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ORIGINAL RESEARCH ARTICLE



Reducing environmental pollution through improved medical waste management: An Assessment of practices and strategies in Patuakhali Municipality, Bangladesh

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ABSTRACT

Effective medical waste (MW) management is crucial because of its significant effects on human health and the environment. In Patuakhali Municipality, improper handling of medical waste in various healthcare facilities is contributing to increased vulnerability to the spread of diseases such as diarrhea, hepatitis, and various skin infections. The aim of the study is to categorize different types of medical waste, determine their generation rates, evaluate current waste management practices, and identify shortcomings by comparing them with standard procedures. The study was conducted across 14 selected healthcare establishments (HCEs) that contribute substantially to the municipality's total medical waste. A descriptive research methodology was used, involving field surveys and interviews with hospital authorities and waste management personnel. Findings revealed that these facilities generate approximately 1495 kg of medical waste per day, of which 1328.6kg/day (88.7%) is non-infectious and 166.4 kg/day (11.13%) is infectious. The average waste generation rate is 1.54 kg per bed per day or 0.30 kg per patient per day. The study highlights the absence of systematic and regulated medical waste management. Key barriers identified include lack of awareness among staff, insufficient financial resources, and limited institutional willingness to improve practices. Furthermore, the existing system lacks proper segregation, storage, and disposal measures. Some examples of proper medical waste management are provided, along with identified gaps in the current system. Therefore, Patuakhali Municipality and HCEs authorities should adopt appropriate policies and implement training programs for personnel involved in medical waste handling to improve overall management practices.

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INTRODUCTION

Healthcare waste poses a greater challenge in developing countries compared to developed nations, primarily due to

inadequate waste management infrastructure (Dixit & Dutta, 2024). Worldwide, Medical Waste Management (MWM) is a public health problem with a huge environmental threat (Jang *et al.*, 2006). In the last decade, due to the increase in the use of disposable medical equipment due to the increase in medical sector worldwide, huge wastes were created. Medical waste with domestic appliances are extremely highly toxic metal, toxic chemicals, microbial viruses and bacteria are highly available. As a result, some studies have shown that these treated waste can present a process of infection of serious health problems because it contains highly toxic chemicals (Janik-Karpinska *et al.*, 2023). Medical wastes are contagious and dangerous. It threatens environmental health and requires specific handling and management prior to its final settlement. This waste is arising from the preventive, healing or harmful activities and diagnosis of veterinary and human medicines. Recent developments in the health care unit are specifically designed to prevent and protect community health. Access to adequate health care remains a significant challenge in developing countries like Bangladesh (Hossain *et al.*, 2011). Sophisticated instrumentation uses increased efficacy for the treatment of diseases. Such progress in scientific knowledge has resulted in per capita per patient generation of wastes in healthcare units (Radha *et al.*, 2009). Safe disposal of medical waste in Bangladesh has been ignored. Medical waste is the source of both environment pollution and contamination. Medical waste is able to causes diseases which are caused by direct contact or indirectly by soil, underground water and air. The air of this dumping area can also carry germ and hazardous substances. Where domestic animals are allowed to graze at the open dumps, the food chain in the human body has the risk of recycling bacterial infections in the body. Therefore, if you do not handle medical waste carefully then the risks of individuals, communities and the environment is must (Hossain *et al.*, 2021). Many research and activity reports are published, related to medical waste management (Singh *et al.*, 2021; Cho *et al.*, 2024). Considering the huge quantity of municipal waste, the hospital is very small part of the wastewater and in very small quantities of infectious wastes, if we understand the correct in-house management from our studies and our experience, it will not be difficult to deal with possible potential feasibility of hospital waste management (Hossain *et al.*, 2021). Adopting sustainable waste management practices in healthcare can yield substantial advantages and provide meaningful guidance for improving hospitals environmental, social, and governance standards (Cho *et al.*, 2024). However, the Government of Bangladesh is insisting on it and it is understood that in our country, we should make a policy of medical waste management (MWM) about our situation and technical and economic strength.

