (Tahmina et al., 2018).

CONCLUSION

It is impossible for any civilization to subsist without clean water. We are fortunate to have a plentiful supply of water. This review attempted to recognize findings from diverse research studies and to evaluate them so that appropriate educational strategies might be proposed. Surface water, groundwater, and drinking water are all intertwined. The quality of groundwater and tap water can only be ensured through improved fortification of surface water and enrichment regions in the soil. The most important thing is for people to understand the importance of clean water in their daily lives. People should also be educated on the causes and effects of water contamination so that they can prevent from engaging in such activities. Research network should be developed by domestic stakeholders (Government, NGO, Private organization), academic network, international stakeholders (funding agencies, INGO, etc.). Harmonized water quality framework research, policy framework development, capacity building, sustainability roadmaps, and sustainable water quality management, as well as rainwater and groundwater conservation, water recycling systems, and an increase in skilled and furnished teams for water quality nursing and investigation, may help to save our water resources. There are various laws and regulations in our country, but due to a lack of enforcement, water worth remains deteriorating gradually. So it is appropriate that the enforcement of rules and regulation be made possible. Geographic Information Systems (GIS), remote sensing, EIA (environmental impact assessment) might be used for unified policy formulation, decision-making, evaluation and monitoring of environment. A vigorous ecosystem and healthy environment are very vital for all mankind. Only a pollution-free environment can affirm this, and only humans can make the environment pollution-free. Through a better understanding of the cause and source of pollution we can safeguard the water resource for us and for our future generations.

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