

Possible Causes of River Waste in Southeast Asian Cities: A Literature Review

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Abstract

Ever-growing Southeast Asian cities are facing resilience and sustainability issues with regard to their rivers. While the impact of municipal solid waste disposed of in rivers (river waste) is highly discussed, the causes of river waste need more exposure. This paper aims to clarify the current understanding of the causes of river waste in Southeast Asian cities by undertaking a review of the literature on river waste and theories on waste disposal behavior. We analyze the causes of river waste in terms of its sources, as in the actors, and factors, as in reasons for behaviors. We elaborate on three types of causal factors: physical, psychological and governance. Our results show that most of the causes of river waste in Southeast Asian cities from the physical, psychological and governance perspectives intersect at issues related to informal settlements, which have inadequate MSW services, and a lack of risk perception as the most frequently reported causes, while other aspects are still rarely brought up in the literature.

Key words: cause, community, MSW, river waste, source, Southeast Asia

1. Introduction

Rapid urbanization is posing challenges related to resilience and sustainability in Southeast Asian (SEA) cities (Sharif, 2021). One issue that has been commonly reported is the disposal of municipal solid waste (MSW) in rivers (river waste, hereinafter). River waste is known to cause environmental pollution (Nguyen *et al.*, 2020), increase the risk of flooding (Iglesias & Yu, 2008; Vollmer & Grêt-Regamey, 2013) and end up as marine plastics (Windsor *et al.*, 2019). In fact, empirical evidence from laboratory experiments and field surveys shows that plastics and timber end up clogging trash racks installed in rivers and increase flood risks (Honihg *et al.*, 2020; Schmocker & Hager, 2013). To reduce river waste, a comprehensive understanding of how and why MSW ends up in rivers is essential. Although some literature sheds light on the causes of river waste, there has been no attempt to synthesize that knowledge to date. This paper aims to clarify the current understanding of the potential causes of river waste in SEA cities through a review of the literature regarding river waste and theories on MSW disposal behavior.

2. Methods

2.1 Sources and Factors behind River Waste

We will discuss the causes of river waste from two perspectives, namely, sources and factors. By sources, we refer to the “who” aspect of the cause. Anthropogenic sources of river waste can be households, businesses (including shops, markets and restaurants), construction and demolition work, agriculture and more. In addition, solid waste from natural sources, particularly vegetative waste, can also enter rivers.

By factors, we refer to the “why” aspect of the cause. Raghu and Rodrigues (2020) reviewed the factors behind MSW management behavior and identified 34 psychological factors (e.g., attitude, intention, norms), eight situational factors (e.g., opportunities, costs), five community factors (e.g., community groups, support) and five demographic factors (e.g., age, gender). From a SEA context, Yukalang *et al.* (2017) explored barriers to appropriate MSW management in Thailand and summarized them into technical and physical factors (e.g., lack of MSW collection points and capacities), organizational factors (e.g., inadequate planning and policies), social-cultural factors (e.g., lack of participation

and cooperation), financial factors (e.g., collection fees, funding) and legal and political factors (e.g., weak legislation).

While these classifications are detailed and context-specific, we propose consolidating the factors into three broader categories—physical factors, psychological factors and governance factors—by referring to the integrated sustainable waste management framework used in the Global Waste Management Outlook (Wilson *et al.*, 2015). This approach is based on the following rationale:

1. Physical factors: This category encompasses technical and situational aspects (e.g., MSW collection points, capacities and opportunities) that directly relate to the tangible and infrastructural aspects of MSW management.
2. Psychological factors: This category includes individual and community-level psychological factors such as attitudes, norms, intentions and community support. Additionally, it integrates social-cultural factors, recognizing that cultural norms, social participation and cooperation significantly influence MSW management behavior.
3. Governance factors: This category merges organizational, financial, legal, political, social and demographic aspects, reflecting the overarching influence of policy, legislation and resource allocation on MSW management.

By consolidating these factors into three categories, we aim to provide a comprehensive, manageable framework that captures the essence of the diverse factors identified in the literature. This categorization facilitates a more straightforward analysis and discussion while maintaining the depth and breadth of the identified causal factors. We believe this approach effectively integrates detailed classifications from existing studies into a cohesive structure that enhances understanding and application in MSW management research.

