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Evaluation of Surface Water Pollution from an Operation at Controlled Dumpsite: A Case Study in Samutprakarn Province, Thailand

Nittaya Pasukphun[1*], Tanika Tingsa[2], and Yanasinee Suma[2]

[1]*Faculty of Public Health, Thammasat University (Rangsit Campus), Pathumthani 20121, Thailand*
[2]*Faculty of Public Health, Thammasat University (Lampang Campus), Lampang 52190, Thailand*

*Corresponding author: nittapsp@gmail.com
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Abstract

Both engineered and non-engineered landfills are used for the disposal of solid waste. Although modern landfills are designed to reduce the negative effects of waste, the generation of leachate remains a problem for landfills due to the potential contamination of groundwater and surface water caused by seepage and diffusion of leachate through soil. Moreover, it is unfortunate that open dumpsites, which are unregulated and illegal landfills, are common in many developing countries. This study aims to assess the impact of leachate from a controlled dumpsite operation in a municipal solid waste landfill on surface water. The study analyzes the main physicochemical, chemical, and heavy metal parameters of surface water samples during the rainy and dry seasons to evaluate the extent of pollution caused by the controlled dumpsite. The surface water samples from various locations surrounding the controlled dumpsite were found to be polluted by leachate. The winter season showed higher pH, BOD_5 and COD levels in the surface water compared to the rainy season through surface runoff in the surrounding areas. The ratios of BOD_5 and COD in the surface water from four sites near the controlled dumpsite were in the range of 0.51 - 0.89, indicating the controlled dumpsite being in mature stages that can be in the acceptable toxin range; however, its BOD_5/COD ratios tended to be more toxic as they decreased in summer and rainy season. The heavy metals with the highest average level in the surface water were Fe, followed by Cr, Cd, Ni, Mn, Zn, Pb, and As, respectively. In addition, every water source had Cr, Cd and Ni concentrations much higher than the WHO standards (exceeding 0.05 mg/L, 0.003 mg/L and 0.02 mg/L, respectively) at the average concentration of 2 mg/L, 0.56 mg/L and 0.48 mg/L, respectively. The results indicated that the leachate from the controlled dumpsite had a detrimental impact on surface water quality due to lack of engineered liners and adequate leachate collection systems. Consequently, there is movement of toxic leachate from leachate ponds with inadequate or no liner into groundwater and surface water.

Keywords: Water pollution; Dumpsite; Landfill; Heavy metal

1. Introduction

The problem of waste disposal only worsens as consumption and production increase. Poor waste management endangers both the environment and people's health. Landfills, which are sites designated for waste disposal, contribute significantly to environmental pollution. (Amano *et al.,* 2021). Many countries, especially developing ones with rapid population growth, face a great challenge in solid waste management. In these countries, both engineered and non-engineered landfills are used for the disposal of solid waste. (Jaskelevičius & Lynikiene, 2009) Economic, organizational, and technological factors partly impede waste recycling and utilization and reinforce waste disposal in landfills. Although modern landfills are designed to reduce the negative effects of waste, the generation of leachate remains a problem for municipal solid waste (MSW) landfills due to the potential contamination of groundwater and surface water caused by seepage and diffusion of leachate through soil. (Bisht *et al,* 2022; Amano, *et al.,* 2021).

Surface runoff or groundwater infiltration due to precipitation can affect waste discarded in landfills. As water moves through the waste, it carries various colloidal inorganic and organic compounds to the bottom of the landfill. (Amano *et al.,* 2021; Mavakala *et al.,* 2016). This process leads to the formation of contaminated water known as leachate, which has the potential to permeate through the soil, surface water, and groundwater in the landfill area. As a result, leachate pollutes the water in the immediate vicinity of the landfill in the subsoil with significantly higher levels of dissolved organic matter, inorganic macrocomponents, heavy metals, and xenobiotic organic compounds. (Bhalla *et al.,* 2012; Mavakala *et al.,* 2016). The combination of chemical, physical, and microbial processes that interact with the discarded waste leads to water pollution, and the presence of heavy metals in the leachate can pose serious environmental and health risks. (Kjeldsen *et al.,* 2010; Kulikowska& Klimiuk, 2008; Ishak *et al.,* 2016)

A study by Paul *et al.* (2019) revealed that the MSW management in Bangladesh had a considerable environmental impact. In particular, the leachate from MSW caused water pollution and adversely affected aquatic species. In addition, open dumping in Islamabad resulted in soil pollution, negatively affecting soil quality, crop growth, production, and agriculture. Similarly, in Nepal, solid waste disposal through open dumping contributed to the spread of infectious diseases. The study also indicated that as landfills age, the waste mineralization process occurs, leading to increased leaching characteristics of the waste within the landfills. Adamcová *et al.* (2017) assessed the environmental effects of a MSW landfill on the content and distribution of trace elements of pollution in Tanacetum vulgare, commonly known as tansy. The study showed the significant impact of landfills on water sources, emphasizing the urgency of implementing mitigation measures, especially given that most of the local population relies on the water from those sources for their daily needs. Another study conducted in the Varanasi district of Uttar Pradesh, India, examined an unlined MSW landfill. This investigation revealed that precipitation plays a significant role in the migration of leachate components, including iron (Fe), nitrate (NO_3^-), total dissolved solids (TDS), phosphate (PO_4^{3-}), and electrically conductive ions (Mishra *et al.,* 2019).

