IMPACT OF SOLID WASTE DUMPING ON GROUNDWATER AND SURFACE WATER QUALITY IN GACHA UNION, GAZIPUR, BANGLADESH

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ABSTRACT

Water quality degradation from improper solid waste management causes significant risks to ecosystems and human health. Solid waste dumping critically threatens water resources; however, its localized impacts remain understudied in rapidly urbanizing regions such as Gazipur. This study therefore investigates the impacts of solid waste dumping on groundwater and surface water quality in Gacha Union, Gazipur, Bangladesh. For this purpose, groundwater samples from five wells and surface water samples from three ponds near the waste dumpsite were collected. Then major key parameters including dissolved oxygen (DO), pH, total dissolved solids (TDS), electrical conductivity (EC), Hardness, Turbidity, Alkalinity, Nitrate, Phosphate, Iron, Arsenic, Biochemical oxygen demand (BOD), and Chemical oxygen demand (COD) were analyzed. The results indicated that most groundwater parameters, including pH, TDS, hardness, turbidity, nitrates, phosphates, and iron, complied with Bangladesh drinking water standards (Environmental Conservation Rules [ECR] 1997). Arsenic and color were not detected in any samples. The DO levels in three wells satisfied the drinking water standard, whereas the remaining two wells did not. On the other hand, surface water exhibited significant contamination. The DO level in one pond was below the threshold required for fish growth (5 mg/L), while the others exceeded this level due to aeration. All ponds exceeded the BOD limits according to the ECR fisheries guideline (≤6 mg/L) , and the high COD values further indicate extreme organic contamination probably linked to runoff and leachate of the dumpsite. Additionally, turbidity and phosphate concentration surpassed aquaculture standards (ECR 1997). These outcomes demonstrate that the dump site is contributing organic and particulate pollution to nearby surface waters and may be affecting groundwater oxygenation in certain locations. The investigation indicates that urgent need for remedial actions like source control, leachate management, water treatment, and continued monitoring of both surface and groundwater to protect ecosystem health and community water supplies. The Implementation of these measures will facilitate to mitigate environmental and public-health risks associated with the waste dumping site.

Keywords: *Groundwater pollution, Surface water quality, Solid waste, Water quality parameters.*

1. INTRODUCTION

Water is the most important substance, constituting 71% of the Earth's surface, but 2.5% of that is only fresh water, appropriate for utilization, and even that some of it is interlocked in glaciers form (Juneja & Chaudhary, 2013). It is essential in the enhancement of the aquatic ecosystem, the provision of safe drinking water, irrigation, and industrial affairs. However, poor waste management practices and high rates of urbanization in the world have continued to expand dumping sites for solid waste, which have become serious threats to water resources (Parvin & Tareq, 2021). Leachate is a high-concentration effluent that forms when water seeps through the decomposing solid waste; it is characterized by the presence of heavy metals, a number of organic contaminants, and pathogenic microorganisms, which threaten ground water as well as surface water severely (Kjeldsen et al., 2002). When leachate seeps into the soil and filters into the aquifers, it contaminates the groundwater, a major drinking water source for 35% of the population of Bangladesh, and causes serious health hazards like cancer, neurologic disorders, and kidney failures (Ahmed et al., 2015). Surface water bodies are also susceptible to contamination by runoff from the dump site. At its various sources, the runoff that contains debris of solid waste, chemicals, and microbial contaminants at the dump site, can be directly deposited into rivers, lakes, and other surface water bodies, distorting aquatic ecosystems, and impairing its usefulness in many ways, such as drinking water, irrigation, and recreations uses (Hossain et al., 2018). The uncontrolled accumulation of wastes leads to the production of leachate that pollutes ground and surface water with heavy metals (Ahmed et al., 2015; Alam et al., 2020), nutrients, and pathogens (Gupta et al., 2024), and impacts the aesthetics of water (Azim et al., 2011) that is potentially harmful to human health and ecosystems. The amount of municipal solid waste produced in urban areas in Bangladesh is high and in most places the disposal methods are still based on landfilling and open dumping which enhances the chances of production of leachate and water pollution. The Bangladesh Waste Database (2021) estimates that during an average day, there is a total waste production of 33,574.30 tons/day in the cities. In addition, the Solid Waste Management Rules (2021) provide a regulatory framework for improved solid-waste handling and management responsibilities, which is relevant for assessing dumpsite impacts on local water resources.

