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Why do cities in the global South pursue waste incineration rather than source segregation and recycling? Insights from Bangladesh

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Introduction: Source segregation and recycling of waste are crucial components of sustainable solid waste management. They receive little attention due to lack of political interest and institutional capacity, weak regulatory frameworks and enforcement, lack of economic incentives and low priority in planning. A complex economic system is involved in waste management in the global South, along with an informal sector that collects and recycles valuable materials. Rather than searching for solutions to improve collection and disposal services, this study uses a political ecology approach to understand how political economy influences and controls municipal solid waste management practices on the ground focusing on source segregation and recycling and how power relations influence how waste is handled, disposed of, and recycled. Dhaka's waste governance regime emphasizes waste-to-energy generation without considering source segregation and recycling. Waste governance wants to benefit from informal waste collection and recycling without integrating them into policy frameworks, even though they have high resource recovery potential. The paper asks why, despite the potential to implement the 3R strategy by source segregation and promote sustainable waste management, the government opted for a centralized mechanical solution (incineration) for handling waste.

Methods: This study uses qualitative social research techniques to investigate a contemporary city-scale case study. The data collection techniques consisted of interviews with key stakeholders, focus group discussions, field observations and document reviews in Dhaka, Bangladesh between July and September 2022.

Results: The city authorities are interested in incineration technology due to the scarcity of land and the difficulty of obtaining it, while the existing dump sites are overflowing. Incineration technology can help city authorities avoid acquiring land by reducing their waste disposal footprint. City authorities perceive segregated waste collection as an additional burden because they lack the institutional and financial capacity to develop reliable separate waste collection systems. Additionally, high-level politicians have used images of incineration technologies to support modernist ideas about national development by emphasizing a centralized mechanical waste management system. On the other hand, international investors are interested in investing in technology and finance for incineration. In addition, city authorities believe composting and recycling on a small scale are not effective at managing the city's large volumes of waste. It is likely that the new waste policy intervention (incineration) in Dhaka will lead to conflict over resources if city authorities do not properly recognize the existing waste infrastructures and informal recycling sector.

Discussion: Using the political ecology approach, the study examines why the government is less interested in implementing the 3R strategy (reduce, reuse, recycle) by segregating waste at the source level through the use of existing waste infrastructure rather than promoting centralized mechanical solutions. The city authorities are not interested in source segregation due to lack of institutional and financial capacity. The government needs to provide incentives for household source segregation and primary waste collection. City authorities are not interested in supporting incentives for source separation or waste recycling due to lack of financial capacity and political risk. Source segregation is essential for reducing waste volume and promoting sustainable resource recovery. Effective and sustainable waste management in the global South requires an integrated formal and informal approach to enhance source segregation and resource recovery. The study provides an evidence-based understanding of political ecology's influence on MSW management practices, policy interventions and decision-making processes and offers insight into how to support effective 3R strategy implementation, facilitate policymaking, and contribute to additional knowledge for other megacities in the global South that face similar challenges.

KEYWORDS

urban political ecology, infrastructure, source segregation, recycling, incineration, Dhaka

Introduction

Globally, municipal solid waste (MSW) management is an emerging issue, especially in the global South (GS) with limited financial resources, inadequate technologies, and an absence of a policy framework (Batista et al., 2021; Khan et al., 2021). Municipalities manage MSW, including separation, collection, transfer, treatment, and disposal, but cities in GS have reported difficulties managing this task due to technical, institutional, and financial limitations (Aparcana, 2017; Gutberlet, 2016). Santos (2007) defines municipalities in the GS as countries that occupy peripheral and semi-peripheral regions encompassing developing countries (or transition economies) located south of industrially developed countries (except Australia and New Zealand) (Brandt, 1980). MSW management systems in GS cities are often inadequate or weak at all stages of collection, handling, treatment, and disposal, resulting in serious environmental and public health problems (Abubakar et al., 2022). In the GS, MSW is primarily collected and disposed of in landfills by the public sector (Onyanta, 2016). With limited finances and institutional capacity, and weak policy enforcement, the public sector often cannot effectively deliver MSW management services (Sandra and Wegmann, 2019).

Incineration of waste is widely used in the global North (GN) and is now being promoted in GS cities as a solution to waste challenges, altering the local waste management system (Mbuli, 2015; Baker and Letsoela, 2016). In GS cities, neoliberal governments privatize public services, including waste management, which boosts national or international cooperations companies' interest in exploring waste-based commodities, creating attractive markets (Gutberlet et al., 2020). In Brazilian cities, waste pickers have developed alternative technologies and systems for collecting, sorting, and selling recyclable materials, which are also common in other GS cities (Rutkowski and Rutkowski, 2015). This offers opportunities for socio-productive inclusion and creates many jobs (Tangri, 2003). Privatization of public waste management services, low public participation, and large-scale

waste management technologies (incineration) in GS cities result in a disconnect between local politics and social reality that leads to accumulation by dispossession (waste pickers participate in MSW recycling), which negatively affects their livelihoods (Harvey, 2004). Using expensive technology to treat waste (e.g., incineration) may restrict city administrations from developing sustainable waste infrastructures and behaviors over time in Goteborg Metropolitan Area, Sweden (Corvellec et al., 2012).