2.2 Literature Review Methods

We summarized the causes of river waste by reviewing the existing literature. Literature (journal articles and proceedings) related to river waste issues in SEA cities was collected using a scientific literature search engine, with conditions that are summarized in Table 1. The initial search extracted 35 papers focusing on

six different countries. We read the abstracts and excluded 24 papers that were irrelevant to MSW or did not focus on the source or management of river waste. We additionally reviewed 13 papers that were cited in those papers. This resulted in a total of 24 papers that discussed the causes of river waste in SEA cities. The full texts of the extracted papers were reviewed, and the sources and factors of river waste discussed in those papers were organized.

3. Causes of River Waste in Selected SEA Countries

3.1 Sources of River Waste

Sources of river waste can be traced through two distinct waste disposal pathways: intentional, where MSW is discharged through proper or improper disposal, and unintentional, stemming from accidental spills and drifts (Fig. 1). One common source of river waste in SEA cities is riverside communities that consist of formal settlers in registered houses and informal settlers in, mostly, non-registered ones (Embi, 2005; Iglesias & Yu, 2008; Neolaka, 2013). Informal settlers are commonly poor, marginalized groups that have occupied riverbanks and other disputed land for generations, or migrants from other locations seeking opportunities in the city (Neolaka, 2013; Winayanti & Lang, 2004). Furthermore, in Bangkok, it is a common practice to have the riverside community properly dispose of their MSW to be collected by municipal collection boats from collection points along the banks of rivers (Tajima *et al.*, 2019). Both official (Tajima *et al.*, 2019) and unofficial (Iglesias & Yu, 2008) practices of establishing collection points along riverbanks have been widely reported. Even if proper disposal has been implemented, some factors like natural forces and human error can lead to the unintentional generation of river waste, like spills into rivers (Iglesias & Yu, 2008; Tajima *et al.*, 2019) or waste drifting from land into rivers through the actions of wind and rain (Widjaja *et al.*, 2020).

Improper disposal by riverside communities also occurs, but the extent to which direct dumping by riverside communities along rivers should be blamed for river waste seems to depend on location, and further study is required to clarify the connection. For example, while Vollmer and Grêt-Regamey (2013) reported that nearly

Table 1 Search conditions.

Date of search	19–20 Oct. 2023
Database	Web of Science core collection
Search area	Title, keywords, abstract
Search query	TS = ((river OR canal) AND (waste OR garbage OR trash) AND flood AND [country name]) *country name: Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Thailand, Vietnam

Note: “TS” stands for “topic search,” i.e., a search for terms within titles, abstracts, major concepts, and various data tables defined by the Web of Science.

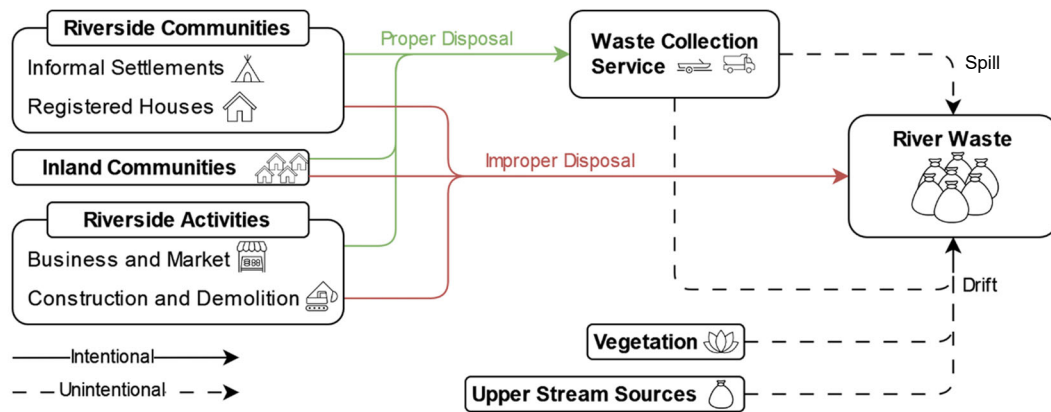


Fig. 1 Sources of river waste in Southeast Asian countries.

50% of the households in their sample region in Jakarta disposed of MSW into rivers, Tajima *et al.* (2018) reported that 12% of the sample households in the community they investigated in Bangkok did that. Additionally, Vollmer and Grêt-Regamey (2013) found that even residents living further inland with access to rivers also generated river waste.