The waste produced in most urban and rural areas is disposed of by the open dumping at the digging holes or lower areas. As a result, soil in waste is polluted by bacterial microbiology, heavy metals, salt and chlorinated hydrocarbons (Marsum & Rajiani, 2023). Dump space is very respected and is available beside many residential areas. Medical waste safe disposal in Bangladesh has been ignored. A source of both medical waste and envi-

ronmental pollution and pollution Drug waste directly and indirectly to pollute soil, underground, surface water and air to cause public diseases and diseases. The air from this dome can also carry germ and hazardous substances. Where domestic animals are allowed to eat open dumps, through the food chain there is a risk of recyclable bacterial reuse in the human body. Therefore, the untreated person is risky for the person, community and environment unless it is carried out carefully. To ensure sustainable medical waste management practices within the broader community, it is essential to implement prompt policy reforms, foster collaboration among stakeholders, strengthen training initiatives, raise public awareness, and actively involve and empower citizens (Islam *et al.*, 2025).

Patuakhali Sadar had a population of 314,462, with Males constituted 50.12% of the population, and females 49.88%. The population aged 18 or over was 152,588. Due to the widespread healthcare needs of the population, healthcare facilities are increasing rapidly. Thus the generation rate of medical waste is increasing day-to-day. Patuakhali municipality's maintenance department is involved in waste management and medical waste management. The amount of medical waste collected by Patuakhali Municipality is about 2.5 tons/day (Patuakhali Municipality website). Generally, Patuakhali Medical College Hospital e (PMCH) is disposed of their dangerous waste every day. Various clinics generated non-hazardous waste are temporarily stored either in containers or heap up at the side of premises and finally handed over to different settlement sites, for the permanently driven dumping of the Patuakhali municipality. Despite the extensive global and national research on medical waste management, limited studies have systematically quantified medical waste generation and evaluated existing management practices in mid-sized urban areas of Bangladesh, particularly in coastal municipalities like Patuakhali Sadar. This study uniquely addresses this gap by providing first-hand field data, identifying critical deficiencies in segregation, collection, and disposal and offering context-specific recommendations aligned with local infrastructural, economic, and policy realities. The main objective of the study was to estimate the amount of medical waste produced in the healthcare establishment of Patuakhali Sadar and also study the types of systems operated for these medical waste. The specific objectives of this study was to explore the present medical waste management system of Patuakhali Municipality and to identify the constraints and the potential options to enhance the present Healthcare Waste Management (HCWM) system there.

MATERIALS AND METHODS

Study area

Patuakhali Sadar is located at 22.3542°N 90.3181°E . It has 55,194 households and a total area of 362.62 km². It is the largest municipality in the Patuakhali District with an area of 27.03 sq. km. There are about 14 clinics/hospitals, in this municipality.

Data collection and analysis

A descriptive cross-sectional survey was conducted to assess medical waste generation, composition, and management practices in healthcare establishments (HCEs). Fourteen HCEs, including public hospitals and private clinics, were purposively selected based on bed capacity, patient flow, contribution to total municipal medical waste, ownership type, and geographic distribution. Data collection involved direct waste measurement, key informant interviews, structured observations, and review of secondary data. For waste quantification, materials generated over 24 hours in each facility were collected, weighed, and classified into categories-general, infectious, plastic, liquid, and sharps-following WHO guidelines. This process was repeated for several days to obtain average daily generation rates. Key informant interviews with hospital administrators, municipal waste staff, and healthcare workers used a semi-structured format to explore current collection, segregation, storage, transport, treatment, and disposal practices. Observations were conducted using a checklist to record handling procedures, container use, color-coding, personal protective equipment (PPE) usage, and waste storage conditions. Secondary data, including municipality waste records and national waste management policy documents, were reviewed for contextual understanding. Quantitative data were analyzed using descriptive statistics in Microsoft Excel, while qualitative information from interviews and observations was thematically analyzed to identify recurring challenges and improvement opportunities. The study involved no human or animal experimentation; permissions were obtained from all participating facilities, and verbal informed consent was secured from interviewees, ensuring confidentiality and voluntary participation.