The environmental impacts of landfills can differ based on the specific procedures or methods employed. In their study, Yadav and Samadder (2018) investigated various scenarios of MSW landfilling. These scenarios included collection and transportation (S1), recycling, open burning, open dumping, and unsanitary landfilling without energy recovery (S2), composting and landfilling (S3), recycling, composting, and landfilling (S3), and recycling, composting, and landfilling of inert waste without energy recovery (S4). The findings demonstrated that each scenario had varying levels of environmental impact. For instance, S1 contributed most to ecotoxicity in the marine ecosystem, while S2 significantly affected eutrophication, acidification, global warming, and human toxicity. S3 also considerably contributed to the depletion of abiotic resources such as fossil fuels and had other effects, including aquatic and terrestrial ecotoxicity. These results show the interactions between processes within the landfill system, even with human interventions, that give rise to diverse environmental effects.

Most landfills are regulated and engineered facilities that impose strict regulations on the quality and quantity of waste they accept. However, it is unfortunate that open dumpsites, which are unregulated and illegal landfills, are common in many developing countries (Siddiqua *et al.,* 2022) Following the measures to control and reduce pollution from open dumps, Thailand uses controlled dumps for MSW management in areas where daily waste production is more than 50 tons. As of 2022, there were four waste management facilities in the country employing controlled dumps.

The use of controlled dumps must have the following initial measures: 1) Designation of responsible persons and authorized personnel in the area 2) Inspection and control of vehicles and waste collection trucks entering and leaving the area 3) Regulations limiting the entry of waste into the facility, allowing only disposal of MSW 4) Regulations governing the operation and control of machinery, equipment, and vehicles involved in the MSW disposal 5) Prohibition of open burning of waste within the area 6) Control of freelance garbage collectors involved in MSW separation in the area 7) Prohibition of all pets within the area However, the mentioned operating guidelines do not include leachate collection and treatment, as well as monitoring and tracking the effects of leachate on environmental quality (PCD, 2019).

This study aims to assess the impact of leachate from a controlled dump operation in a MSW landfill on surface water. The landfill in the Phraek Sa Mai District of Samutprakarn Province was chosen because it is located in Thailand's third-highest waste-generating province and operates as a controlled dump without any pollution control measures for leachate. Therefore, it is vital to investigate the quality of the surface water and groundwater around the landfill, which may be affected by the leachate. The study analyzes the main physical and chemical parameters of surface water samples to evaluate the extent of heavy metal pollution caused by the landfill and determine the safety level of the controlled dump operation for preventing leachate pollution.

2. Materials and methods

2.1 Study area

The Phraek Sa Mai controlled dump site is located at 13°34'51.3"N and 100°40'22.0"E in Praeksa Mai Town Municipality, Samut Prakan Province as show in Figure 1. A daily collection of solid waste in the province, weighing about 2,329 tons per day, is treated at the site. With an area of over 150 Rai (240,000 m^2), it is the largest solid waste management facility in the province. A private company is now being hired by the Praeksa Mai Town Municipality Office to operate the landfill.

During the winter, rainy and summer seasons, the sample collection was conducted at four different water sampling points, once for each season. The samples were then analyzed to indicate the quality of the water resources in the study area. Each sampling point was identified, and the sampling was done between the distances of 0.5 and 3.5 km, as shown in Figure 2.