Although GN countries like Sweden emphasize sustainable and climate-friendly alternatives to waste incineration, waste incineration is emerging on the waste-based commodity frontiers in GS cities (Gutberlet et al., 2020). Waste incineration has a negative social and environmental impact in GS cities and contributes to climate change and social exclusion (Cudjoe and Acquah, 2021; Gutberlet et al., 2020). Boding et al. (2003) demonstrated that waste should only be utilized for energy production if it cannot be re-used or recycled, such as residues from food processing that could be converted into biogas. The literature reviewed by Chimuka and Ogola (2015) and Friedrich and Trois (2010) found that renewable energy derived from waste anaerobic digestion can solve the energy problem in sub-Saharan African cities, as well as reduce environmental problems. A study by Dlamini et al. (2019) suggests GS cities could improve MSW management by incineration of non-recyclable waste and anaerobic digestion of organic waste. The feasibility study on waste to energy generation in six Bangladeshi municipalities suggests that combining anaerobic digestion, recycling, and composting will allow for the creation of a biogas plant capable of handling organic MSW and producing useful and profitable end products. Mixed waste incineration is not a sustainable solution for Bangladeshi cities due to high moisture content, low caloric value, and high installation, maintenance, and infrastructure costs (United Nations Development Programme, 2018). There is a question why the government opted for mixed waste incineration as a solution for MSW management in urban Bangladesh?

Many megacities across the GS, including Dhaka, have long benefited from informal primary waste collection and a large informal recycling system that unofficially handles a significant amount of the city's waste (Matter et al., 2013; see Gidwani and Chaturvedi, 2011; Kornberg, 2020). In Dhaka, a well-established informal sector is active in primary waste collection efficiency and the recycling of valuable materials (Matter et al., 2013). The current waste governance regime in Dhaka focuses on waste-to-energy generation by incineration, and little attention is paid to source separation and recycling. Existing landfills are nearly full, and public opposition to landfill construction and high land prices make waste landfilling challenging (Leonard, 2012; Jazat et al., 2023). International investors are interested in investing in waste-to-energy generation projects. Politicians are interested in such big projects as a way to showcase their technological credentials and manage waste and generate energy without investing money. Furthermore, city authorities lack the institutional and financial capacity to collect segregated waste and promote recycling.

In this paper we draw attention to the potential to implement recycling and reuse by an integrated formal and informal approach to managing waste rather than a centralized mechanical solution (incineration). We take Dhaka as a case study to understand why, despite the potential to implement the Government 3R strategy (reduce, reuse, recycle) by source segregation and promote sustainable waste management involving all local stakeholders, the local government opted for a centralized mechanical solution (incineration) for handling waste. We investigate how politics and political ecology influence MSW management policy interventions, as well as how they affect waste infrastructure and waste management systems in GS megacities like Dhaka. There are limited empirical studies on how political ecology influences and controls MSW policy interventions and practices on the ground, focusing on source segregation and recycling and how power relations influence how MSW is handled, disposed of, and valued in GS cities.

We draw on insights from the concept of the “urban mine” (see Corwin, 2020; Knapp, 2016; Millington et al., 2022; Schindler and Demaria, 2019). Millington et al. (2022) argue that “contestation over waste are not just about permission to create value but are underwritten by different visions of what infrastructure is and ought to be, who ought to know and govern it, and in whose interest, waste flows” (2022, 1942). In this article, we analyze how state-backed policy interventions affect waste infrastructure and the creation of value, enhanced and captured by powerful strategically positioned actors, as well as how politics influences waste management decisions in Dhaka. Millington et al. (2022) define infrastructure as an arrangement of materials (such as bins, trolleys, and trucks), spaces, people, and social relationships that facilitate waste flow. We use the term infrastructure to refer to the combination of informal primary waste collection, sorting, transportation, materials recycling facilities, people, and social relations that allow waste to flow.

GS infrastructure configurations are dynamic and contested, and are not always determined by established practices, patterns, and rules; they can consist of many different assemblies of components (Lawhon et al., 2018). GS cities are grappling with questions about what effective infrastructure is and ought to be (Lawhon et al., 2018; Lawhon et al., 2022; Sseviiri et al., 2020). In addition, there is a question of how waste management policy interventions affect waste infrastructure and value creation. Using interviews with elite actors in Dhaka's waste industry, this study examines how public authorities

(powerful actors) impose changes in institutions (e.g., waste ownership) or adopt MSW technologies (e.g., incinerators) that reconfigure waste flows.

This article makes two significant contributions. First, we identify the factors influencing local governments to adopt centralized mechanical solutions (incineration) for handling waste despite the possibilities of source segregation and recycling. We explore how different actors involved in the MSW management system in Dhaka are often at odds due to insufficient institutional and financial capacity, and reliance on informal livelihoods. Secondly, we examine how existing infrastructure can be reconfigured sustainably by integrating formal and informal approaches to waste flow. The study provides an evidence-based understanding of sustainable MSW management practices, supports effective 3R strategy implementation, facilitates policymaking, and contributes to additional knowledge on the topic. This study also provides valuable insights for other megacities in the GS that face similar challenges.

The political ecology of urban waste in the GS

Waste is a profitable commodity that has already created a multi-billion-dollar industry in the GN (Sabetai, 1999; Gutberlet et al., 2020) argue that one of the major waste-based commodity frontiers today lies in large cities and metropolitan areas in the GS. In order to explore the complex nature of waste-based commodity frontiers, we use the political ecology approach to understand how politics and political ecology influence how MSW is managed and disposed of, and how these decisions affect waste-based commodity frontiers in GS megacities.

There is a growing body of contemporary research exploring the politics of waste in GS cities (Bjerkli, 2013; Moore, 2009). It is evident from these cases that MSW is a complex network of actors, and waste plays a part in broader urban political strategies. Myers (2014) explored the political and governance processes associated with waste through the ‘dirty politics of inclusion and exclusion’ (Myers, 2014, p. 448). Moore (2009) highlights how waste has been embedded into the opposing political strategies of residents and city officials in Oaxaca. In South Africa, Lawhon (2012), using a relational political ecological approach, examined how power is built through engagement between members of the e-waste association and with others apart from it. Using a political ecology approach, Cornea et al. (2017) examined the complex nature of solid waste politics by exploring multi-scalar networks and power relationships, as well as ecological processes and resource characteristics in a small town in West Bengal, India.