In recent times, several studies (Alam et al., 2020; El-Mathana et al., 2021; Igboama et al., 2022; Mishra et al., 2019; Njewa et al., 2025; Parvin & Tareq, 2021) have extensively revealed the adverse effects of solid-waste dump sites on water quality. The dissolved Oxygen (DO) is also important to aquatic life, and low DO, which is frequently a result of elevated organic loads such as found in leachate, may result in hypoxia and kill aquatic life (Christensen et al., 2001). pH is a scale that indicates acidity or alkalinity, which is changed by the chemical process in the dump itself, and this influences the toxicity and solubility of other contamination (Kjeldsen et al., 2002). EC and TDS can be used to measure the concentration of dissolved inorganic salts and minerals, and can be considered a pollution indicator when at high levels (Ramakrishnaiah et al., 2009). Parameters such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are direct measures of organic pollution, whereby higher values indicate severe contamination by both biodegradable and non-biodegradable organic pollution (Samudro & Mangkoedihardjo, 2010). Moreover, it is of significant concern whether there are certain contaminants like arsenic, nitrates, and phosphates. Arsenic is very toxic both naturally and through anthropogenic sources, and its occurrence above the limit in water has bleak health effects (Haque, 2018). Previous research has established that leachate and runoff from open dump sites considerably change these parameters. For instance, Mishra et al., (2019) observed a sharp decline in DO and an increase in BOD and COD near municipal dumps in Varanasi, India. Similarly, El-Mathana et al., (2021) indicated high concentrations of EC and TDS below an Egyptian dumpsite because of leachate leakages. In Bangladesh, (Parvin & Tareq, 2021) observed that leachate contamination enhanced phosphate and nitrate levels in surface waters around landfills. Nitrates which are produced by agricultural runoff and sewage, can lead to a risk of methemoglobinemia in infants, but dissolved excessive phosphates, which occur to a large extent as a byproduct of fertilizers and detergents, can cause eutrophication and harmful algal blooms (CUMINGS, 1962).

Although the studies mentioned above and other regional investigations have evaluated the impact of open dumpsites on water quality, most have focused on either groundwater or surface-water conditions individually and primarily within large municipal landfill systems. However, the scope of localized studies, which have a combined evaluation of both groundwater and surface-water quality of unregulated, small dumpsites, is limited, especially within the rapidly urbanizing context of Bangladesh. Therefore, this paper discusses the quality of water surrounding a solid waste dump site situated in Gacha Union, Gazipur Sadar Upazila, Gazipur, particularly concerning the effects on the immediate water sources and people in the locality.

2. MATERIALS AND METHODS

This paper used a systematic approach to investigate the impact of the solid-waste dumpsite on the groundwater and surface-water quality of Gacha Union, Gazipur Sadar Upazila, Gazipur. The objective of this study was to investigate the quality of water near the solid waste dump site, particularly concerning the effects on the immediate water sources and people in the locality. The study fills this gap by determining the important water quality parameters near the Gacha dump site, comparing them to national and international standards to identify deviations and threats to human health, as well as to aquatic environment, to inform intervention and sustainable waste management plans. The general process of the work consists of careful sample collections, site selection, and thorough laboratory analysis with data interpretation.

2.1 Study Area and Site Selection

Gacha Union is a union under the Gazipur Sadar Upazila in the Gazipur District in Bangladesh with an area 28.042 square kilometres and a total population of 67,691 people. The Gacha open dumping site was selected as the study area due to its direct relevance to the research objectives. This is an unregulated, open-air, municipal solid waste dumping site receiving mixed-solid waste from nearby local households, markets, and roadside commercial activities. According to the field observations, dumping is done on a daily basis but official records on site capacity or monthly/annual quantities were not available at the time of this study. There is no designed containment (e.g. liner or leachate-collection system) and, therefore, leachate and runoff can penetrate adjacent soil and affect on ponds and shallow groundwater. The dump site is located beside the Gacha Road bus stop, which is close to the Dhaka-Mymensingh highway. Latitude 23.9368443°N and longitude 90.38473°E are the coordinates of the dumping site. Moreover, Gacha represents a typical semi-urban community in Bangladesh with high rates of urbanization and inadequate waste management, thus, a typical example in the evaluation of the effects of open-dumps on water quality. Figure 1 shows the study area's location map including sampling sites.