RESULTS AND DISCUSSION

Waste management scenarios of different hospitals and clinics in Patuakhali

Patuakhali Medical College Hospital (PMCH): Patuakhali Medical College Hospital (PMCH) has approximately 250 beds across 10 wards and 30-40 cabins, serving around 250 inpatients and 1000 outpatients daily. However, this number often rises to 400-600 inpatients and about 1500 outpatients. Food and non-hazardous wastes are stored in open buckets, often shared by multiple beds, leading to frequent overflows. Patients and cleaners blame each other for the mismanagement of waste, citing inadequate cleaning schedules and insufficient buckets. PMCH generates around 700 kg of non-hazardous waste and 80-100 kg of hazardous waste daily, yet there is no proper segregation, disinfection, or incineration system in place. All waste types are dumped together in roadside bins, where some plastic items are collected and sold for recycling before municipal cleaners dispose of the rest at a dumping station.

Healthcare Clinic (HC): Health Care Clinic, a private facility on Sher-e-Bangla Road in Patuakhali, has around 30 beds, including

two wards and ten cabins, serving 30 inpatients and 20 outpatients daily. The clinic generates approximately 50 kg of waste per day, including 10-15 kg of hazardous medical waste such as syringes, gloves, and biological materials. Waste is stored in open buckets, often shared between beds, leading to frequent overflows and disputes between patients and cleaners. Although some segregation is practiced, all waste is eventually dumped in roadside bins, with recyclable plastics sometimes separated and sold before municipal cleaners transport the rest to a dumping station.

Himi Poly Clinic (HPC): Himi Poly Clinic, located on Circuit House Road in Patuakhali, has 25 beds and serves about 30 inpatients and 20 outpatients daily. It generates around 60 kg of waste per day, including 10-15 kg of hazardous medical waste such as syringes, blood bags, and laboratory chemicals. While some waste segregation is practiced, all waste is eventually stored in roadside bins, with recyclable items occasionally separated and sold before municipal cleaners transport the rest to the dumping station.

Abdullah Clinic (AC): Abdullah Clinic, located at Mitha Pukurpar in Patuakhali, has 25 beds and serves around 30 inpatients and 20 outpatients daily. It produces approximately 60 kg of waste per day, including 10-15 kg of hazardous medical waste, with cleaners managing disposal two to three times daily. Although some waste segregation is practiced and recyclables like syringes and saline bags are sold, the clinic lacks proper disinfection methods such as incineration, and all waste is eventually dumped in roadside bins for municipal collection.

Marie Stopes Clinic (MSC): Marie Stopes Clinic, located at Puran Bazar in Patuakhali, serves 50-70 outpatients daily and does not provide residential care. It generates about 40 kg of waste per day, including 2-5 kg of hazardous medical waste, and practices comprehensive waste management, including segregation, disinfection, special treatment for liquid waste, and recycling. Different colored bins are used for various waste types, with hazardous items like syringes and body parts buried, and all remaining waste collected by municipal cleaners for disposal at the dumping station.

Maternity Hospital (MH): Maternity Hospital, a government facility at Bayamagar Mor in Patuakhali, has 60 beds and provides care for around 30 inpatients and 100 outpatients daily. It generates approximately 140 kg of waste per day, including 20 kg of hazardous medical waste, but does not follow any segregation practices. All waste is dumped in roadside bins, with some recyclables occasionally separated and sold, before being collected by municipal cleaners for final disposal.

Apollo Hospital (AH): Apollo Hospital, a private clinic on PTI Road in Patuakhali, has 20 beds and provides services to about 20 inpatients and 30 outpatients daily. It generates around 40 kg of waste per day, including 10 kg of hazardous medical waste,

and practices basic segregation before storing all waste in roadside bins. Some plastic items are separated and sold for recycling, while the remaining waste is collected by municipal cleaners and taken to the dumping station.

Ma o Shishu kollyan Clinic (MKC): Ma o Shishu Kollyan Clinic, located at Puran Bazar in Patuakhali, has 20 beds and serves around 20 inpatients and 35 outpatients daily. It produces approximately 45 kg of waste per day, including 5-10 kg of hazardous medical waste, and follows basic segregation and some incineration practices for disinfection. All waste is stored in roadside bins and later collected by municipal cleaners for disposal at the dumping station.

Mukti Clinic (MC): Mukti Clinic, a private facility on PTI Road in Patuakhali, has 25 beds and serves about 30 inpatients and 50 outpatients daily. It generates around 70 kg of waste per day, including 10-15 kg of hazardous medical waste, with limited segregation; some plastic items are separated and sold for recycling. All waste is eventually dumped in roadside bins and collected by municipal cleaners for disposal.