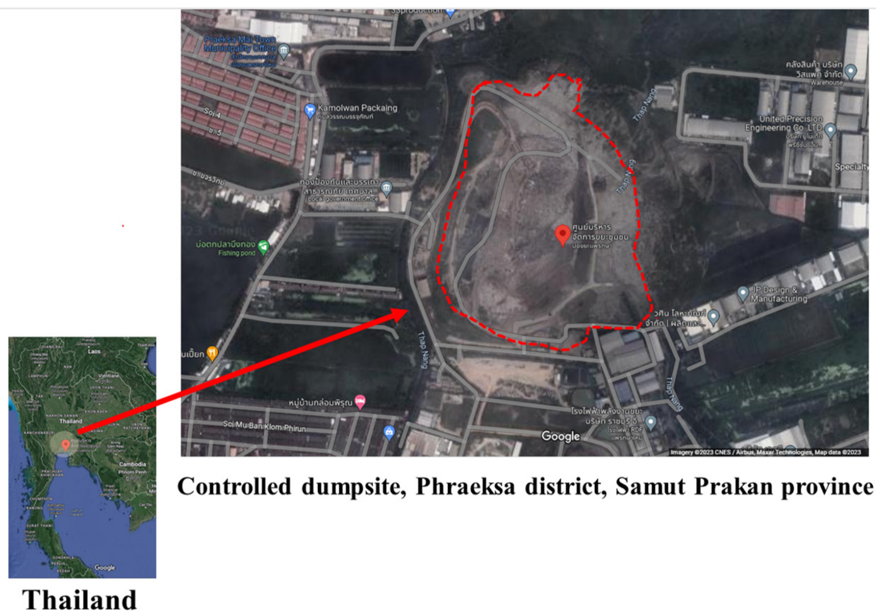


Figure 1. Area of controlled dumpsite of Praeksa Mai town municipality

Using Google Earth software, which offered clear satellite images of the study area, the sampling points selected in degrees, minutes, and seconds of latitude and longitude were then mapped. Water samples were collected from different points: L1, which is a canal flowing near the controlled dumpsite; L2, a surface water source in the form of a closed fishpond used for agricultural purposes; SF-UP, a swamp located in the community at the upstream end of the controlled dumpsite, also with a closed structure; and SF-DW, a canal situated at the downstream end of the controlled dumpsite and flowing through the community. Since this landfill is operated as a controlled dumpsite, there are no requirements for groundwater monitoring wells and assessing the quality of surface water following the impact of the landfill operation.

2.2 Chemical analysis methods

At each sampling point, water samples were physically collected and placed in high-density polyethylene (HDPE) bottles. To prevent contamination with metal and 563 non-metal ions, the HDPE bottles were acid-washed with 10% v/v hydrochloric acid (HCl) prior to sampling, in accordance with the American Public Health Association's recommended protocols and methodologies (APHA, 2012). Six of the total 17 parameters (pH, temperature, DO, TDS, BOD5, COD) exceeded the standard level permitted by the Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations 2009.

Before collecting the samples, the pre-washed bottles were rinsed three times with the water on site. The samples of bottled water were kept in a cooler box for transportation to the lab, where they were kept at 4°C in a refrigerator. After that, the samples were examined within 48 hours. During sampling on site, the Hanna Instrument (HI9829) was used to measure temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), and TDS in compliance with APHA (2012) procedures.

The photometric method was used to find out the concentrations of heavy metals (Fe, Cu, Cd, Cr, Pb, Mn, Hg, Ni, Zn, and As) in samples of leachate and water. For the analysis, the HACH DR890 colorimeter was applied. A pH meter was used to calculate the pH of the landfill leachate. At temperatures between 0 and 100 °C, this method can determine the concentration of hydrogen ions in a range of 0 to 14. Before the pH was measured, the instrument was calibrated using Etalon with constant pH solutions in accordance with the buffer solutions (Paliulis 2004).

Figure 2. Sampling points of surface water surrounding controlled dumpsite

3. Results and discussion

3.1 Physicochemical and chemical of surface water quality

Table 1 presents the temperature, DO, and pH levels of surface water near the Phraek Sa Mai controlled dumpsite. The pH levels in the surface water varied from 7.39 to 8.40, 7.12 to 8.06, and 7.21 to 8.11 for the winter, summer, and rainy seasons, respectively. Even though the pH value fell within the range of the water quality standards, L1, L2, and SF-UP are the sampling points located less than 0.5 kilometers from the controlled dump site, which, according to Bhalla *et al.* (2014), can demonstrably serve as representatives of leachate contamination that may seep into water sources. In addition, the pH levels at these three sampling points ranged between 7.12 and 8.40, indicating their alkaline nature. The alkaline nature of the leachate suggested that the landfill is an older and more balanced landfill with anaerobic fermentation (methanogenesis) (Adjiri *et al.,* 2015). On the other hand, leachate with acidic characteristics typically originates from younger landfills (Eldin *et al.,* 2010). The pH of the controlled dumpsite leachate could also be linked to the low concentration of volatile organic compounds. During the beginning of anaerobic waste decomposition, known as acid fermentation, the leachate tended to have a pH below 4 (Tchobanoglous *et al.,*1993) due to the abundance of volatile organic compounds. However, as the leachate aged, the volatile organic compounds decreased while the levels of carbonates ($CaCO_3$) and ammonium (NH_4^+) increased (Kulikowska *et al.,* 2008), resulting in a rise in pH, reaching 7 or higher (Kjeldsen *et.al,* 2002).