How and where MSW is handled and disposed of can influence political actors' strategies (Moore, 2009). By using a political ecology approach, Ernstson and Swyngedouw (2018) describe the dynamic institutional, technical, social, and political ecological landscape of South Africa's waste management system, and how this influences the manner in which waste is transformed into social and economic value, as well as who can claim these benefits. Using the political ecology approach, Bjerkli (2013) has shown that power dominates as a capacity to take decisions and control how matters should be organized. In Addis Ababa, informal recycling actors are limited in their ability to participate in any decisions affecting them, and instead need to adjust

to the realities of their situation (Bjerkli, 2015). This work demonstrates how MSW management is embedded within multiple power structures, subject to multi-scale forces, and used by power holders to bolster their position. In Bangladesh, MSW and waste-based work are intertwined with socio-political dynamics, and privatization or other reforms of MSW typically value waste (materials, energy, etc.) without addressing the livelihood needs of informal waste workers (waste pickers, recyclers, etc.) (Uddin et al., 2020). Using the political ecology approach, we investigate how power relations affect implementing new waste policy interventions (incineration) and how these policies impact waste infrastructure (primary waste collection efficiency, informal waste worker activities, etc.) as well as the overall MSW management system in Dhaka, the metropolis of Bangladesh.

Traditionally, the public sector treats waste as a single subject that must be collected from every urban location and transported out of the city in a one-way flow into landfills (Oyoo et al., 2014). According to Graham and Marvin (2001), this practice embodies the modern infrastructure ideal of a centralized, networked waste infrastructure (see Sseviiri et al., 2020). Globally, landfilling faces challenges because of resource scarcity and decreasing space (Doherty, 2019; Oyoo et al., 2014). Waste incineration has become an attractive option to eliminate waste from landfills and produce energy (Demaria and Schindler, 2016). The GS cities need to rethink assumptions about appropriate waste infrastructures and social-material reconfiguration (Reno, 2015). GS cities have attempted to adopt the modern infrastructure ideal in many cases: separation at source, truck collection, and materials recycling facilities (Sseviiri et al., 2020). But how can they implement this ideal with limited financial, institutional, and infrastructural capacities?

In many studies, waste has been viewed as undesirable, emphasizing who bears the burdens associated with its management and disposal (Pellow, 2004). Our study instead draws from growing recognition waste as a resource instead of an externality (Gutberlet, 2012; Velenturf, 2017). Schindler and Demaria (2019) explain, modes of valorization introduce new waste management regimes to enhance waste value and enable waste to become a commodity frontier. Increasingly, governments and multinational corporations are seeking to capture the value of waste and its processing, resulting in fierce contestations throughout the world. There is heterogeneity across waste flows in terms of materiality (composition, volume, density), as well as in terms of socio-technical management systems (see Bjerkli, 2015; Demaria and Schindler, 2016). It is evident from these ecological distribution conflicts that waste represents a commodity frontier whose exploitation offers strategically positioned stakeholders a chance to accumulate capital. The power relations governing waste management are altered, and some powerful actors are able to transform socio-material configurations, while new actors control solid waste flows and introduce new waste treatment technology (incinerations) (see Coe et al., 2004).

In the GS, modernist approaches to waste management often focus on technologies, practices, and policies that can manage heterogeneous collections of objects (Szpilko et al., 2023; Salman and Hasar, 2023). In southern cities, this discourse is repurposed as a solution, as in Addis Ababa's recent Integrated Solid Waste Management policy (Bjerkli, 2015) and Lagos' new MSW management system (Mbah et al., 2019). The complexity of material flows of waste (organic, metal and plastic) makes it difficult to separate valuable materials, which requires both labor and technology (Millington and

Lawhon, 2019; Stokes, 2020). Due to limited state oversight, many informal actors are involved in waste recycling in GS cities (Owusu et al., 2013; Oyake-Ombis et al., 2015). Informal practices have been the subject of many academic studies, which often considered how these practices create conflict between formal and informal practices (Fredericks, 2018; Millington and Lawhon, 2019; Samson, 2015). GS cities face challenges in implementing the modernist infrastructure ideal (Niessen, 2002).

Urban scholars have long demonstrated that waste infrastructure flows shape and are shaped by social power dynamics (Heynen et al., 2006; MirafTAB, 2004; Moore, 2009). As material and symbolic resources, waste mobilizes fears and anxieties and can be particularly visceral when used in political protest (Arefin, 2019; Fredericks, 2018; Moore, 2009). In their study, Demaria and Schindler (2016) examine conflict erupted when city authorities of Delhi, India, embraced waste-to-energy incinerators that threatened waste pickers' access to waste, despite opposition from middle class residents. The authors described an unlikely alliance between these groups emerging within the city, whose politics oppose the production of waste-based commodity frontier. Materials and political ecologies are intrinsically linked and produce urban metabolisms—there is no original or real moment in which either materiality or political ecology acts as a framework or context. This study examined, why local governments tend to adopt a centralized mechanical solution (incineration) and how waste management interventions may threaten waste infrastructure and waste management systems in GS cities.

In this paper using the political ecology approach, we try to understand why, despite the potential of implementing the Government 3R strategy (reduce, reuse, recycle) by source segregation, the government chose to handle waste by means of a centralized mechanical solution (incineration). The paper considers how politics and political ecology influence this MSW management decision. In addition, we consider how politics affects waste infrastructure and waste management systems in megacities like Dhaka.

Research methodology

By utilizing qualitative social research techniques, this study investigates contemporary city-scale MSW politics, how politics and political ecology influence policy intervention and how it affects existing waste infrastructure and the waste management system in Dhaka.

