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Environmental Impact of Landfill on Groundwater Quality in City Hut Landfill Area, Rajshahi

P. K. Roy[1], M. M. Islam[2 *], T. Murshalin[3], M. S. U. Miah[4]

[1,3]Department of Civil Engineering, RUET, Bangladesh (proticroyce@gmail.com, tabiul.ce.140035@gmail.com)
[2] Department of Civil Engineering, RUET, Bangladesh (mohayminul.islam37@gmail.com)
[4]Department of Civil Engineering, RUET, Bangladesh (shafi_ruet@yahoo.com)

Abstract

Groundwater is a vital resource, used for industry, commerce, agriculture, and most importantly, drinking. The impact of leachate from landfills on groundwater quality has become a matter of increasing concern due to its significant environmental implications. This study aimed to estimate the impact of leachate percolation on groundwater quality from an unlined landfill site at the City Hut of Rajshahi District, Bangladesh. To determine the impact of leachate on groundwater quality, physical and chemical analyses were conducted on water samples collected from deep and shallow tube wells at distances ranging from 7.00 to 97.00 m from the site. The study assessed various water quality parameters such as pH, turbidity, conductivity, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD), alkalinity, hardness, odor. Three water samples were collected for the research. However, TSS values (60, 110, and 85 mg/L) and BOD values (0.85, 3.90, and 3.43 mg/L) exceeded the standard limit, while pH, turbidity, TS, total hardness, COD, DO, and TDS were within the standard limit. A foul odor and foaming were also identified in the samples. Although the sampling stations were not strongly polluted, treatment was required before use as a precaution.

Keywords: *Landfill, Water Pollution, Groundwater Quality; Groundwater contamination; Groundwater Quality Parameters.*

1 Introduction

Groundwater is immensely valuable as a crucial resource utilized extensively in industries, commerce, agriculture, and, most significantly, for drinking purposes. However, the raw water employed for domestic use is often susceptible to contamination as a result of human daily activities, leading to pollution. The contamination of groundwater primarily stems from the relentless advancement of industrialization and urbanization, which have historically disregarded the environmental repercussions (Alslaibi et al., 2011). In recent years, the profound environmental significance of leachates' impact on groundwater and other water sources has garnered considerable attention (Alslaibi et al., 2011).

In recent years, the detrimental impact of leachates on the environment and its hazardous effects on groundwater and other water resources have drawn serious attention. If appropriate management procedures are not put in place, the migration of leachates from waste sites or landfills site will occur (Smahi et al., 2013)). The release of pollutants from sediments poses a significant risk to the integrity of groundwater resources (Gunjan et al., 2012, Longe, and Balogun, 2010).

Preserving groundwater is a significant environmental concern. Open dumps have long been the traditional and prevalent means of solid waste disposal. While numerous open dumps have been closed in recent years, many continue to be utilized [3]. Commonly employed methods for municipal solid waste disposal encompass composting, sanitary landfill, pyrolysis, as well as reuse, recovery, and recycling (Kanownik, and Policht, 2016).

Toxic chemicals with high concentrations of nitrates and phosphates, originating from waste in landfills, can permeate through soil and contaminate both groundwater and surface water (Longe, and Balogun, 2010, Li et al., 2012)). Aesthetic issues associated with sanitary landfills include the presence of insects, rodents, snakes, and scavenger birds, as well as problems related to dust, noise, and unpleasant odors. Unprotected landfills also pose potential threats to the environment due to leachate contamination of soil and groundwater as well as airborne emissions of toxic gases like methane (CH4) and carbon dioxide (CO2) (Ritzkowski, and Stegmann, 2007).

Every day, it is estimated that Rajshahi City in Bangladesh produces approximately 644 tons of Municipal Solid Waste. This waste comprises various materials, including food waste, paper, polythene, plastic, wood, metal, rubber, textile, and dust ashes. Notably, food and vegetable waste contribute to around 70-71% of the total waste generated (Das et al., 2014).

The waste management system in Rajshahi City is still in its early stages of development. Currently, the city relies on a single landfill site located on the outskirts. The management of the only landfill site is inadequate which leads to environmental issues such as air pollution and water contamination. If the solid waste as well as the waste water is not managed properly it may become hazardous for both surface and ground water (Rashid et al., 2019). Further improvements and measures are necessary to address these concerns effectively.

The present study analyzed various physicochemical parameters of groundwater samples near the landfill to understand the potential chance of groundwater contamination. The effect of depth and distance of landfill from groundwater sources play roles in contamination (Słomczyńska, and Słomczyński, 2004, Han et al., 2014). The study's main objective and essential goal is to investigate groundwater quality in the City Hut landfill of Rajshahi, Bangladesh. Evaluating the quality of groundwater in the landfill by estimating the parameters like pH, electrical conductivity, turbidity, total hardness, total solid, total dissolved solids, total suspended solids, alkalinity, Organic content, DO, BOD & COD.