Table 1 displays the surface water temperatures near the Phraek Sa Mai controlled dumpsite in Samut Prakan Province, ranging from 18.8 °C to 25.88 °C, indicating that temperatures measured during all seasons were provided favorable conditions for the growth of mesophilic microorganisms, which thrive within a temperature range of 20 °C to 40 °C (Kouame *et al.,* 2010). The temperature rise can also drive bacterial enzymatic activity, resulting in enhanced oxidation, hydrolysis, and remineralization of waste, thereby enriching the leachate with mineral elements (Kouame *et al.,* 2010).

The concentrations of dissolved oxygen (DO) showed the reduction with seasonal variations. Specifically, the DO concentration was considerably low during the winter, measuring 0.03 - 3.78 mg/L, similarly during the summer season, the DO concentration was 1.09 - 3.85 mg/L. DO concentration was notably low, measuring 0.03 mg/L - 0.73 during the winter for L2 and SF-Up which are closed surface water bodies. Since the decrease in DO might impact the aquatic flora and fauna at the bottom of the stream and produce ammonia toxicity, oxygen depletion in the surface water could be a primary consequence of leachate discharge to water bodies (Kjeldsen *et al.,* 2002).

When considering the sources of wastewater discharge that could impact the water quality of the sampling points in this study, at both L1 and SF-DW, there are communities within and outside housing estates. Since every housing estate has installed wastewater treatment systems, the water quality may be affected by wastewater discharge from communities outside the housing estate area. However, when considering the water quality of all sampling points, the levels of BOD_5 and COD were beyond the limits set for community wastewater, at 110 to 400 mg/L for BOD_5 and 250 to 1,000 mg/L for COD (Metcalf & Eddy, 1991). As shown in Figure 3, the surface water exhibits high levels of BOD, ranging from 207 to 1,556 mg/L, 157 to 1,356 mg/L, and 129 to 1,005 mg/L, and COD, ranging from 304 to 2,288 mg/L, 294 to 1,988 mg/L, and 254 to 1,570 mg/L, during the winter, summer, and rainy seasons, respectively. These indicate a substantial organic load, suggesting the potential infiltration of leachate into the water sources. Furthermore, the high levels of TDS ranging from 833 to 26,166 mg/L highlight the presence of abundant suspended matter and dissolved organic materials in the waste stream, as supported by Bhalla *et al.* (2014). Therefore, the surface water samples collected from various locations surrounding the controlled dumpsite were found to be contaminated by leachate.

Table 1. pH, temperature and DO of surface water near the Phraek Sa Mai controlled dumpsite