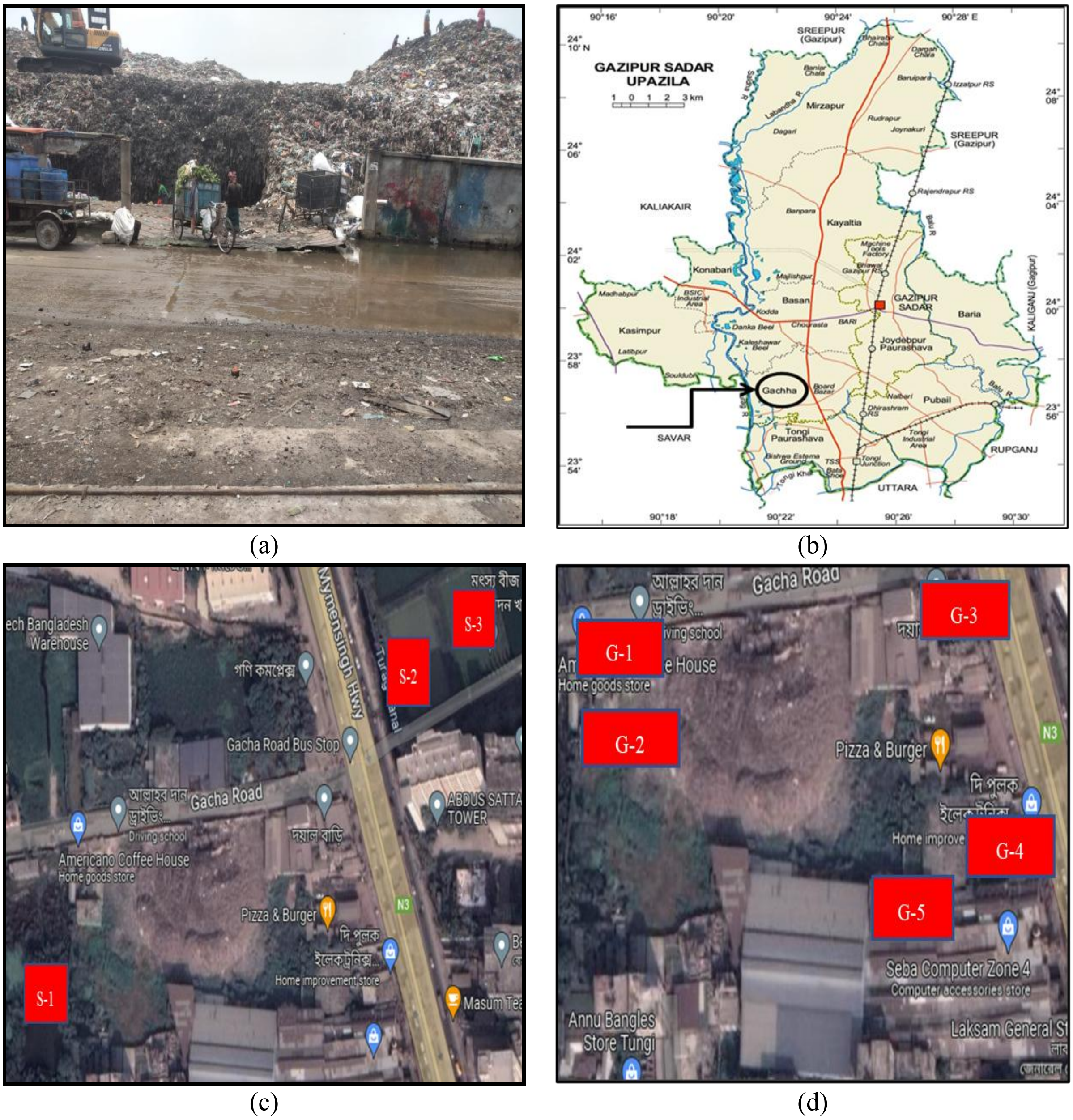


Figure 1: Study site and water-sampling locations near the Gacha solid-waste dumping area, Gazipur: (a) dumping site; (b) location within Gazipur Sadar Upazila; (c) surface-water sampling points (S1-S3); (d) groundwater sampling points (G1-G5). (*Source: field photograph and Google Maps*)

2.2 Sample Collection Procedures

The water sampling collection was held on 15 July 2022 between 11:00 am and 12:00 pm in the summer season. Samples were collected from five groundwater wells (G1-G5), which are tube wells that have been utilized by local residents as well as three surface-water ponds (S1-S3) that are frequently used in fishing. This sampling is a single-day, single-season, snapshot hence the seasonal variability was not observed in the current study. Using a handheld GPS device, the well coordinates were recorded. 1.5L plastic bottles that had been cleaned were used to collect the samples to prevent contamination by any physical, chemical, or microbiological agents. To evaluate and assess the impact of contaminants, distinct wells were selected for the collection of groundwater samples, while the surface water samples were collected from the edges of ponds. The bottles were filled, sealed, and stored in an icebox, and then transported to the laboratory for analysis within 6 hours, following the standard procedures recommended by the American Public Health Association (APHA, 2017). A detailed summary of the groundwater and surface water sampling locations is presented in Table 1.

Table 1: Details of the Sampling locations

Location	Sample Name	Latitude (N)	Longitude (E)	Distance (ft)	Distance from GL (ft)	Environmental Attribute
Gacha, Gazipur	G-1	23.93693°	90.38400°	33	450	Ground water sampling
	G-2	23.93675°	90.38402°	16.5	400	Ground water sampling
	G-3	23.93712°	90.38563°	289	400	Ground water sampling
	G-4	23.93585°	90.38547°	361	450	Ground water sampling
	G-5	23.93619°	90.38538°	100	400	Ground water sampling
	S-1	23.93636°	90.38375 °	15	–	Surface Water sampling
	S-2	23.93761°	90.38611°	130	–	Surface Water sampling
	S-3	23.93791°	90.38655°	160	–	Surface Water sampling

2.3 Analytical Methods and Standards for Water Quality Assessment

Table 2 summarizes the analytical procedures used on the fourteen water quality parameters measured in this study. Calibrated instruments were used and standard laboratory procedures were applied (e.g. pH and turbidity by probe meter, EC by conductivity meter, color, turbidity, nitrate, phosphate and COD by spectrophotometric method, BOD by incubation/pressure-drop method, TDS by gravimetry, arsenic, iron, hardness and alkalinity by standard titrimetric or instrumental methods). The quality assurance and calibration were done before the analysis to achieve accuracy, repeatability, and comparability to the relevant environmental standards.

Table 2: Analytical methods and procedures for water quality parameters.