2 Methodology

2.1 Study Area

The study area for this research is the city hut landfill, Noadapara, Rajshahi. It's an open unlined landfill. The area of the landfill is more than 10 Acres. It is situated at a latitude of 24° 24' N and a longitude of 88° 35'E. Being an unlined and unprotected landfill, the leachate comes out in the rainy season. A strong odor is always present there. The RCC has thirty wards, and all the waste from all wards is disposed of there since 2009. The geographical location of the study area is shown in Figure 1.

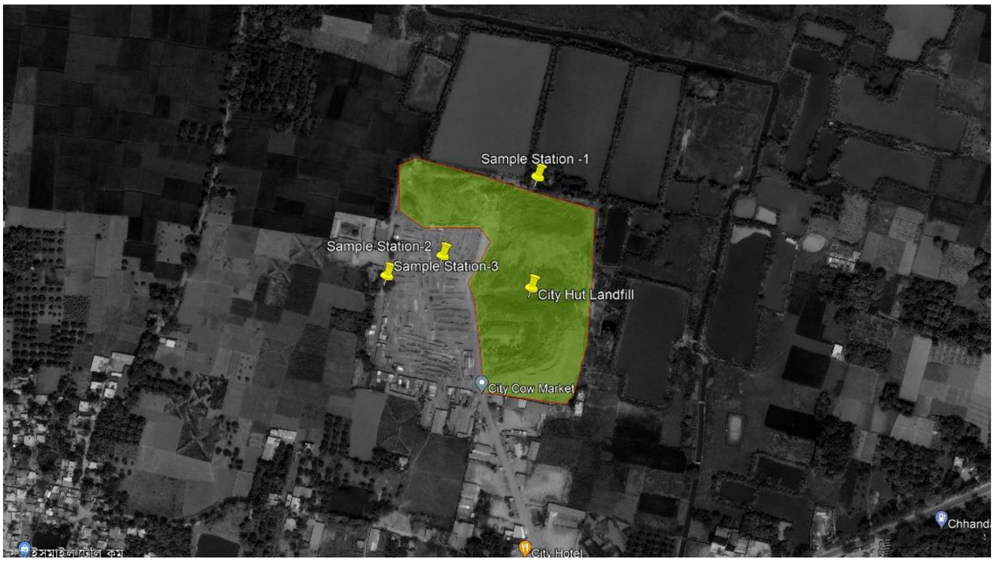

Figure 1. Satellite view of the study area (City Sanitary landfill area, Rajshahi).

2.2 Sampling stations

From three existing tube well near the landfill site, the sampling for the study was done and taken to the lab. Details of the sampling stations are presented in Table 1.

Table 1. Description of Samling stations.

Sample Station	Sample ID	Geographical Location	Shortest distance from Landfill Periphery (m)	Stainer Location of the wells (m)
Sample Station-1 (Figure 2 (a))	SP-01	24.410707° N, 88.592228° E	7.00	40.00
Sample Station-2 (Figure 2 (b))	SP-02	24.410171° N, 88.591731° E	35.00	24.00
Sample Station-3 (Figure 2 (c))	SP-03	24.410418° N,	97.00	27.50

88.591582° E

Figure 2. (a) Sample Station-1: Deep tube well (b) Sample Station-2: Shallow tube well (c) Sample Station-3: Shallow tube well.

2.3 Laboratory testing of the samples

The analyses of this study cover the physical and chemical parameters of the water samples from each station. Priority was given to test the samples prompt after collection the test which was not possible to test same day was preserved at a temperature of 4° C not more than 3 days. The qualitative analyses were carried out at the Public Health Laboratory at the Department of Civil Engineering of the Rajshahi University of Engineering & Technology (RUET). The physical parameters tested included: Turbidity and Conductivity. Chemical parameters were pH, dissolved oxygen (DO), total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), total hardness (TH), total alkalinity, total acidity, organic content, biochemical oxygen demand (BOD), chemical oxygen demand (COD). All the parameter was tested using standard methods for the examination of water According to APHA 2005, AWWA. All the results were compared with the standard of the World Health Organization (WHO 2004) and the Bangladesh Standard for Drinking Water Quality values.

3. Results and Discussions

The analytical results of the various physio-chemical analysis of the groundwater samples of selected sample stations are tabulated in Table 2.

Table 2. Water quality parameters of the study area.