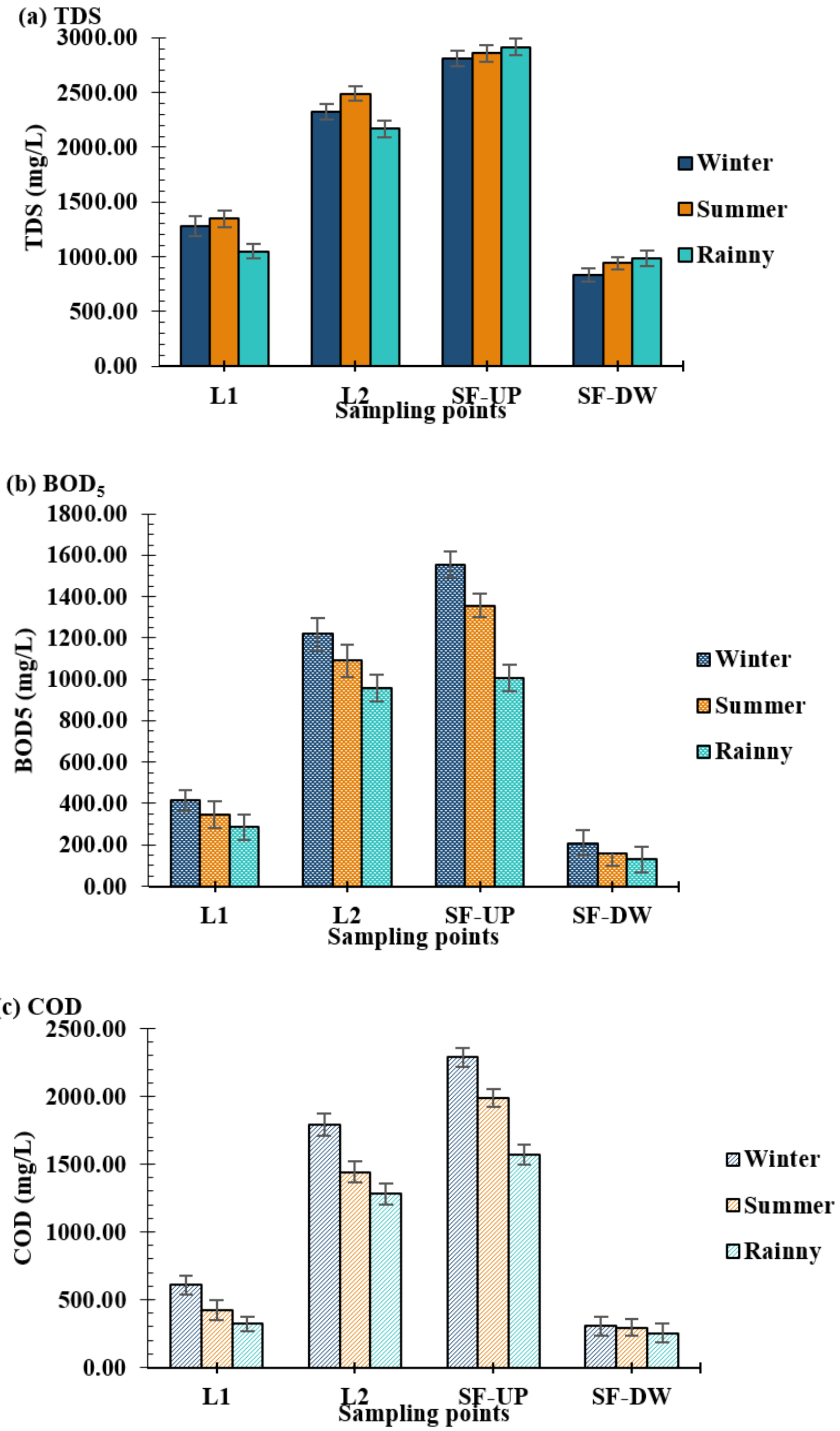
Seasons	Parameters	L1	L2	SF-UP	SF-DW
Winter	pH	7.73 ± 0.01	8.40 ± 0.04	8.28 ± 0.04	7.39 ± 0.05
	Temperature (°C)	19.35 ± 0.22	19.10 ± 0.20	19.45 ± 0.13	18.80 ± 0.16
	DO (mg/L)	3.11 ± 0.04	0.73 ± 0.03	0.03 ± 0.00	3.78 ± 0.03
Summer	pH	7.65 ± 0.02	7.12 ± 0.02	8.06 ± 0.04	7.85 ± 0.02
	Temperature (°C)	24.47 ± 0.21	25.10 ± 0.12	26.45 ± 0.12	25.88 ± 0.15
	DO (mg/L)	1.86 ± 0.02	1.09 ± 0.13	2.28 ± 0.13	6.85 ± 0.05
Rainy	pH	7.84 ± 0.01	7.56 ± 0.01	7.21 ± 0.01	8.11 ± 0.01
	Temperature (°C)	25.29 ± 0.24	24.92 ± 0.13	25.45 ± 0.17	25.88 ± 0.14
	DO (mg/L)	2.71 ± 0.13	2.56 ± 0.09	3.05 ± 0.07	3.79 ± 0.15

Mean ± Standard deviation

*The water quality for the sampling points L1, SF-UP, and SF-DW comply with Class 3 surface water quality standards, which are a temperature not exceeding 3°C, a pH from 5 to 9, a DO ≥ 4 mg/L, and a $BOD_5 \leq 2$ mg/L. The water quality for the sampling point L2 complies with Class 2 surface water quality standards, a temperature not exceeding 3°C, a pH from 5 to 9, a DO ≥ 6 mg/L, and a $BOD_5 \leq 0.5$ mg/L (PCD, 2020).

The fact that the samples were collected at different points could explain the difference in results. The winter season showed higher pH, BOD and COD levels in the surface water compared to the rainy season. These results are according to DCC and JICA (2004), which reported that the concentrations of pH and other pollutants from the Matuail dump site in Dhaka were lower during the rainy season. Even though, normally during the rainy season would risk of leachate being flushed of the confined area in the controlled dumpsite and contaminating nearby surface water bodies however, the pollutants can be diluted and flowed though in open-surface water bodies such as L1 and SF-DW in this study.