Other sources of river waste can be inferred from river waste composition. Ishigaki *et al.* (2018) discussed the sources of river waste from a canal in Bangkok based on its composition. Their composition analysis suggested that deteriorated houses and construction works generated timbers. This statement is backed up by MONRE (2017), cited by Hoang *et al.*, (2020), who reported that non-valuable construction and demolition (C&D) waste in developing SEA countries commonly ended up being illegally dumped, including in water bodies. One analysis also showed that vegetation itself generated branches, leaves and water hyacinths, a free-floating invasive aquatic plant notorious in many tropical and subtropical countries as a source of flood risks and other environmental impacts (Derseh *et al.*, 2019). Vegetation along riverbanks can trap waste, which may eventually drift into the river as a result of natural processes. Additionally, waste drifting from upper stream sources is considered a significant contributor to river waste through unintentional waste disposal pathways (Van Emmerik *et al.*, 2023; Widjaja *et al.*, 2020).

3.2 Causes of River Waste

Behind the sources of river waste and the two waste disposal pathways illustrated in Fig. 1, the causes of river waste in SEA cities involve a complex interplay of physical, psychological and governance-related factors, summarized in Table 2. The physical causes involve practical challenges in MSW management, while psychological factors encompass individual attitudes and behaviors. Governance-related issues relate to broader societal structures. This discussion examines these three categories, offering an overview of the factors contributing to river waste issues.

Among the various factors, physical aspects are the most frequently reported causes of river waste. Reports from Indonesia (Muhamad & Tajima, 2023b; Vollmer & Grêt-Regamey, 2013) and the Philippines (Iglesias & Yu, 2008) indicate that these riverside communities are facing a lack of access to MSW collection services, which are reported to be irregular, inefficient (Iglesias & Yu, 2008), deficient in coverage (Iglesias & Yu, 2008; Vollmer & Grêt-Regamey, 2013) or limited (Muhamad & Tajima, 2023b). The community expresses a willingness to refrain from discarding trash into the river if adequate MSW services are provided (Neolaka, 2013). Besides direct dumping, another significant cause of river waste is unintentional spills of collected household waste (Tajima *et al.*, 2019). When MSW collection points are already positioned along rivers, they should be regularly emptied, otherwise, the waste might fall or spill into the river as a result of natural phenomena or human error (Tajima *et al.*, 2019). Tajima *et al.* (2019) pointed out that many of these collection points had excess waste bags placed outside the bins, indicating a lack of collection capacity. In contrast, most settlements lacking any MSW collection points nearby resort to littering into the river (Neolaka, 2013). This underscores proximity to the river as one major cause that in itself might be the result of a lack of adequate MSW services. Vollmer & Grêt-Regamey (2013) assumed that in zones within a kilometer of a riverside, it is common practice to dispose of waste via the river, relying on downstream bar screens to handle it (Muhamad & Tajima, 2023a). This practice intensifies during and after floods when bulky waste is generated (Muhamad & Tajima, 2023a) and MSW collection schedules are disrupted. River waste is not confined to specific areas or communities; rather, upper streams of rivers can serve as sources (Van Emmerik *et al.*, 2023) and exacerbate the impact on the downstream areas of rivers (Widjaja *et al.*, 2020). Additionally, river waste can originate from various riverside activities. These include littering by inland communities or passersby, which can be transported by wind and rain (Sulaeman *et al.*, 2019; Vollmer and Grêt-Regamey, 2013; Widjaja *et al.*, 2020);

Table 2 Causes of river waste in Southeast Asian countries.

Type of causal factors	Source of waste	Causal factors	Countries	Sources
Physical	Riverside communities	Lack of access to MSW collection services	Indonesia	[1], [2], [3]
		Collection points along rivers (spills)	Philippines	[4]
			Thailand	[5]
			Philippines	[4]
	Lack of collection capacity	Thailand	[5]	
	Proximity to river (easy access to improper disposal)	Indonesia	[2], [6]	
	Upper stream	Downstream impact	Indonesia	[7]
			Thailand	[8]
	Inland community	Improper disposal (littering)	Indonesia	[2], [9]
	Riverside activity	Surface drift	Indonesia	[7]
			Indonesia	[10]
			Thailand	[11]
Vietnam			[12]	
Psychological	Riverside communities	Behavioral control	Indonesia	[7]
		Social norms	Thailand	[13], [14]
		Risk perception	Indonesia	[1], [15], [7], [3]
	Environmental appreciation	Thailand	[14]	
		Indonesia	[2]	
		Thailand	[14]	
Governance	Riverside communities	Formal recognition (leading to public service provision)	Indonesia	[16]
		Non-payment of taxes (leading to no access to public services)	Philippines	[17]
		Malaysia	[18]	
		Low income	Indonesia	[2]