Life Care Clinic (LCC): Life Care Clinic, located at Sobujbag Mor in Patuakhali, has 25 beds and serves about 30 inpatients and 20 outpatients daily. It generates approximately 60 kg of waste per day, including 10-15 kg of hazardous medical waste, and follows basic segregation and some incineration practices. Recyclable plastic items are occasionally sold, while all other waste is stored in roadside bins and collected by municipal cleaners for final disposal.

Patuakhali Clinic (PC): Patuakhali Clinic, located on Kazi Bari Road, has 30 beds and serves about 30 inpatients and 50 outpatients daily. It generates approximately 70 kg of waste per day, including 10-15 kg of hazardous medical waste, and practices some segregation and incineration for hazardous waste disinfection. Recyclable plastic items are separated and sold, while all other waste is stored in roadside bins and collected by municipal cleaners for disposal.

Fortune Clinic (FC): Fortune Clinic, located on DC Bungalow Road in Patuakhali, has 25 beds and serves about 30 inpatients and 20 outpatients daily. It generates approximately 60 kg of waste per day, including 10-15 kg of hazardous medical waste, and follows some segregation and incineration practices. Recyclable plastic items are separated and sold, while all other waste is stored in roadside bins and collected by municipal cleaners for disposal.

Green view Hospital (GVH): Green View Hospital, a private clinic at Titash Mor in Patuakhali, has 25 beds and serves about 30 inpatients and 20 outpatients daily. It generates approximately 60 kg of waste per day, including 10-15 kg of hazardous medical waste, and follows comprehensive waste management practices such as segregation, incineration, liquid waste treatment, and recycling. Waste is stored in color-coded bins, with

hazardous items buried by authorities, and all waste is eventually collected by municipal cleaners for disposal.

BNSB Eye Hospital: BNSB Eye Hospital, located on Govt. College Road in Patuakhali, provides outpatient and occasional surgical treatments to about 100 patients daily. It generates approximately 40 kg of waste per day, including 2-5 kg of hazardous medical waste, and practices some waste segregation before storing all waste in roadside bins. Municipal cleaners collect the waste from these bins for disposal at the dumping station.

Composition of hazardous and non-hazardous waste

Based on the analysis, the generation of HCW depends on some factors such as different healthcare center specializations, size and type of healthcare center, social and economic status of the country, the application of modern treatment facilities and the education level of employees and cultural features of patients, as well as the waste management activities and application of reusable item. The physical composition of the generated waste was found to be 75% general, 14% infectious, 5% plastic, 4% liquid and 2% sharp waste (Figure 2). The comparison of hazardous and non-hazardous waste is shown in Figure 1. The highest amount of non-hazardous waste is generated by PMCH at 70%, whereas the lowest is BNSB Eye Hospital at 5.5%. On the contrary, the hazardous waste generation rate of PMCH is 18.73%, which is higher.

Medical wastes are produced by various activities. Different units within hospitals and clinics such as medical ward, operation theatres and surgical ward, health-care units, laboratories and pharmaceutical and chemical stores would generate different wastes. The amount of waste generated in hospitals depends upon various factors such as the number of beds, types of health services provided, economic, social and cultural status of the patients and the general condition of the area where the hospital is situated. It was observed that the surveyed hospitals generated pathological wastes, sharp instruments (e.g. needles, syringes, and broken glassware instruments), saline bag and urine bags, cotton-bandages, papers, food wastes etc. (Table 1). All the surveyed hospitals collectively generated 1,695 kg of medical waste per day, of which 166.4 kg/day were infectious and 1,328.6 kg/day were non-infectious. As shown in Table 1, infectious wastes include items such as sharp instruments, cotton bandages, body parts, and blood or urine bags, while non-infectious wastes consist of vial-ampoules, saline bags, general waste (e.g., food waste, paper, medicine boxes), and other materials like liquid drugs, tissue paper, and solid drugs. The results indicate that the average medical waste generation rate based on the number of available beds across all surveyed hospitals is 1.325 kg per bed per day (Table 2). It was found that most of the clinics/diagnostic centers generated 30-40 kg waste per day. Few small hospitals and clinics generated 46-65kg waste, and two hospitals generated 70-150 kg waste per day. Only PMCH generated the largest amount of waste compared to other hospitals and clinics (Figure 3). Therefore, it can be suggested that the priority should be given to large and government hospitals to introduce proper in-house management system.