Sl. No.	Water quality parameter	Unit	Bangladesh Standard	WHO Standard	SP-01	SP-02	SP-03
01	pH	-	6.50-8.50	6.5-8.5	6.95	7.12	6.88
02	Turbidity	NTU	10.00	1-5	0.68	2.22	1.68
04	Electric Conductivity	μS/cm	-	-	800.00	1050.00	910.00
04	TS	mg/L	-	-	370.00	540.00	430.00
05	TDS	mg/L	1000.00	-	310.00	430.00	345.00
06	TSS	mg/L	10.00	-	60.00	110.00	85.00
07	COD	mg/L	4.00	10.00	1.00	4.80	4.30
08	DO	mg/L	6.00	-	2.10	5.40	4.60
09	BOD	mg/L	0.20	6.00	0.85	3.90	3.43
10	Total Alkalinity	mg/L	-	-	42.00	76.00	64.00
11	Hardness	mg/L	200-500	60-180	102.00	172.00	146.00
12	Organic Content	mg/L	-	-	240.00	350.00	350.00
13	Odor	-	Odorless	-	Odorless	mild	mild

The pH values of all three samples fall within the acceptable range according to the standards set by both Bangladesh and the WHO. The pH of SP-3 is the least and SP-2 the most. Turbidity measures the clarity or cloudiness of water. The values obtained for all three samples are well below the standards set by both Bangladesh and the WHO. This indicates that the water samples are relatively clear and free from suspended particles. Electric conductivity is a measure of the water's ability to conduct an electric current, which is influenced by dissolved solids. The level of dissolved solids in the tested samples in this study keeps a large merging below the highest limit. This indicates that the concentration of dissolved solids in the water is within the acceptable range. The TSS values for all three samples are significantly higher than the Bangladesh standard of 10 mg/L. This suggests that the water samples contain higher levels of suspended solids. It's evident that in the shallow tube well the suspended matters are in more amount. The highest value of TSS is observed in SP-2 which is a shallow tube well of Stainer depth 24 m and the least was observed in SP-2 which is of depth 40 m. But all three samples exceed the TSS limit given. It needs to be observed keenly to find the nature and source of the suspended matters. All three samples exhibit COD values below the standards set by both Bangladesh and the WHO. This indicates that the water samples have relatively low levels of organic pollutants, which is a positive characteristic. The measured DO values for all three samples are below the Bangladesh standard of 6 mg/L, suggesting lower oxygen levels in the water. The BOD values for all three samples are below the WHO standard of 6 mg/L, but all exceed the Bangladesh standard of 0.2 mg/L. Elevated BOD levels indicate a higher organic pollution load in water bodies, which may require further investigation. All three samples demonstrate hardness values within the ranges specified by both Bangladesh and the WHO. This suggests that the water is within the acceptable hardness limits. All three samples either exhibit no odor or a mild odor, aligning with the Bangladesh standard of odorless water. This suggests that the water samples are relatively free from offensive odors.

The water quality at SP-01 is better than the other two stations, even though it is closer to the landfill. This is because the depth of the strainer at SP-01 is deeper than the strainers at the other two stations. The depth of the strainer at SP-01 is 40 m, which is 1.67 times deeper than the strainers at SP-02, which is 24.00 m, and 1.40 times deeper than the SP-03, which is 27.50 deep. The additional depth of the strainer at SP-01 allows the water to be filtered through more layers of soil, which removes more of the contaminants. This results in better water quality at SP-01, even though it is closer to the landfill. That's why the negative relation between the quality parameter and the distance of the sample station from the source of contamination is noticed.

4. Conclusions

An unlined open landfill could be hazardous to the environment. Out of all elements of the environment waterbody near such land is the most susceptible to pollution and the spreading of the pollutant. Bangladesh is majorly dependent on groundwater for drinking, household use, and irrigation. So, infiltration from such an unlined landfill can pollute the groundwater. If such pollution occurs then the consumer of the groundwater around the vicinity of the landfill will be the vulnerable most. On this scope, this study investigated the groundwater quality around the landfill and ended up with some very important insights. It was observed from the investigation that among all of the water quality parameters Total Suspended solid, BOD exceed the standard limits. It requires further study to find the source of this issue. On the other hand, pH, Turbidity, TS, Total Hardness, COD, DO, and TDS are near or within the standard limit according to BDS and WHO. These results to some extent look satisfactory now if the waste in the landfill is not properly managed leachate may cause harm to groundwater in the long run as it is an unlined landfill. The leachate has not polluted the groundwater yet doesn't mean the scenario will be the same shortly. The landfill must be redesigned with clay or plastic liners to prevent leachate from getting to the water table. The adoption of clean technology for recycling greenhouse gases eliminating from landfill will keep it safe from air pollution as well.

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