[1] Neolaka (2013), [2] Vollmer and Grêt-Regamey (2013), [3] Muhamad and Tajima (2023a), [4] Iglesias and Yu (2008), [5] Tajima *et al.* (2019), [6] Muhamad and Tajima (2023b), [7] Widjaja *et al.* (2020), [8] Van Emmerik *et al.* (2023), [9] Sulaeman *et al.* (2019), [10] Cordova and Nurhati (2019), [11] Ishigaki *et al.* (2018), [12] MONRE (2017) cited by Hoang *et al.* (2020), [13] Marks and Thomalla (2017), [14] Tajima *et al.* (2018), [15] Marfai *et al.* (2015), [16] Winayanti and Lang (2004), [17] Purwar *et al.* (2020), [18] Embi (2005)

or mishandling of solid waste generated by businesses or markets (Cordova & Nurhati, 2019) or waste from C&D projects (Hoang *et al.*, 2020; Ishigaki *et al.*, 2018).

In conjunction with physical aspects, psychological factors play a significant role in the causes of river waste in SEA cities. The issue is deeply rooted in the riverside communities, where rivers have been used for garbage disposal over many generations (Neolaka, 2013) and this practice has become a social norm (Marks & Thomalla, 2017; Tajima *et al.*, 2018). Factors behind the intentions of the behavior of current and future generations include descriptive norms (perceptions of which behaviors are typically performed) and injunctive norms (perceptions of which behaviors are typically approved or disapproved) (Cialdini, 2003). These norms normalize actions (Widjaja *et al.*, 2020), obscuring communities' risk perception of riverine issues (Marfai *et al.*, 2015; Muhamad & Tajima, 2023a; Neolaka, 2013; Widjaja *et al.*, 2020). Scientific evidence supports a correlation between higher risk perception and a reduced likelihood of MSW disposal into canals (Tajima *et al.*, 2018), emphasizing the importance of environmental appreciation in river waste disposal behavior (Tajima *et al.*, 2018; Vollmer & Grêt-Regamey, 2013). Fostering a heightened awareness of the environmental consequences and cultivating a collective

appreciation of the importance of preserving our rivers may serve as pivotal elements in addressing and mitigating the persistent challenge of river waste in SEA cities.

The perspective of riverside communities, defending their actions by demanding better MSW services from the government, has been acknowledged. There is, however, an additional influential aspect affecting MSW pollution in rivers across SEA cities: the governance-related dimension. Illegal settlers are prevalent along riverbanks, particularly in urban areas, with limited provision of basic sanitation services because of the absence of formal recognition from the government, as in Indonesia (Winayanti & Lang, 2004) and the Philippines (Purwar *et al.*, 2020). The Malaysian government attributes the lack of MSW services for such settlers to their non-fulfillment of tax payments (Embi, 2005). Apart from the necessity of having adequate MSW services, inhabiting the riverside may be the most viable settlement solution for some, given their dire financial circumstances (Neolaka, 2013). Financial constraints may force individuals to resort to dumping MSW into the river to avoid community MSW collection fees (Vollmer & Grêt-Regamey, 2013). This multifaceted perspective calls for comprehensive governance solutions to address these intertwined issues

in effectively tackling MSW pollution in rivers.

To tackle the river waste problem in SEA cities, practical solutions involve implementing effective MSW collection services for riverside communities, raising public awareness about responsible MSW disposal and fostering environmental responsibility. Meanwhile, governance changes are crucial to addressing the root causes, such as the lack of formal recognition for settlements along riversides. Combining these efforts in a holistic approach is essential to mitigating the persistent issue of river waste.

4. Discussion on Future Study and Policy Intervention

Based on the current understanding of the causes of river waste, we can point out five approaches to its reduction. Firstly, appropriate processes for riverside community redevelopment need to be clarified. Redevelopment and eviction of informal settlements along rivers have been implemented widely in SEA cities (Iglesias & Yu, 2008; Tajima *et al.*, 2018; Winayanti & Lang, 2004). For example, in Marikina, resettlement areas were made available with improved utilities, infrastructure, MSW collection and access to emergency services, which had not been available on the riverbanks where the settlers resided previously (Iglesias & Yu, 2008). Although this can potentially reduce river waste from direct and indirect disposal from riverside communities (Fig. 1), there are also challenges. For example, a study on the relocation of informal settlements in Jakarta from 2014 to 2016 showed that relocation led to decreased welfare and social capital among the displaced (Ichwatus Sholihah & Shaojun, 2018). As social capital is a key element of appropriate MSW management in communities, this may lead to other MSW management issues such as improper disaster waste management (Tajima *et al.*, 2023). Another challenge is speed of implementation. Redevelopment projects may stall when agreements on compensation for relocation cannot be reached with the residents (Neolaka, 2013). Considering that the demolition of informal settlements is a potential source of river waste (Fig. 1), it is also crucial to ensure that no C&D waste is dumped into rivers during redevelopment work. The processes and conditions of redevelopment that effectively involve riverside residents of informal and formal settlements, local and national governments, redevelopment companies and other stakeholders need to be further clarified.