Data collection techniques consisted of semi-structured interviews, focus group discussion, field observation and document reviews. The first author conducted 65 interviews, 3 field observations and collected relevant documents from July to September 2022. Respondents were selected for interviews based on their direct involvement in MSW management and the associated institutional decision-making process. The respondents included 10 waste professionals (city corporation officials), 22 industry partners (informal workers, informal recyclers, PCSP owners, informal waste workers association leaders, community members, service users), 4 academic researchers, 9 NGOs, 3 environmentalists, and 2 policy experts directly involved in MSW management in Dhaka. A similar number of waste professionals (city corporation officials) and industry participants were selected from the Dhaka North City Corporation (DNCC) and the Dhaka South city Corporation (DSCC). Focus group discussions among

15 participants focused on shifting access, ownership, rules, and responsibilities that often lead to conflict over waste value creation, enhancement, and capture. In the focus group discussion, government officials, waste policy experts, NGOs, academic researchers, leaders of informal waste worker associations, community members and users discussed the factors that led local governments to adopt centralized mechanical waste management solutions (incineration) despite emphasizing source segregation and recycling.

There were two field observations conducted on DNCC and DSCC's MSW management processes, including generation, collection, transportation, disposal and landfill. It was done at four levels of field visits: (a) household (b) primary waste collectors' workplaces (c) secondary transfer stations/containers/dustbins/open places and (d) landfills. One field observation was conducted to understand waste flows in Dhaka. It was done on six levels of field visits: (a) primary waste collector collects household waste and sorts recyclable scrap into different bags in his rickshaw-van (b) recycling buyers buy household scrap (c) Dhaka City Corporation collection points where recyclable scrap is sorted by primary waste collectors and waste pickers, (d) recyclables shops at *Lalbagh, Rampura, Mirpur* (e) wholesaler in *Dolaikhal* and (f) plastic and paper recycling factory.

Interviews lasted about 50–60 min and focus group discussions lasted about 2.5 to 3 h. In accordance with an ethics protocol approved by the University of Manchester ethics committee, interviews were conducted and recorded with appropriate verbal and written consent. According to respondents' convenience, interviews were conducted either in Bengali or in English. The interviews were all audio recorded and transcribed verbatim into English from Bengali. Data was coded to facilitate analysis. To identify how urban politics are involved in MSW management, extensive documents were analyzed including different policy documents and newspaper articles. This study collected MSW management policies, acts, rules, regulations, and strategy from the Ministry of Forest and Environment, Department of Environment (DoE), city corporations, and its official website. Interview data was cross-referenced and validated with secondary data.

Waste management in Dhaka

Dhaka City Corporation supervises MSW management in an area of 360 km² generating more than 6,500 tons of waste each day (BIGD, 2015). City authorities are responsible for collecting MSW from municipal collection points within the city's 90 wards (i.e., neighborhood administrative units) and disposing of it in designated landfills (Matter et al., 2013). Households are responsible for bringing their MSW to municipal collection points themselves.

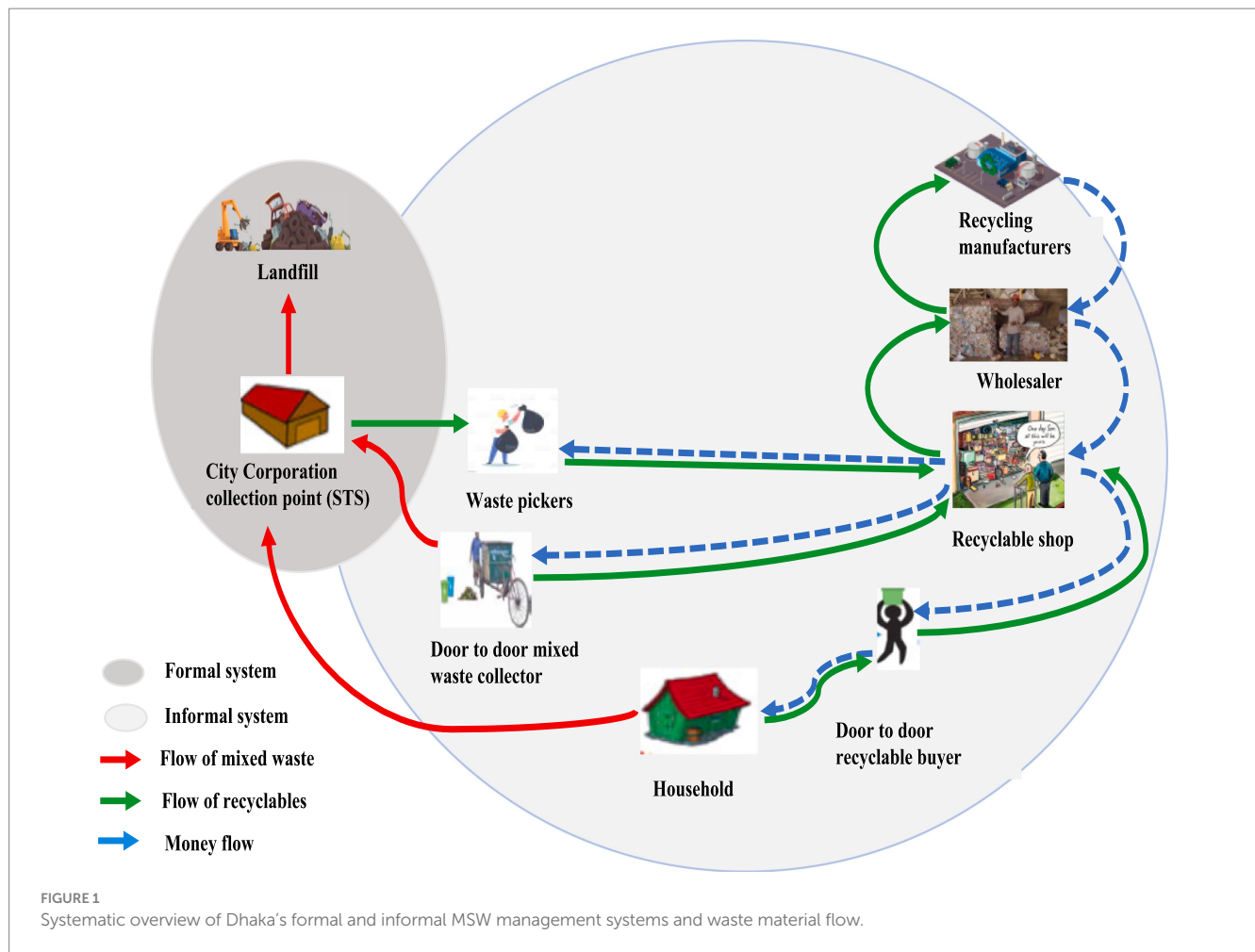
Primary waste collection (door-to-door) is labor-intensive, and the City's limited financial and institutional capacity makes it impossible to provide efficient and appropriate service in the entire city. To address this issue, city authorities encourage community-based organizations (CBOs)/local NGOs and private sectors to take part in primary waste collection services, now known as primary collection service providers (PCSPs). In practice city authorities nominate PCSPs through tendering processes in every ward in order to collect door-to-door MSW and transport it by rickshaw-vans to the city corporation's designated places (secondary transfer stations (STs)/containers/dustbins/open places). The PCSP collects monthly payments from residents. PCSPs do not pay taxes to the government