Sl No.	Parameter	Units	Method adopted
1	Color	Hazen	Spectrophotometer
2	Turbidity	NTU	Spectrophotometer
3	pH	-	Digital pH meter (calibrated probe)
4	EC	µS/cm	Electrical Conductivity meter (calibrated)
5	TDS	mg/L	Gravimetric method (filtration + evaporation)
6	COD	mg/L	Spectrophotometric method after digestion at 150 ± 2°C for 2 h.
7	BOD	mg/L	Incubation / pressure-drop technique with CO_2 absorption (LiOH).
8	DO	mg/L	DO meter (calibrated probe)
9	Nitrate	mg/L	Spectrophotometric method (calibration curve)
10	Phosphate as PO_4^{3-}	mg/L	Spectrophotometric method (calibration curve)
11	Arsenic (As)	mg/L	Atomic Absorption Spectroscopy (AAS)
12	Iron (Fe)	mg/L	Atomic Absorption Spectroscopy (AAS)
13	Total Hardness	mg/L as $CaCO_3$	EDTA Titration Method
14	Alkalinity	mg/L as $CaCO_3$	Titration Method

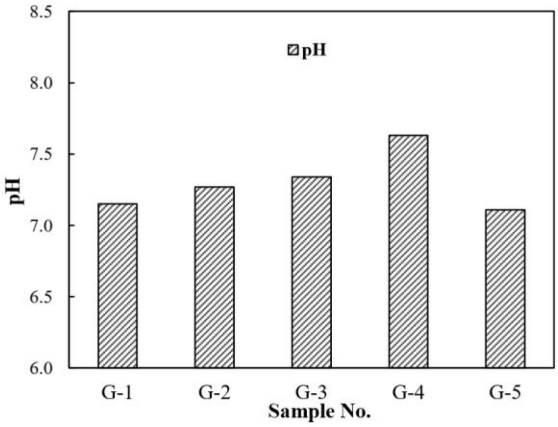
All tests were conducted in accordance with the procedures described in the Bangladesh standards and World Health Organization (WHO) water testing procedures (WHO 1993; Environmental Conservation Rules [ECR] 1997). The findings were compared with the Bangladesh drinking water standards (ECR, 1997) for groundwater and Bangladesh fisheries and irrigation guidelines (Water Environment Partnership in Asia [WEPA], WHO, Water Quality Guidelines [WQG]) for surface water, which served to identify the parameters beyond the safe limits. The results of the measured parameters were checked against the Bangladesh drinking-water standards (ECR 1997) that are still used extensively in the existing literature to maintain consistency despite the publication of updated guidelines (ECR 2023).

3. RESULTS AND DISCUSSIONS

3.1 Assessment of Ground water Bodies

Table 3. Ground water Assessment.

Sl. No	Test Parameters	Units	G-1	G-2	G-3	G-4	G-5	Test Standards (ECR 1997)
1	Color	Hazen	0	0	0	0	0	15
2	Turbidity	NTU	0.28	0.26	0.23	0.2	0.11	10
3	pH	-	7.15	7.27	7.34	7.63	7.11	6.5-8.5
4	EC	µS/cm	430	430	431	189.3	388	-
5	TDS	mg/L	241	248	243	104.4	212.7	1000
6	DO	mg/L	5.04	3.57	4.75	9.57	6.51	6.00
7	Nitrate	mg/L	0.40	0.50	0.30	0.10	0.20	10
8	Phosphate	mg/L	0.47	0.53	0.52	0.22	0.21	6
9	Arsenic	mg/L	0.00	0.00	0.00	0.00	0.00	0.05
10	Iron	mg/L	0.03	0.02	0.02	0.03	0.04	0.30-1.00
11	Total Hardness	mg/L	26	28	30	32	24	200-500
12	Alkalinity	mg/L	110	90	100	87	98	-



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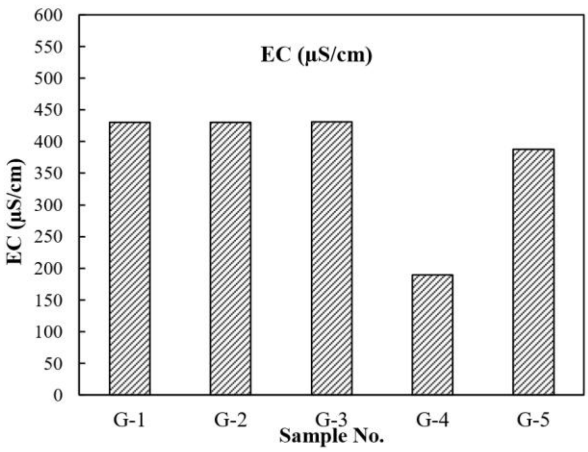

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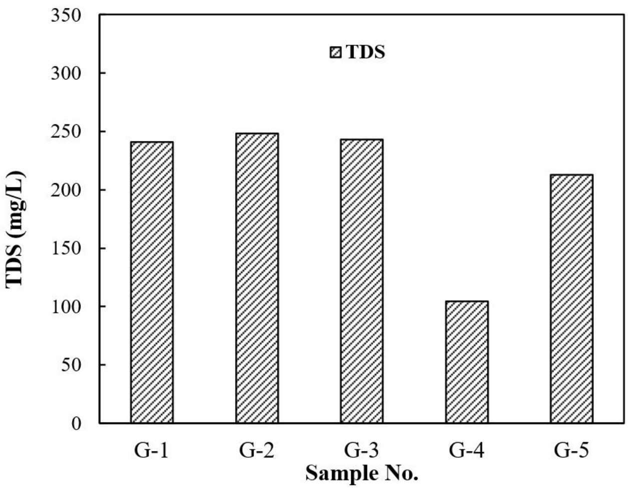