A second potential approach is to clean up and beautify the local environment through the efforts of community members themselves. This is based on the finding of Tajima *et al.* (2018) that residents of riverside communities that value their living environment (including the river nearby) tend to discard trash less in waterways. This is consistent with the well-known study

of Cialdini and colleagues that people tend to litter consistently less in cleaner environments even when observing someone littering in front of them, due to the descriptive norm salience procedure (Reno *et al.*, 1993). Community activities for beautifying the local environment have been reported in Bangkok (Tajima *et al.*, 2019) and Jakarta (Winayanti & Lang, 2004). Winayanti and Lang (2004) go further to argue that although many local authorities believe that riverside communities destroy the environment, past examples of community efforts demonstrate that those communities have the potential to act as an environmental guard.

A third approach is to improve MSW collection services. To enhance MSW collection services in SEA cities, particularly within riverside communities, a comprehensive strategy is needed. Local governments must actively enforce rules and regulations in these communities, with penalties for non-compliance (Iglesias & Yu, 2008). A community-driven approach, unlimited by formal government recognition but supported by it, involves the establishment of waste banks (Iglesias & Yu, 2008; Muhamad *et al.*, 2021). Waste banks engage the public in separating and collecting recyclables, providing incentives such as cash or credit (Muhamad *et al.*, 2020). This approach is beneficial for financially constrained riverside communities, offering an income source while reducing the amount of MSW (Neolaka, 2013; Vollmer & Grêt-Regamey, 2013). By combining regulations with community initiatives like waste banks, SEA cities can make significant progress in enhancing MSW collection services and creating a cleaner, more sustainable environment.

A fourth proposed initiative that merits implementation is the promotion of awareness, recognized for its efficacy in addressing the issue of river waste, along with attitude, sense of environmental responsibility and societal norms (Mudjiardjo *et al.*, 2021). These initiatives should include community engagement programs aimed at informing residents about the environmental consequences of river waste, with an emphasis on proper MSW disposal and recycling practices (Wilson *et al.*, 2015). Raghu and Rodrigues (2020) emphasized the goal of shifting behavior towards eco-friendly practices, highlighting the environmental harm caused by unnecessary MSW discharge and the benefits of adopting greener habits for individuals and the community. Simultaneously, there should be efforts to gain formal recognition of riverside communities by local governments (Winayanti & Lang, 2004), granting access to essential public services such as water and sanitation (Purwar *et al.*, 2020). This formal recognition can pave the way for further improvements, encouraging residents to follow proper MSW management practices. Integrating community-based initiatives with formal recognition and regulatory frameworks offers a comprehensive strategy to prevent river waste and promote sustainability in riverside

communities.

River waste is not stationary; rather it travels further downstream (Pertiwi *et al.*, 2019). This highlights the need for the fifth approach, effective watershed management in both upstream and downstream areas using the right methods and community participation (Mudjiardjo *et al.*, 2021). Any lack of awareness or coordination between related stakeholders in designing the plan might endanger both the environment and the riverside community (Pertiwi *et al.*, 2019). Plans should include strategies for preventing upstream waste, like promoting sustainable practices and MSW reduction. Additionally, the establishment of buffer zones and vegetation along riverbanks can act as natural filters, reducing the inflow and generation of river waste (Widjaja *et al.*, 2020). Integrating these strategies into a comprehensive watershed management approach is crucial for mitigating drifting river waste and ensuring the health of aquatic ecosystems.

5. Conclusions

This study has synthesized existing literature to identify the primary causes behind river waste, categorizing them into physical, psychological and governance-related factors. Our review emphasizes that physical factors are major contributors to river waste. It also clarifies that the most frequently reported cases consist of riverside communities, with inadequate MSW services and a lack of risk perception. Additionally, easy access to a river and a lack of behavior control exacerbate the problem. On the other hand, riverside communities have the highest expectations for government recognition and subsequent improvements in public services.

It is important to note that sources of river waste beyond riverside communities and causes other than those from physical, psychological, and governance perspectives are rarely studied, for instance, industrial waste and debris from upstream factories, as well as marine waste transported upstream through tidal movements and hydrological processes. Further research addressing these overlooked sources and causes is crucial to a comprehensive understanding and effective resolution of these river waste issues.

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