The ratios of BOD_5 and COD in the surface water from four sites near Phraek Sa Mai controlled dumpsite are shown in Figure 4, it was in the range of 0.51 - 0.89 indicating the Phraek Sa Mai controlled dumpsite is mature stages according to the study of Rikta *et al.* (2018) that calculated BOD_5/COD ratios for each leachate stage, the fresh leachate had a ratio of 0.08, which increased as the leachate became young and mature stages namely 0.2 and 0.38, respectively. Furthermore, Rikta *et al.* (2018) revealed that fresh leachate had more toxicity than mature leachate. If fresh leachate enters the groundwater system or overflows into surface water, it may pose a significant toxic threat to aquatic creatures and humans who utilize that water. According to Samudro and Mangkoedihardjo (2010), leachate from landfills with a ratio of BOD_5 and COD below 0.1 is considered toxic since a low ratio indicates a considerable amount of COD that is difficult to biodegrade. The high COD concentration can alter the physiochemical properties of groundwater and initiate organic contamination in the water (Kaur *et al.,* 2016; Mor *et al.,* 2018). Therefore, the leachate from the Phraek Sa Mai controlled dumpsite can be in the acceptable range however, its BOD_5/COD ratios had trend to decreased in summer and rainy season especially in SF-DW indicating overflows into surface water in the periods.



*The water quality for the sampling points L1 , SF-UP, and SF-DW comply with Class 3 surface water quality standards, which include a DO ≥ 4 mg/L and a $BOD_5 \leq 2$ mg/L, with no specified standards for COD and TDS. The water quality for the sampling point L2 complies with Class 2 surface water quality standards, a DO ≥ 6 mg/L and a $BOD_5 \leq 0.5$ mg/L, with no specified standards for COD and TDS (PCD, 2020).

Figure 3. (a) TDS, (b) BOD_5 and (c) COD of surface water in winter summer and rainy seasons.

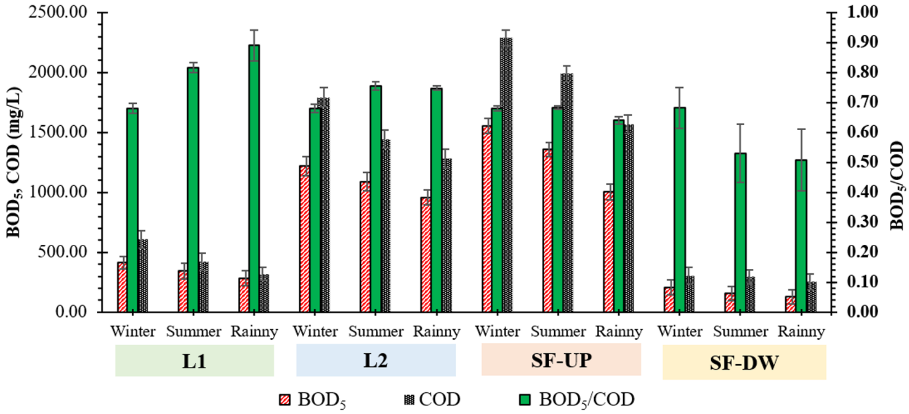


Figure 4. Ratios of BOD_5 and COD in the surface water from four sites near the Phraek Sa Mai controlled dumpsite

3.2 Heavy metals concentration

As depicted in Figure 5, Fe had the highest average concentration among the heavy metals detected in the surface water, followed by Cr, Cd, Ni, Mn, Zn, Pb, and Asin, respectively. However, Cu and Hg were not detected, indicating possible dilution of heavy metals in the water medium, which could explain the lower concentrations in the surface water (Anita *et al.,* 2010). Throughout the three seasons, the Fe concentrations were consistently higher than other metals. Typically, natural water does not contain high concentrations of Fe, except in groundwater resulting from high levels of iron in the soil and bedrock. The Fe concentration in drinking water should not exceed 0.5 mg/L (Masawat, 2011). In this study, high levels of Fe in surface water sources were observed, which could be attributed to the controlled dumpsite. The lack of a leachate collection system and the substantial amount of waste deposited contribute to the contamination and transportation of leachate into the soil surrounding the controlled dumpsite, resulting in increased Fe levels in the water sources (Othman *et al.,* 2016). According to PCD (2020, the water quality standards for surface water specify the allowable concentrations of heavy metals, namely Cr, Cd, Ni, Mn, Zn, Pb, and As, which should be equal to or less than 0.05, 0.005, 0.1, 1.0, 1.0, 0.05, and 0.01 mg/L, respectively. In this study, the concentrations of Cr, Cd, Ni, and Pb in the surface water exceeded the standards. These contaminants were particularly elevated, especially during the rainy season. As reported by Han *et al.* (2016), wet-season precipitation accelerates the leaching process of pollutants from the contaminated upper layer of soil. Increased rainfall also can moderately lead to higher discharge and permeability of leachate. In addition, due to the lack of systematic hazardous waste separation and regulatory laws in Samut Prakan Province, the toxic metals observed in this study, such as Pb, Hg, Ni, and Cd, could be from e-waste through leachate and then reached the surface water (Chakraborty *et al.,* 2022).