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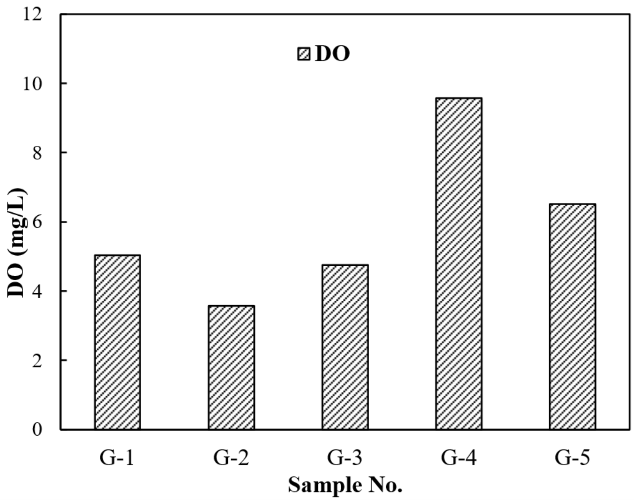

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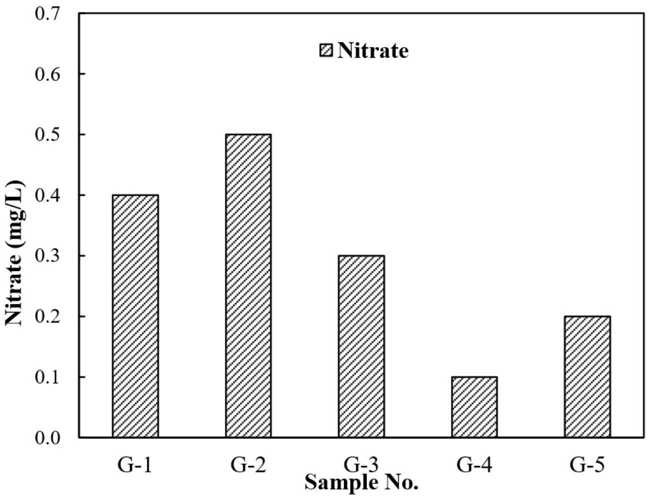


(e)

Figures 2 (a–e): Variation of groundwater quality parameters (pH, EC, TDS, DO, and Nitrate) at five sampling locations (G-1 – G-5).

From Table 3 and Figure 2, it was observed that the color of the five well samples are all zero, which falls under the desirable limit (≤ 15 Hazen), set by ECR 1997. The amount of turbidity in the five ground water samples varied from 0.11 NTU to 0.28 NTU, which is far below the permissible standard limit of 10 NTU (ECR 1997). The pH of the ground water samples varies from 7.11 to 7.63, which comfortably falls under the ECR (1997) limit of 6.5–8.5. The EC of ground water samples ranges between 189.3 µS/cm to 431 µS/cm, which denotes moderate mineral contents in general; according to irrigation classifications, the majority of the samples are classified into medium-salinity (250-750 µS/cm) category, with G-4 being considered as low-salinity (100-250 µS/cm) of water (SW19). The TDS in the ground water samples varied from 104.4 mg/L to 248 mg/L, which is well under the 1000 mg/L permissible limit set by (ECR 1997). The DO in the ground water samples varied from 3.57 mg/L to 9.57 mg/L. Measurements demonstrated that two samples were within the drinking-water standard (≥ 6 mg/L), whereas G-2 (3.57 mg/L) and G-3 (4.75 mg/L) were found below the drinking-water standard and G-1 (5.04 mg/L) being a marginal standard, but acceptable in assessment. The amount of nitrates present in the samples varied from 0.1 mg/L to 0.5 mg/L, falling well below the desirable limit (≤ 10 mg/L) set by ECR 1997, also, phosphate 0.21–0.53 mg/L (≤ 6 mg/L), and iron 0.02–0.04 mg/L (well below the 0.3–1.0 mg/L range), indicating minimal risk from these constituents. The arsenic in the ground water samples was not detected, falling below the ECR standards (≤ 0.05 mg/L). The Total Hardness in the ground water samples varied from 24 mg/L to 32 mg/L, indicating soft water relative to the permissible limit of 200–500 mg/L set by ECR guidelines. The alkalinity present in the ground water samples varied from 87 mg/L to 110 mg/L.

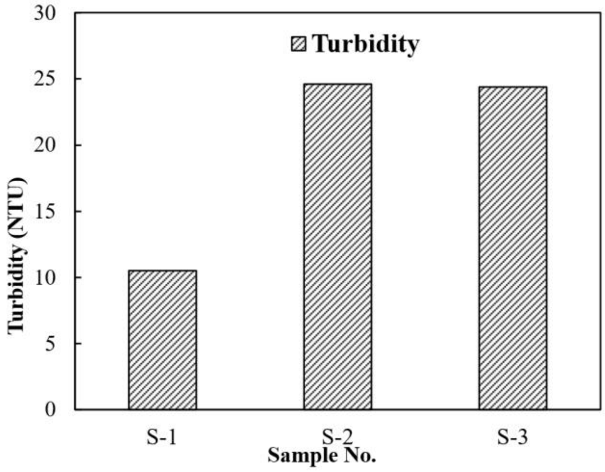
3.2 Assessment of Surface water Bodies

The quality of the surface water was assessed by comparing the measured parameters with regulatory standards shown in Table 4 and Figure 3. These standards are intended to protect the development of healthy fish growth; in some cases, parameters were also compared with irrigation standards to establish its suitability in agricultural applications.