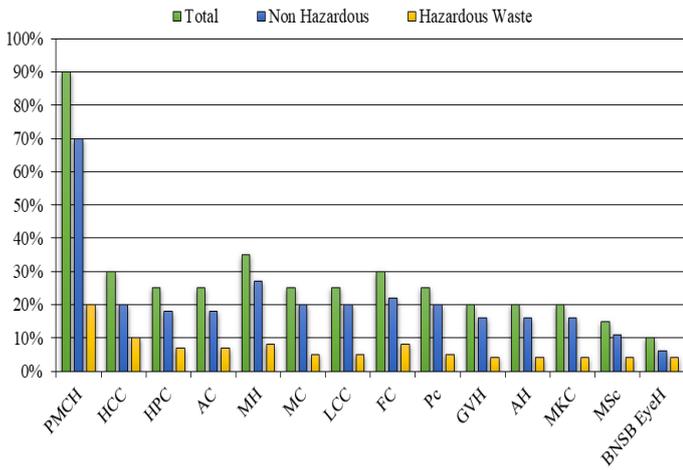


Figure 1. The comparison of hazardous and non-hazardous waste.

Physical composition of medical waste

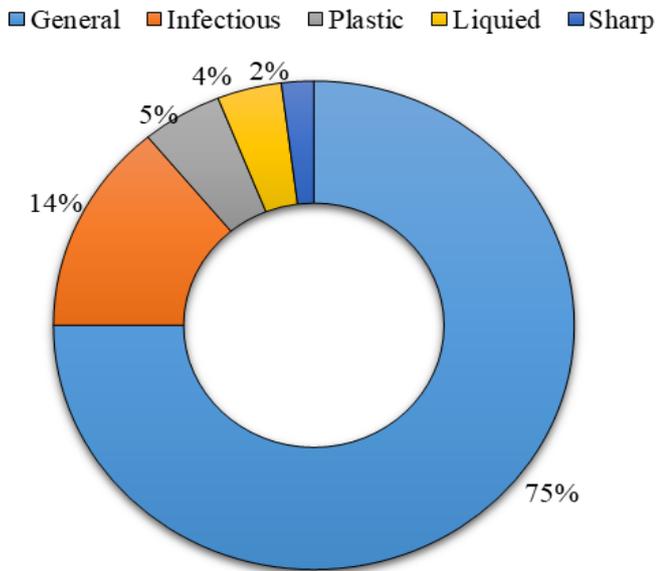


Figure 2. Physical composition of the HCW generated by HCEs (Source: Field Survey).

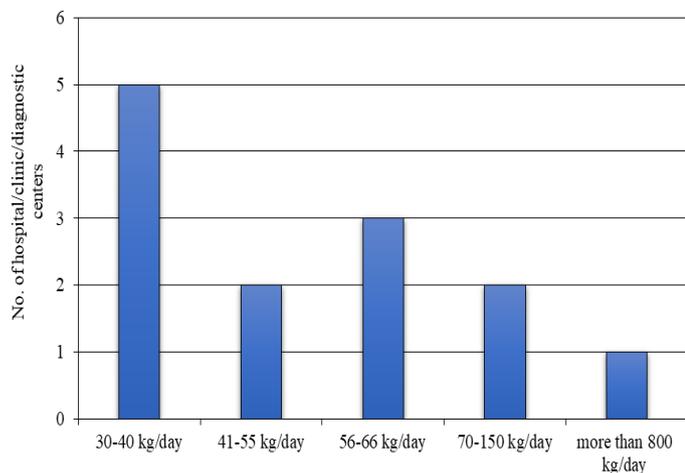


Figure 3. Quantity of medical waste in different surveyed hospital (Source: Field Survey).

Table 1. Amount of wastes with types generated in all surveyed HCEs (Source: Field Survey).