Toxic metals released into the environment have harmful consequences for human health, aquatic creatures, and plant life. The average concentrations discovered in the water samples included a rather high Fe level of 5 mg/L, According to WHO (2012), total iron concentrations exceeding 0.30 mg/L can result in stains in clothing and plumbing fixtures, as well as turbidity and color changes in the water. Meanwhile, every water source had Cr, Cd and Ni concentrations much higher than the WHO standards (exceeding 0.05 mg/L, 0.003 mg/L and 0.02 mg/L, respectively) according to the average concentration of 2 mg/L, 0.56 mg/L and 0.48 mg/L, respectively. With a biological half-life of 10 - 35 years in humans, Cd is harmful to the kidneys and carcinogenic (WHO, 2012). Fernandes *et al.* (2007) concluded that the high contamination and exposure of heavy metals in an aquatic ecosystem can severely impair human health due to metal accumulation in the food chain. All the water sources must undergo treatment to reduce the Cd concentration in accordance

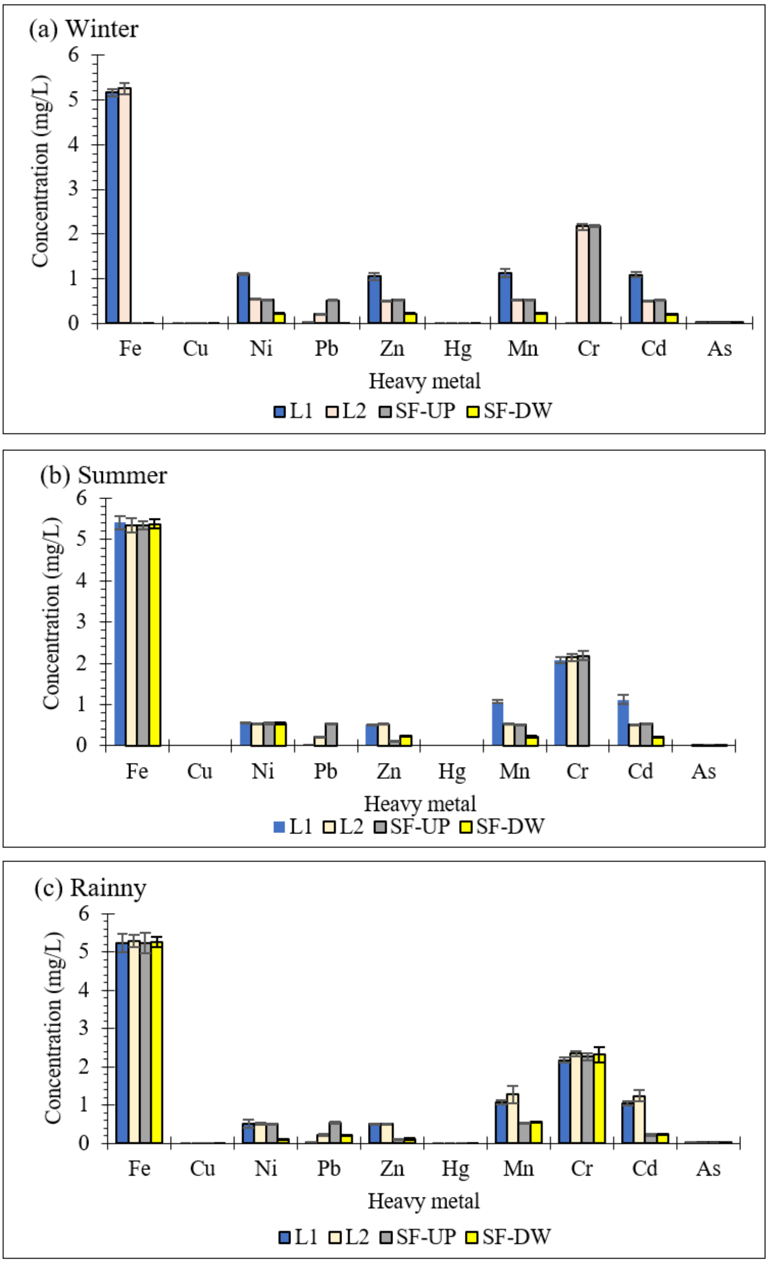


Figure 5. Heavy metal concentration in surface water surrounding controlled dumpsite by (a)winter (b) summer (c) rainy

with the standards because the very high levels of Cd make the water unsafe for consumption. Although there is no recommended metal iron concentration, amounts above 0.30 mg/L can have an impact on the flavor and appearance of drinking water, as previously mentioned (WHO, 2012). The leachate seeped into or permeated the water, streams were contaminated by erosion, particularly during rainfall (Bhalla *et al.,* 2012; Lone *et al.,* 2012). The steepness of the land's slope and the properties of the soil, such as its texture and permeability, have an impact on both erosion and leaching, possibly resulting in an extremely high level of pollution in the surface water from the dumpsite. Nevertheless, since the causes of erosion and leaching are outside the purview of this work, further research should be done to determine how these factors affect the contamination of water sources close to the Phraek Sa Mai controlled dumpsite.