Table 4. Surface water Assessment

Sl. No	Test Parameters	Units	S-1	S-2	S-3	Test Standards
1	Turbidity	NTU	10.5	24.6	24.4	≤ 5 NTU (WEPA, 2017).
2	pH	-	7.07	7.23	7.27	6.5-8.5 (ECR, 1997)
3	EC	µS/cm	690	222	217.2	≤ 2250 µS/cm (ECR, 1997)
4	TDS	mg/L	404	128.2	135.7	≤ 1000 mg/L (ADB, 1994).
5	BOD	mg/L	16	34	20	≤6 (ECR, 1997)

6	COD	mg/L	52	53	37	(Not specified for fisheries water in ECR, 1997)
7	DO	mg/L	2.41	7.5	8.28	≥ 5 (ECR, 1997)
8	Nitrate	mg/L	4.3	3.1	2.6	0.2 - 5 mg/L (WHO, 1993).
9	Phosphate	mg/L	3.61	2.59	2.62	≤1 mg/L (WQG and GES, 2016)



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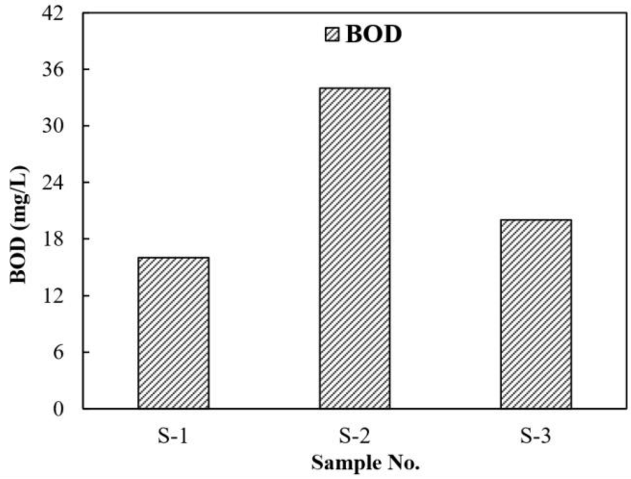

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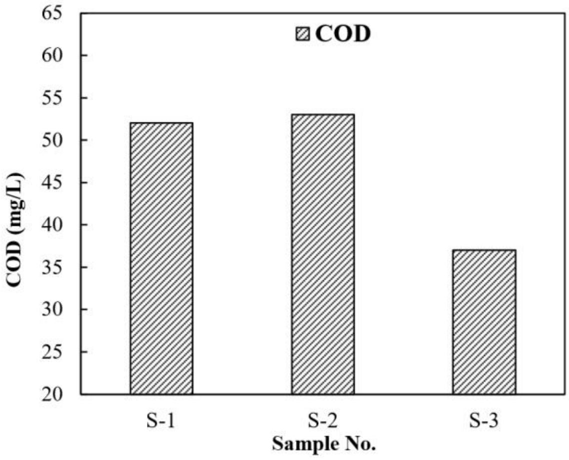

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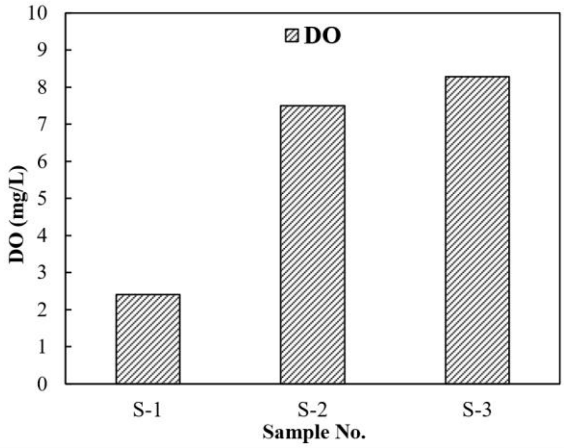

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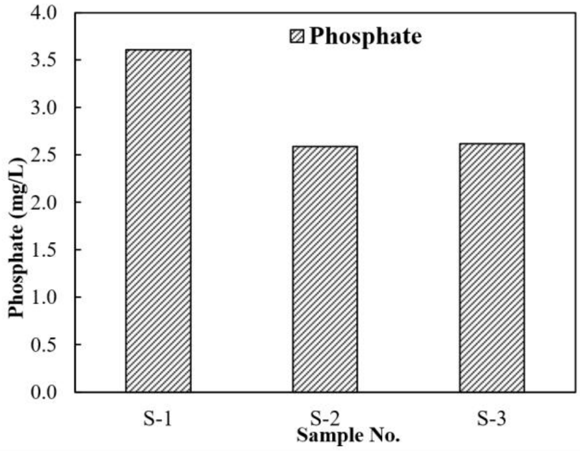

(e)

Figures 3 (a–e): Variation of Surface water quality parameters (Turbidity, BOD, COD, DO, and Phosphate) at three sampling locations (S-1 – S-3).