or follow any formal structure and do not provide health care, safety or job security for their employees. Reclaimers/waste pickers work independently, while PCSPs appoint informal waste workers to collect waste from houses and pay them a monthly salary. Further, waste pickers, informal waste workers of PCSPs sort recyclable scraps and sell them to junk dealers. Waste pickers are individuals or groups involved in the collection and recovery of reusable and recyclable solid waste from street sources, bins, secondary transfer stations, and open dumps. They earn their livelihood by selling recyclable scraps directly or through intermediaries to recyclers. Informal waste workers include individuals hired by PCSPs to collect waste from households, associations and waste traders who are involved in sorting, selling and purchasing recyclable materials.

In Dhaka, waste serves as an entry point into urban politics and the power relations involved in primary waste collection (see Wittmer, 2023). PCSPs and local councilors in Dhaka city are stressed over MSW collection control. An investigative newspaper report stated that PCSPs earn about 110 million dollars a year through their primary waste collection services in Dhaka North City Corporation (Chambugangh, 2023). Thus, the city's primary waste collection business has become lucrative for powerful people. One of the respondents to the primary waste collection service providers (PWCSPs) association leader argued that "PWCSPs are city corporation authorized organizations and have long experience of delivering primary waste collection services successfully in Dhaka. But if responsibility is handed over to councilors', their agents/providers will charge more and provide inadequate service to city dwellers. Due to lack of experience, they cannot handle waste management especially in Eid (festive season) in a feasible manner." As one of the councilors' said, "councils are directly accountable to the people in their communities. Through direct supervision, councilors can provide waste management services better. So, it is likely that a better waste management scenario will be tangible very soon." Local councilors, political powerful people, and primary waste collection service providers are all in conflict over taking over the primary waste collection business (Chambugangh, 2023). It shows how powerful actors influence waste business and complex multi-scalar relationships of power that shape urban political ecologies.

To organize and reduce haphazard situations, city authorities introduced a tendering process to select PCSPs in every ward from 2022. One of the academic respondents mentioned that "through tendering government parties are interested in involving local political people in PCSPs and city authorities want to earn money from PCSPs for collecting waste in specific wards. In every ward, local influential political people are kept in the loop by the political leaders through waste business." Without the councilor's approval, no one can participate in tendering. Some primary waste collection service providers involved in primary waste collection were not recommended by councilors to submit tender applications. The councilor suggested candidates who were relatives or friends. This has led to frustration among existing primary waste collection service providers and accusations of corruption and nepotism (Chambugangh, 2023).

City corporation inspectors supervise PCSP's performance in the wards. PCSPs do not provide services to slums/informal settlements because slum dwellers cannot afford PCSP's monthly charges. NGO's provide waste collection services in some slums/informal settlements with financial assistance from donor agencies. In general, informal settlements and slum areas, waste is dumped at nearby points, and city vehicles transport it to landfills twice or thrice a week.



In Dhaka, MSW is collected without being separated by households which is very common in Asian countries (Dickella Gamaralalage et al., 2022). During the primary waste collection from door-to-door, primary collection service providers sort recyclable waste at collection rickshaw-vans and transfer stations (secondary transfer stations/containers/dustbins/open places) (Figure 1). They sort different types of recyclable waste such as plastic, paper, glass, metal, etc. They store them in different bags in their collection rickshaw-vans. PCSPs hire one waste collector for each rickshaw-van, but one or two others assist them in collecting household waste. One waste collector gets a monthly salary around \$70 to \$75 (\$ 1 = 100 taka) from PCSPs, but the rest of the people maintain their livelihood by selling recyclable materials which they collect during household MSW collections. The PCSP allows their workers to profit 100% from recyclable scrap sales as an incentive to collect more waste. They sell a variety of recyclable materials at various local recycling shops such as paper, metal, and plastic shops. Their daily earnings are approximately \$1.0–\$1.5. These recycling shops are common in middle-income and low-income neighborhoods, but rare in high-income neighborhoods. Waste collectors are mostly uneducated, children, and ultra-poor women. Child labor is widely used in primary waste collection to maximize profit by paying insufficient wages to children. Moreover, recycling buyers buy recyclable and reusable products from house to house and sell them to recycling shops. Recycling waste is collected by reclaimers/waste pickers from secondary transfer stations (STSs)/containers/open spaces, and landfills (Figure 1).