Type of waste	Amount of waste per day (kg)														Total
	PMCH	HC	HPC	PC	MSH	MC	MSC	GVH	LCC	MH	AC	FC	AH	BNSB Eye Hospital	
Sharp instruments	15	2.5	3	2	2.5	2.8	2.5	2	2	3.5	2	1.5	1.5	1.5	44.3
Vial-ampoules	5	1.5	1.5	1.8	1.5	1.2	1	1.5	1.2	1.8	1.7	1	1.2	1.5	23.4
Cottons	10	1.5	1.5	1.2	1	0.75	1.25	0.5	0.8	1.2	0.50	1.5	0.5	0.5	22.7
bandages	15	1.8	1.5	1.5	1.5	1.25	1.25	1	1.7	2.5	1.25	1.8	1	1.5	34.5
Saline bags	20	2	2	2.5	1.5	2.5	1.5	1.5	1.5	3	1.5	1.25	1.5	1.5	43.7
Bodyparts (liquid, solid)	10	1.5	1.5	1.5	2	2	0.5	0.5	1	1.5	0.8	1.2	1	0.5	25.5
General wastes	700	62	57	58	35	57	40	40	50	142	70	65	42	36	1459
Medicine box, papers)	5	0.7	0.5	0.7	0.62	0.5	0.5	0.25	0.30	1.75	0.5	0.25	0.3	1	12.8
Blood and urine bags	20	1.5	1.5	1.5	1	2	1.5	1.5	1.5	2.75	1.75	1.5	1	1	40
Total	800	75	70	70	45	70	45	50	60	160	80	75	50	45	1695

Table 2. Waste generation rates in surveyed HCEs (Source: Field Survey).

Name of Hospital	Patients		Total	Waste Generation Rate		
	Bed	Out Patients		Kg/day	Kg/Bed/day	Kg/Patients/day
PMCH	250	1000	1250	800	1.75	0.75
HC	30	25	55	75	1.5	0.50
HPC	25	20	45	70	1.5	0.50
AC	25	30	55	80	1.3	0.50
PC	30	50	80	75	1.25	0.45
LCC	25	30	55	50	+5	0.34
GVH	20	15	35	45	1.25	0.30
MSH	20	20	40	45	1.5	0.50
MH	60	100	160	160	1.5	0.70
MSC	-	70	45	45	-	0.25
FC	25	20	45	50	1.5	0.45
MC	30	50	80	70	1.3	0.25
AH	20	30	50	60	1.5	0.34
BNSB Eye Hospital	5	100	105	45	1.2	.2
Total	565	1560	1950	1695	18.55	6.03

Effects of improper medical waste management

Due to a lack of awareness in the collection, handling, and disposal of medical waste, serious health and environmental risks have emerged. Waste handlers and cleaners frequently suffer from injuries such as cuts, puncture wounds, sprains, and backaches. Improper disposal leads to persistent pollutants, groundwater contamination, bioaccumulation, and reduced soil fertility, while open burning of plastics releases toxic dioxins into the air. Waste pickers, often unprotected, face high exposure to infectious diseases like hepatitis B/C, typhoid, tuberculosis, and malaria (BAN & HCWH). Sharps such as syringes and needles pose the highest risk, with over 20% of handlers experiencing stick injuries and multiple cases of severe accidents reported due to unsafe waste practices. Similar findings indicate that hospitals should implement clear procedures and policies to ensure the proper disposal of syringes and other medical waste. Emphasis should be placed on every stage of waste management from generation to final treatment and disposal by establishing source separation, hygienic collection, and appropriate storage practices. Waste should be transported in approved packaging, treated using safe and environmentally sound methods, and final residues should be disposed of in secure, well-designed facilities (Alkhaqani, 2022). Hospital and home care medical wastes pose serious threats to public health and the environment in Bangladesh, especially when untrained caregivers dispose of used items like syringes and needles in open spaces, exposing others to infections. Proper healthcare waste management is essential to protect healthcare workers, patients, and communities from toxic exposures and injuries (WHO, Geneva). Despite efforts like the JICA-supported incinerator and ongoing WHO projects, gaps remain in transport, regulation, and coordination among stakeholders. Localized, safe disposal methods- such as protected pit burial or high-temperature incineration should be prioritized based on context and resources. Strengthening public awareness, inter-agency coordination, and training of hospital staff are critical for improving waste management and minimizing health risks. Comparable findings showed that increased awareness among hospital staff about proper waste management and hygiene practices led to reduction in the risks associated with im-

proper waste disposal (Rahadi et al., 2025).