The results of surface water quality reveal an alarming but ambivalent scenario on aquatic health. The measured Turbidity of surface water samples varies from 10.5 NTU to 24.6 NTU. The permissible limit of Turbidity for fish and aquatic life is 5 NTU. All the samples exceeded the WEPA (2017) recommendation and are likely to compromise feeding behaviour and respiratory function in fish. The sample's pH ranges from 7.07 to 7.27, indicating that the water is almost neutral and is within the acceptable limit. For fish water, the permissible standard limit is 6.5 to 8.5 according to ECR (1997). The surface water samples have EC readings ranging from 217.2 µS/cm to 690 µS/cm. EC has a recommended limit of 2250 µS/cm for fish. Although S-1 exhibited medium salinity consistent with proximity to the dump, all the samples were within the limit. The TDS has an acceptable limit of 1000 mg/L as mentioned in the guidelines in samples with a range of 128.2 mg/L to 404 mg/L. Measures of organic pollution were very high. BOD was in the range of 16 mg/L to 34 mg/L. All far exceeded the ECR standard of 6 mg/L (for wastewater), indicating heavy organic loading. Likewise, COD varied between 37 and 53 mg/L in the surface-water sampling points, indicating a high oxidizing organic load presumably due to runoff and leachate of the adjacent dumping region. Since ECR (1997) does not specify a COD limit for fisheries water, the assessment is primarily discussed using the ECR fisheries criteria (pH, DO and BOD), while COD is reported to support the interpretation of organic pollution. Such high BOD/COD values suggest that dump leachate or runoff is adding high levels of organics to the ponds. Dissolved oxygen (DO) at S-1(2.41 mg/L) was critical and well below the 5 mg/L threshold needed to support fish growth, whereas S-2 and S-3 (7.50 and 8.20 mg/L) were within the DO standard, which is likely representative of typical aeration and vegetation conditions at fish-farming locations. One of the most prevalent pollutants in ground water is nitrate. The WHO allowable range of nitrate is 0.2 - 5 mg/L. The water samples have concentrations between 2.6 and 4.3 mg/L. All of the samples fall inside the allowable range. Phosphorus is usually present in the form of phosphates in natural water. The water samples contain 2.59 to 3.61 mg/L of phosphates that are above the recommended concentration of 1 mg/L, and have the potential to cause eutrophication in fish. The findings are based on single sampling exercise during the summer season; therefore, the impact of seasonal variation was not assessed. For a more comprehensive characterization of water quality multi-season sampling is recommended.

4. CONCLUSIONS

This study has evaluated the effects of Gacha Union solid waste dumpsite on nearby groundwater and surface water by analysing the main parameters of physico-chemical indicators. Groundwater quality was found to be mostly within the acceptable range in drinking water, with pH, TDS, EC, hardness, iron, nitrate and phosphate were all below the provided guidelines values. However, dissolved oxygen concentration in two wells was lower than the recommended standard, which is related to local oxygen deprivation that may be connected to the infiltration of leachates. The absence of arsenic and colour indicates that the contamination of groundwater is not severe yet, but further monitoring is required. Surface water, on the contrary, showed more definite indications of contamination. Elevated turbidity, BOD, and phosphate values along with higher COD values suggest high organic and nutrient loading in ponds around the dump site. There was also a pond with a DO level below the threshold required for fish growth. These results indicate that surface water bodies are more susceptible to wastes runoff and leachate exposures. Water quality generally improved with increasing distance from the dumping site, indicating attenuation of contamination with spatial separation. In general, the findings indicate that the dumpsite has a measurable environmental risk, especially to surface water and aquatic ecosystems. To reduce further degradation and safeguard public health, relevant waste management measures including controlled waste disposal, leachate drainage and treatment, and regular monitoring of the water-quality, are to be carried out.

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DECLARATION OF USE OF AI

The authors state that AI tools were used only for minor language editing and improving readability. No AI tools were used to generate research ideas, methodology, results, analysis, or conclusions. All scientific contents, numerical results, discussions, and interpretations were fully prepared, reviewed, and validated by the authors. The authors remain fully responsible towards the originality, accuracy and integrity of the manuscript.

REFERENCES

Ahmed, M. K., Baki, M. A., Islam, M. S., Kundu, G. K., Habibullah-Al-Mamun, M., Sarkar, S. K., & Hossain, M. M. (2015). Human health risk assessment of heavy metals in tropical fish and shellfish collected from the river Buriganga, Bangladesh. *Environmental Science and Pollution Research*, *22*(20), 15880–15890. https://doi.org/10.1007/s11356-015-4813-z

Alam, R., Ahmed, Z., & Howladar, M. F. (2020). Evaluation of heavy metal contamination in water, soil and plant around the open landfill site Mogla Bazar in Sylhet, Bangladesh. *Groundwater for Sustainable Development*, *10*, 100311. https://doi.org/10.1016/j.gsd.2019.100311

American Public Health Association, American Water Works Association, & Water Environment Federation. (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association.

Asian Development Bank. (1994). Training manual for environmental monitoring. Asian Development Bank.