The metabolization of MSW in Dhaka can be viewed as a single production network based on two interrelated waste flows: (1) disposal of waste (as a service) by formal and informal systems and (2) recycling of waste by informal systems (see Velis et al., 2012). In the formal system (dark gray in Figure 1), city employees collect waste from STSs/containers/dustbins/open spaces, transport and dispose of it in landfills. Informal waste workers collect waste from households and dump it in the STSs/containers/dustbins/open spaces (light gray in Figure 1). Resource recovery facilities are not available in the formal system. The informal sector (light gray in Figure 1) is entirely responsible for resource recovery. Informal waste workers, waste pickers collect recyclable waste (paper, metal, plastic, glass etc.) from households, STSs/containers/dustbins/open places and recyclables buyers buy recyclable waste from households. They sell recyclable waste in local recyclable shops. Recyclable shops sell recyclable and reusable waste to wholesalers. The recycling wholesalers/dealer wash, dry and sort recyclable items and trade them to Dhaka's recycling products manufacturers. These informal waste workers, waste pickers, recyclables buyers, wholesalers, and recycling manufacturers all play a crucial role in reducing waste volume, creating the waste value chain and promoting circular economies in Dhaka.

Toward the end of 2019, the local government in Dhaka stressed the importance of improving waste disposal and reducing waste volumes in landfills by using centralized mechanical solutions (incineration), as Dhaka's landfills are almost full, and land scarcity and high prices make it hard to acquire new ones. Several countries in the GS are considering

waste incineration as a waste management strategy, including Brazil (Gutberlet et al., 2020) and South Africa (Dlamini et al., 2019). Landfill waste pick-up was restricted by city authorities due to an energy generation (incineration) project that began construction in 2022 and will operate by 2024. Waste pickers are shifting their activities from landfills to collecting recyclable scrap from STSs/demountable containers/dustbins, and mostly open dumps. Most of the recyclable scrap is segregated during primary collection, and approximately more than 120,000 informal workers are involved in the process (BIGD, 2015).

What is the city authority trying to do? Waste to energy generation through incineration

Every day, more than 6,500 tons of MSW are generated in Dhaka. According to the Dhaka North City Corporation (DNCC) Mayor, waste generation doubles every 5 years in DNCC. According to one of the academic respondents, *“the upgrading of overloaded landfills or constructing new ones is difficult in Dhaka due to land scarcity and high prices. International donor agencies are no longer interested in landfill development without resource recovery. This led to local governments and city authorities arguing in recent years that landfilling could not handle these enormous amounts of waste without resource recovery.”* In order to attract international investors to invest in MSW management, governments need to take action on resource recovery and promote circular economy (Dhaka Tribune, 2020).

Incineration can reduce MSW volumes, solving the energy deficit (Jeswani and Azapagic, 2016; Yesilnacar et al., 2012). Bangladesh's economy is heavily dependent on imported fuels, which pose a serious energy crisis. Currently, the country is trying to shift away from fossil fuel-intensive electricity generation in accordance with global decarbonization initiatives (Debnath et al., 2023). Waste to energy is a renewable energy source that efficiently converts discarded MSW into electricity and steam, resulting in a more sustainable alternative to landfills that reduces land requirements and waste volume (Hou et al., 2019). Additionally, the large volume of waste-based commodities in metropolises attracts international investors for waste-to-energy production (Khan et al., 2022). MSW incineration is the preferred MSW solution because it requires a small installation area, high throughput, and reduces waste volume significantly (Lu et al., 2017; Wang et al., 2018). The by-product of MSW combustion, ash, can be used to make cement, building materials, and other goods (Xuan et al., 2018). Bangladesh governments are recognizing that converting waste into energy by incineration is a promising solution to the energy crisis and to promote eco-friendly waste management (Ferdoush et al., 2023).

The local government agreed to implement waste incineration technology in Dhaka based on the government's vision and plan for urban development and lobbying by many foreign waste-to-energy companies. Using technical and financial investments from foreign companies, the local government is focusing on improving waste disposal and reducing landfill volume in Dhaka through centralized mechanical solutions (incineration). The local government signed an agreement with a Chinese company in 2021 to start a waste-to-energy generation (incineration) project at *Amin Bazar* landfill in Dhaka North City Corporation (DNCC) which will come into operation at the end of 2024. The local government also plans to implement waste incineration in Dhaka South City Corporation (DSCC) and other cities in Bangladesh very soon. The city authorities believe that by

generating waste-to-energy, they can manage large volumes of waste and are therefore not interested in separating waste at source level and resource recovery (e.g., recycling and composting). One of the waste policy expert respondents said international investors prefer waste-to-energy projects instead of composting in Dhaka, and the former government wanted to generate electricity without investing money.

In light of the economic and environmental benefits of informal waste workers and scrap recycling that can promote a circular economy and reduces waste volume, why does local government pursue an expensive incineration method that would effectively displace them, even when it is unlikely to succeed on its own terms? There are several possible explanations for the question. One of the reasons incineration is appealing to cities is that they face a scarcity of land and difficulty in acquiring it, while existing dump sites are overflowing. Incineration technology can help authorities avoid the thorny issue of acquiring land by reducing the geographical footprint of waste disposal.