Health and environmental assessment

Medical waste presents significant threats to both public health and the environment when not managed properly. Improper disposal can lead to contamination of soil, surface water, and groundwater, especially from leachate or toxic chemicals used in laboratories and treatments—such as xylene, phenol, and antineoplastics- which may enter open drains and surrounding areas. Burning medical waste at low temperatures or in the open releases toxic air pollutants like dioxins, posing serious respiratory and carcinogenic risks. Unsecured dumping grounds can expose children, domestic animals, and scavengers to hazardous materials, increasing the chance of infection and reintegrating pathogens into the food chain. Additionally, improper sterilization of instruments and indiscriminate disposal of both biodegradable and non-biodegradable waste reduce soil fertility, hinder water infiltration, and contribute to long-term environmental degradation. Therefore, effective waste segregation, safe disposal systems, and strict enforcement of medical waste management regulations are essential to protect human health and preserve ecological balance. Improper disposal of medical waste can lead to severe health and environmental consequences. Contaminants such as leachate from waste can infiltrate aquifers, surface water, or drinking water systems, posing a serious risk to public health. The disposal of non-biodegradable substances like antibiotics, antineoplastics, and disinfectants into sewage systems can disrupt microbial activity essential for wastewater treatment and may harm aquatic ecosystems if flushed into water bodies. Open burning or low-temperature incineration of medical waste releases toxic air pollutants such as dioxins, while carcinogenic substances like heavy metals and chemical solvents endanger both workers and the general public (Cho et al., 2024). Inefficient waste segregation and unsecured landfills further contribute to health hazards, including exposure to expired drugs and increased risk for nearby residents and scavengers. Environmentally, pollutants from medical waste are persistent and can accumulate in the soil, particularly near agricultural zones, harming soil organisms, livestock, and wild-

life. These pollutants can contaminate groundwater, degrade water quality, and bioaccumulate in organisms, thereby entering and magnifying through the food chain. Long-term chemical use also deteriorates soil microbial populations, reducing decomposition rates and fertility. Pathogens and toxic substances from improperly discarded specimens can spread through soil, air, and water. Windblown waste and exposure to domestic animals grazing on open dumps further intensify these risks, potentially reintroducing harmful microorganisms into the environment. Public nuisances such as unpleasant odors and visual pollution, along with unsafe disposal of degradable and non-degradable materials like plastic bags and containers, degrade natural habitats and obstruct water infiltration. Additionally, improper sterilization of medical instruments can lead to infections, and open-air burning of plastic waste releases highly toxic fumes, worsening air quality and posing serious public health threats (David et al., 2020).

Conclusion

This study assessed medical waste management practices in various healthcare establishments (HCEs) within Patuakhali Municipality. It revealed significant gaps in data collection, segregation, and disposal of medical waste, mainly due to the lack of willingness and systemic support from HCE authorities. Major findings of the study revealed that the 14 surveyed healthcare establishment (HCEs) generated a total of 1.695 tons per day, with RMCH contributing more than half of the total volume. Improper handling and inadequate segregation between infectious and non-infectious waste were common, despite a relatively high level of awareness among personnel. Current waste disposal methods primarily involve transportation by municipal vans for open dumping or incineration, often without adherence to proper procedures. These results highlight a considerable gap between knowledge and the actual implementation of proper medical waste management practices. To ensure safe and sustainable waste management, there is an urgent need to formulate and implement structured policies aligned with WHO guidelines. Future research should focus developing digital tracking systems, training programs for waste handlers, and evaluating the effectiveness of policy interventions in improving medical waste management in semi-urban settings.

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DECLARATIONS

Author contribution statement: Conceptualization: H.I.; M.T. and M.S.R.; Methodology: M.T.; Software and validation: M.T., I.H., and M.S.R.; Formal analysis and investigation: M.T.; M.A.R;

P.K.M. and M.S.R.; Resources: M.T.; Data curation: I.H. and M.A.R.; Writing—original draft preparation: H.I.; Writing—review and editing: P.K.M.; M.T., I.H., S.D., M.F.Y. and M.S.R. Visualization: M.A.R and S.D.; All authors have read and agreed to the published version of the manuscript.

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Ethics approval: This study was conducted following the ethical guidelines of Human Ethics Committee of the institute for the conduct of the research involving human participants.

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