Christensen, T. H., Kjeldsen, P., Bjerg, P. L., Jensen, D. L., Christensen, J. B., Baun, A., Albrechtsen, H. J., & Heron, G. (2001). Biogeochemistry of landfill leachate plumes. *Applied Geochemistry*, *16*(7–8), 659–718. https://doi.org/10.1016/S0883-2927(00)00082-2

CUMINGS, J. N. (1962). Biochemical aspects. In *Proceedings of the Royal Society of Medicine* (Vol. 55). https://doi.org/10.5005/jp/books/11431_8

Department of Environment and Natural Resources (DENR). (2016). Water quality guidelines and general effluent standards of 2016 (DENR Administrative Order No. 2016-08). DENR, Republic of the Philippines. https://pab.emb.gov.ph/wp-content/uploads/2017/07/DAO-2016-08-WQG-and-GES.pdf

El-Mathana, M. E., Mostafa, N. G., Galal, M. M., & Elawwad, A. (2021). Assessment and simulation of a solid waste dumpsite impact on the surrounding water resources: A case study in Abu Zaabal, Egypt. *Heliyon*, *7*(11), e08421. https://doi.org/10.1016/j.heliyon.2021.e08421

Government of the People's Republic of Bangladesh. (2021). Solid Waste Management Rules, 2021. Bangladesh Gazette (23 December 2021). https://wasteconcern.org/wp-content/uploads/2024/03/Solid-Waste-Management-Rules-2021.pdf

Government of the People's Republic of Bangladesh, Ministry of Environment and Forest. (1997). The Environment Conservation Rules, 1997 (ECR 1997) (S.R.O. No. 197-Law/97, 27 August 1997). Department of Environment, Government of Bangladesh. https://faolex.fao.org/docs/pdf/bgd19918.pdf

Gupta, A., Verma, A., & Rajamani, P. (2024). Impact of Landfill Leachate on Ground Water Quality: A Review. *Springer Water*, *Part F2849*(September), 93–107. https://doi.org/10.1007/978-3-031-55513-8_6

Haque, S. E. (2018). *An Overview of Groundwater Quality in Bangladesh*. Springer Singapore. https://doi.org/10.1007/978-981-10-3889-1_13

Hossain, M. F., Jahan, E., Parveen, Z., Ahmed, S. M., & Uddin, M. J. (2018). Solid Waste Disposal and its Impact on Surrounding Environment of Matuail landfill Site, Dhaka, Bangladesh. *American Journal of Environmental Sciences*, *14*(5), 234–245. https://doi.org/10.3844/ajessp.2018.234.245

Igboama, W. N., Hammed, O. S., Fatoba, J. O., Aroyehun, M. T., & Ehiabhili, J. C. (2022). Review article on impact of groundwater contamination due to dumpsites using geophysical and physiochemical methods. *Applied Water Science*, *12*(6), 1–14. https://doi.org/10.1007/s13201-022-01653-z

Juneja, T., & Chaudhary, A. (2013). *Assessment of water quality and its effects on the health of residents of Jhunjhunu district , Rajasthan : A cross sectional study*. *5*(April), 186–191.

Kjeldsen, P., Barlaz, M. A., Rooker, A. P., Baun, A., Ledin, A., & Christensen, T. H. (2002). Present and long-term composition of MSW landfill leachate: A review. *Critical Reviews in Environmental Science and Technology*, *32*(4), 297–336. https://doi.org/10.1080/10643380290813462

MD Azim, M, Mahabubur Rahman, R. H. K. and A. T. M. . K. (2011). *and Probable Risks of Surface and Groundwater Pollution in the Surrounding Areas : a Case Study of Matuail Landfill Site , Dhaka*. *35*(2), 153–160.

Mishra, S., Tiwary, D., Ohri, A., & Agnihotri, A. K. (2019). Impact of Municipal Solid Waste Landfill leachate on groundwater quality in Varanasi, India. *Groundwater for Sustainable Development*, *9*(December 2018), 100230. https://doi.org/10.1016/j.gsd.2019.100230

Njewa, J. B., Mweta, G., Sumani, J., & Biswick, T. T. (2025). The impact of dumping sites on air, soil and water pollution in selected Southern African countries: challenges and recommendations. *Water Emerging Contaminants and Nanoplastics*, *4*(1). https://doi.org/10.20517/wecn.2024.71

Parvin, F., & Tareq, S. M. (2021). Impact of landfill leachate contamination on surface and groundwater of Bangladesh: a systematic review and possible public health risks assessment. *Applied Water Science*, *11*(6), 1–17. https://doi.org/10.1007/s13201-021-01431-3

Ramakrishnaiah, C. R., Sadashivaiah, C., & Ranganna, G. (2009). Assessment of water quality index for the groundwater in Tumkur taluk, Karnataka state, India. *E-Journal of Chemistry*, *6*(2), 523–530. https://doi.org/10.1155/2009/757424

Samudro, G., & Mangkoedihardjo, S. (2010). *Review on Bod , Cod and Bod / Cod Ratio : a Triangle Zone for Toxic , Biodegradable and Stable Levels*. *2*(4), 235–239.

Waste Concern. (2021). Bangladesh Waste Database 2021. Waste Concern. https://wasteconcern.org/wp-content/uploads/2024/02/22-Bangladesh-Waste-Database_2.pdf

Water Environment Partnership in Asia (WEPA). (n.d.). WEPA database: Water quality standards and related information. Institute for Global Environmental Strategies (IGES) / Ministry of the Environment, Japan. Retrieved January 2, 2026, from https://wepa-db.net/database

World Health Organization. (1993). Guidelines for drinking-water quality (2nd ed., Vol. 1: Recommendations). World Health Organization. https://apps.who.int/iris/handle/10665/25956