Secondly, city authorities lack institutional and financial capacity to collect segregated waste. Source segregation is perceived as an additional burden for city authorities because they have no reliable separate waste collection systems. The Chief waste management officer of Dhaka South City Corporation (DSCC) said that *“DoE and local community try to segregate waste at household level, but DSCC refuses to collect waste separately because of lack of infrastructure, manpower and finance. The DoE recently suspended a \$200 million World Bank project for source segregation for effective waste management in Dhaka due to DNCC's refusal to participate.”* The chief waste management officer of Dhaka North City Corporation (DNCC) said that *“we will need to supply 3,000 tons of mixed waste to CEMS for energy generation every day. We have no choice but to think about source segregation or composting. Our solid waste will completely transform from waste to energy within a couple of years.”*

Dhaka's primary waste collectors are unwilling to collect segregated waste because it may reduce their extra income from the sale of recyclable materials, and lack of infrastructural capacity. One international NGO respondent mentioned *“primary waste collectors refused to collect segregated waste when they provided different bins at households to facilitate source segregation of waste in their project areas. Primary waste collectors separate recyclable waste from non-segregated waste collection and store it in different bags in their collection vans. They earn extra money by selling these recyclable scraps. When the household began to segregate waste, household sold the recyclable scrap directly to the recycling buyer (feriwalla). Primary waste collectors do not get recyclables during primary waste collection due to source segregation at household level, which reduced their income and some of them quit their job. Their earnings were lower than in other non-project areas (where source separation is not practiced). We need to increase the salary of primary waste collectors in project area.”* This illustrates how significant it is to incentivize primary waste collectors in project areas that encourage source segregation. Primary waste collectors may not collect waste from households without these incentives, resulting in delays and decreased efficiency in waste collection (see Cornea et al., 2017).

Thirdly, high-level politicians have emphasized the mechanization of garbage systems to support modernist ideas of national development by using images of incineration technologies. According to one of the academic respondents, *“big projects attract voters because they are visible to society. Political leaders attract people by taking on big projects, which also applies to waste management in Dhaka.”* According to a

feasibility study on waste to energy conversion in six municipalities of Bangladesh, anaerobic digestion and gasification are more eco-friendly than incineration (United Nations Development Programme, 2018). High-level government officials ignored local waste experts and environmentalists' opinions about mixed waste incineration and implemented it at *Amin Bazar* landfill without conducting any feasibility studies (Dhaka Tribune, 2023). Waste research experts and environmentalists stated that the *Amin Bazar* incinerator would create more problems than solutions. The incinerator project would produce 300 metric tons of ash daily and require a landfill site to dispose of this ash. If dumped, heavy metals would penetrate groundwater, contaminate soil and pollute the environment (Dhaka Tribune, 2023). Burning waste is unwise from an environmental perspective because waste is wealth, not waste (Chowdhury, 2024).

Furthermore, international investors are interested in investing in technology and finance for incineration. In contrast, local investors seek subsidies (land, loans, tax exemptions) for recycling/composting/biogas and so forth whereas governments do not need subsidies for incineration. The Dhaka North City Corporation (DNCC) provided land for the incineration project and will supply 3,000 tons of mixed waste per day free of charge. The Bangladesh Power Development Board will purchase electricity from the incineration project for \$0.21 (21 taka) per unit, while consumers currently pay around \$0.07 (between 7 and 7.5 taka) per unit of electricity. Whether a project for incineration is financially viable is still being debated.

In addition, city authorities believe composting and recycling on a small scale are not effective to manage city's large volumes of waste. Moreover, quality compost depends on the source segregation of organic waste. Compost requires a great deal of land and subsidies, which are quite difficult for city authorities to provide. The local government desire to find land-scarce solutions for garbage disposal and receive monetary benefits from massive infrastructure development motivates centralized mechanical solutions such as incineration. Consequently, local bureaucrats and politicians are eager to utilize these technologies since they allow energy to be created from garbage, thereby reducing garbage's stigma and maximizing its value. Finally, a centralized mechanical system may be easier to manage for Dhaka's dense bureaucracy, compared to overseeing a large, dispersed workforce.

In Dhaka, new policy interventions (centralized mechanical solution) have created conflicting logical and rational arguments about waste flows, leading to a metabolic configuration which involves consolidating waste throughput into a formal value chain, resulting in waste-to-energy generation. Waste collection and processing have therefore become commodity frontiers at doorsteps, transfer stations, and landfills. Dhaka's commodity frontier indicates waste conflicts will be over value creation, enhancement, and capture, as commodity frontiers historically have been located in the hinterlands where resources are extracted.

How could waste flows become sustainable through the valuing of waste infrastructure in Dhaka and beyond

Waste flow and who benefits from it have never been straightforward answer (Millington et al., 2022). A recent attempt to recognize and capture waste value in Dhaka has resulted in new flows

and conflict. Dhaka's waste flows consist of two interrelated flows: waste disposal (a service) and waste recycling. Dhaka's current waste government focuses on waste disposal (a service) and reducing landfill volume through centralized mechanical solutions (incineration). Local government and city authorities have paid little attention on reduce waste volume by source segregation and recycling. Due to limited financial and institutional capacities and full reliance on primary waste collection by the informal sector, waste-to-energy generation and sustainable MSW management are quite challenging in GS cities like Dhaka.

Dhaka benefits from an informal primary waste collection and recycling system. This unofficially handles approximately one fourth of MSW. Dhaka's waste management infrastructure is organized and provides livelihoods for thousands of urban poor, as well as eliminating waste volumes for environmental sustainability. Dhaka's primary waste collection and recycling is entirely done by the informal sector, but other GS cities have integrated formal and informal sectors that are involved in waste collection, recycling and waste management (see Bjerkli, 2015; Demaria and Schindler, 2016; Muheirwe et al., 2023). In accordance with the Solid Waste Management Handling Rule 2021, Dhaka's waste government is required to involve local stakeholders in collection, transportation and resource recovery based on city dynamics. City authorities could prioritize source separation at the household level to ensure efficient handling and processing. This would boost resource recovery, encourage reuse and recycling, and reduce operational costs.