3.3 Risk of landfill leachate and mitigation of surface water contamination

The results of the study indicated that the leachate from the controlled dumpsite had a detrimental impact on surface water quality through surface runoff in the surrounding areas. The controlled dumpsite lacks engineered liners and adequate leachate collection systems therefore there is movement of toxic leachate from leachate ponds with inadequate or no liner into groundwater and surface water. Similarly, in developing countries, particularly Bangladesh, most landfills lack engineered liners and adequate leachate collection systems (Kjeldsen *et al.,* 2002; Alam *et al.,* 2020). Consequently, hydraulic connections may simplify the movement of leachate from groundwater to surface water. In sub-tropical countries like Bangladesh, especially during monsoons, food waste can often find its way into surface water because of the weak design of landfill sites and poor waste management. Leachate migration concerns various physical, chemical, and biological factors that can lead to a change in composition and a decrease in the strength of leachate from its initial state. Fadhullah *et al.* (2019) and Mishra *et al.* (2019) stated that leachate typically migrates into aquatic ecosystems by percolating through unsaturated soil layers from the base of landfills to reach groundwater.

In addition, heavy metals, similar to microplastics, can be bioaccumulated in fish and other aquatic organisms residing in water bodies. Some heavy metals have a high bioaccumulative property and can bind to microplastics in landfills. Fish and other marine creatures may mistake microplastics for food or plankton. Consequently, fish consumption can increase the risk of heavy metals entering the human body through the food chain. Furthermore, Amin Bazar and Mogla Bazar landfills are two examples of landfills in Bangladesh that are commonly located in food flow areas (Kamal *et al.* 2016; Alam *et al.* 2020). During monsoon season, these areas experience flooding, which might cause the toxic leachate to merge with the neighboring surface water and agricultural soil. The locals living close to the landfills claimed that the municipal corporations released untreated leachate onto private agricultural properties. The previous work depicts the proximity of the agricultural area and water body to the landfill (Amin Bazar landfill), indicating that the toxic heavy metals in the leachate can easily migrate into the nearby water body and soil. Heavy metals can bioaccumulate in crops cultivated in the area. By consuming food crops irrigated with contaminated water, people absorb heavy metals into their bodies and can develop serious health issues (Mahmood & Malik, 2014).

The migration factors might be affected by soil stratification under the landfill, the hydraulic properties of the groundwater system, and leachate chemical composition. The mobilization process can potentially minimize leachate toxicity and its impact on groundwater and surface water (Naveen *et al.,* 2018). It is crucial to conduct assessments of heavy metal and organic contamination in both surface and groundwater near landfill sites in developing countries, as these areas serve as habitats for aquatic plants and animals. Moreover, locals also consume the groundwater routinely, putting them in danger of heavy metal contamination.

Therefore, necessary measures should be taken to avoid additional leachate contamination. The municipal corporations should prioritize effective leachate management, including leachate generation, treatment methods, and recycling. The design of the landfill site should facilitate leachate collection for recycling or treatment. One approach is to spray the collected leachate across the landfill surface, allowing it to permeate throughout the waste. While some water may evaporate, this method helps reduce the overall volume of leachate for subsequent treatment. Therefore, controlled dumpsite should add the operation of the leachate management such as building embankment and leachate collection around the controlled dumpsite to minimize surface runoff of leachate during the rainy season and extracting the leachate collected at the base to help reduce the amount that seeps into the aquifer.

4. Conclusion

The Phraek Sa Mai controlled dumpsite in Samut Prakan Province is a significant source of surface water contamination and a major threat to the environment. The results showed that across the research area, physical parameters like TDS, COD, and BOD_5 were above the recommended standards. Most of the metal concentrations examined in this study, especially those close to the dumpsite, exceeded the level that met the WHO drinking water safety standards. Hence, the water quality is unfit for domestic use, and proper waste management procedures and an appropriate engineered landfill design are crucial to preventing surface water contamination.

It is strongly advised that the government uphold national environmental regulations on solid waste management and disposal in order to avoid unsuitable waste disposal and geophysical conditions that could have a negative impact on water sources, as well as to prevent contamination in the water sources through regular monitoring to put in place the necessary measures to ensure that the laws, regulations, and policies pertaining to environmental issues are followed.

In order to prevent long-term cumulative exposure dangers to health and to ensure that the water sources are safe for aquatic life and other domestic functions, the implementation of proper management procedures is required. Controlled dumpsite should be located at a safe distance from water sources; thus, indiscriminate leakage of leachate from landfills can be prevented or reduced. Moreover, Controlled dumpsite might be reconsidered of operation in an appropriate engineered landfill design.

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