Source segregation of MSW requires strong political commitment (Dickella Gamaralalage et al., 2022). Achieving source separation at the household level requires raising awareness about hygienic and clean-living conditions, providing economic incentives and instruments to motivate citizens to separate waste efficiently and effectively, and actively involving all stakeholders. Biodegradable waste needs to be collected separately, effective business models and domestic markets need to be developed to ensure waste is collected and efficiently used, as well as a system governed by bylaws enforced with strict penalties for non-compliance. Solutions for source separation must be tailored to each city's specific circumstances, and strong political will and leadership are essential. Cornea et al. (2017) demonstrate that source segregation at the community reveals complex ways in which power is enacted in the everyday, and how discursive strategies aimed at creating environmental, hygienic, and moral subjects affect behavior indirectly. Waste labor incentives and differentiated user fees may contribute to the source segregation of waste in small and large metropolises, as in Dhaka and other cities too.

Waste incineration has re-emerged in GS cities as waste-to-energy generation (Demaria and Schindler, 2016; Platt, 2004). In other GS countries like India, informal collectors and scrap recyclers expressed concern over the threat to their livelihoods caused by waste incineration (Chaturvedi and Gidwani, 2011; Demaria and Schindler, 2016). Incinerators would create a demand for materials which could directly affect recyclers' access to materials (Kornberg, 2020), which could also occur in Dhaka if city authorities do not properly recognize the existing waste infrastructures and informal recycling sector. Local government entities want a modern, high-tech solid waste system that may exclude informal actors. Due to this, power is viewed as the ability to decide how waste flows should be conducted. Actors in the informal recycling sector are unable to participate in decisions that affect them and instead must adapt to reality. Decisions are motivated and justified by cultural factors such as reputation, stigma, and

development. In this way, incinerators facilitate capital accumulation by recirculating material flows (Gidwani, 2013; [Gidwani and Reddy, 2011](#)) since they manage huge volumes of waste and generate electricity. Incineration may not be cost-effective or environmentally sustainable in Dhaka because of the volume of organic waste and its low calorific value ([United Nations Development Programme, 2018](#)). Sustainable resource recovery depends on city dynamics and the active participation of local stakeholders.

Dhaka's waste government could leverage existing infrastructure to promote interrelated waste flows (service and recycling) through an integrated formal and informal governance approach. Therefore, city authorities might be more willing to promote informal recyclers' low-technology approach to waste management if they are seen as more environmentally responsible than centralized solutions, such as signaling a more sustainable approach to waste management. In Dhaka, waste fuels capitalist growth and national prowess. This sheds light on how postcolonial concerns with international reputation influence transforming institutional landscapes and knowledge regimes, influencing governmental policy. While technically engineered large-scale solutions are viewed as more advanced and even environmentally friendly, they may have negative effects on the sustainability of megacities across the GS. Further research is required to determine sustainable resource recovery based on the socio-material dynamic of waste in GS megacities.

Conclusion

Waste is increasingly being viewed as a resource by government actors, community organizations, and urban citizens in the GS. Trash is cash and its value can be created (by labor), enhanced (by technology, method, or organizational structure) and captured by strategic actors. In the process of changing a mode of value creation, conflicts arise over how waste is created, enhanced, and captured ([Schindler and Demaria, 2019](#)).

Through the political ecology approach, we attempt to understand why the government is less interested in implementing the 3R strategy (reduce, reuse, recycle) by segregating waste at source level through the use of existing waste infrastructure rather than promoting centralized mechanical solutions. Due to lack of institutional and financial capacity the city authorities are not interested in source segregation. Moreover, the government needs to give incentives to encourage source segregation at the household level and primary waste collection. City authorities are not interested in providing incentives for source separation or waste recycling due to lack of financial capacity and political risk. However, source segregation is essential for reducing waste volume and promoting sustainable resource recovery. Despite informal waste workers and scrap recyclers challenging the introduction of centralized mechanical solutions, incineration remains a powerful influence on urban environmental trends because of its governance logic.

A political ecology approach can be useful to understand how material flow is affected by the government's decision to implement a centralized mechanical solution (incineration). It consolidates waste throughput into a single formal value chain that ends at a waste-to-energy facility, negatively impacting the informal sectors. Using a political ecology perspective, we examined which socio-political factors influence governments to take a centralized mechanical

solution (incineration), as well as why governments are less interested in recycling and source segregation. It is likely that the new waste policy intervention (incineration) in Dhaka will lead to a conflict over resources. We also examine in what ways these policy interventions may affect existing waste infrastructure (primary waste collection efficiency, recycling facilities, livelihoods and social relations of informal waste workers) and how an integrated formal and informal approach can leverage existing infrastructure for the promotion of interconnected waste flows (recycling and disposal).

GS's waste governance regime needs to coordinate its efforts to reduce waste by source segregation, community-based waste recycling programs, and partnerships to improve waste governance ([Stokes, 2020](#)). For sustainable waste management, Dhaka needs to focus on source segregation and promote recycling by reconfiguring existing waste infrastructures and change in institutions (e.g., waste ownership) and/or promote MSW technology (e.g., incinerators) by integration formal and informal approaches.

Collectively, the socio-ecological metabolic flow of waste illustrates the contradictory and conflicting mechanisms that shape processes for transforming waste circulation in a sustainable and socially equitable way. In sum, this paper provides an evidence-based understanding of political ecology's influence on MSW management practices, policy intervention and decision-making processes. Also, it provides insight into how to support effective 3R strategy implementation, facilitate policymaking, and contribute to additional knowledge for other megacities in the GS that face similar challenges. Based on city dynamics, further research is required to determine sustainable resource recovery at the micro-level in densely populated megacities like Dhaka.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Author contributions

SA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. JE: Supervision, Writing – review & editing. NM: Supervision, Writing – review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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