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From source to solution: Efficiency of the litter trap performance on plastic collection in Ngong – Cai Khe canal basin, Can Tho city, Vietnam

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ABSTRACT

This study addresses the rising issue of plastic pollution in surface water body, specifically investigating the efficiency of a passive floating litter trap in collecting plastic waste within the Ngong – Cai Khe canal basin in Can Tho city, Vietnam. A 5.7-meter passive floating litter trap was strategically deployed in the Ngong canal after a bend to maximize capture during low tide, with waste collected, weighed, and categorized over a six-day period from September 30 to October 5, 2024. The trap effectively captured a substantial amount of floating plastic waste, averaging 544.67 pieces and 28.23 kg per day. Non-recyclable items constituted 56% of the collected plastic by weight, predominantly low-value materials like foam and plastic bags. Conversely, recyclable items accounted for 44%, highlighting a notable recovery potential. These findings underscore the litter trap's effectiveness in intercepting plastic waste from surface water body, support a comprehensive approach integrating scaled-up trap deployment, and enhanced community participation for sustainable urban water management.

Keywords: Can Tho city, litter trap, plastic pollution, riverine plastics, waste management.

INTRODUCTION

Plastic pollution is an increasing concern due to its harmful effects on organisms, ecosystems, and human health (Allen et al., 2022; Blettler and Wantzen, 2019; Cássio et al., 2022). A major reason of this issue is the mismanagement of land-based solid waste, which is often transported into marine body through river systems (González-Fernández et al., 2021; Mai et al., 2020). Recent evidence shows that plastic trash does not always reach the sea, but it can accumulate in fluvial habitats, posing significant ecological risks within freshwater systems (Gallitelli et al., 2024; Liro et al., 2020; Tramoy et al., 2020; van Emmerik et al., 2022; Weiss et al., 2021). In freshwater environments, macro-plastics can harm aquatic species through its swallow, stuck, or by being used in nest building or casing (Azevedo-Santos et al., 2021; Battisti et al., 2023; Blettler and Mitchell, 2021).

The issue of plastic littering is prevalent in both developed and developing countries; however, approximately 90 percent of all global plastic pollution in the world's oceans originates from ten rivers, placed in developing countries (Schmidt et al., 2017). In Vietnam – home to over 100 estuaries – plastic pollution in rivers remains a critical environmental challenge. The country is among the five Asian nations with the highest marine plastic litter levels and ranks 17th globally (Vietnam News, 2019). Severe

pollution has been recorded in water bodies such as Ba Lat river, Huong river, and Vu Gia - Thu Bon river, with hundreds of tons of plastic waste remaining uncollected (An, 2019; IUCN, 2021). In the Saigon river basin, plastic comprises 12 to 43% of total waste (Chung et al., 2016), while in the Mekong Delta, up to 30% of waste is unmanaged and discharged directly into water bodies (Hai, 2023).

Can Tho city, located in the Mekong Delta of Vietnam, has an extensive waterway network that supports agriculture, aquaculture, and commerce sectors (MONRE, 2020). However, these sectors discharge plastic wastes into waterways (Thanh et al., 2022). The urban's waste collection rate is under 70%, with remaining waste often dumped into nearby waterways (Hai, 2023). This issue is particularly severe in small alleys and remote areas where waste collection services are lacking. Notably, "waste that is spilled outside is not collected. Therefore, waste is not thoroughly collected, causing pollution and not ensuring urban aesthetics" (People's Committee of Can Tho city, 2022a). A previous survey also found that "single-use plastic products are the most common, accounting for 72% of the waste volume" along riverbanks in Can Tho (Truc, 2022).

Various techniques exist for detecting and quantifying macro-plastics, including visual survey, drone surveys, satellite imagery, GPS/GNSS tracking, etc. Among these, traditional visual and drone deployment were deemed as the most popular approaches by researchers who evaluating plastic litter (Gallitelli et al., 2024). Visual surveys are particularly effective in monitoring the floating debris and vegetation on rivers as used by Tramoy et al. (2020), van Emmerik and Schwarz (2020), and Hurley et al. (2023).

To mitigate river plastic debris before it reaches to larger water bodies, it is essential to improve waste collection service efficiency through integrated keys involving waste recovery, treatment, and recycling (Xuan, 2022). Promoting circular economy models with community participation offers a sustainable approach. Thus, it is necessary to install trash traps in canals to provide a comprehensive understanding of plastic pollution and management practices in Can Tho city. This study investigates the efficiency of a passive floating litter trap in collecting plastic waste within the Ngong – Cai Khe canal basin in Can Tho city, Vietnam, to address the rising issue of plastic pollution in surface water bodies.

METHODOLOGY

Study area

The Ngong – Cai Khe canal basin comprises three main waterways of Cai Khe canal (located in Cai Khe ward), Ngong canal (in An Nghiep ward), and Sao canal (in Phong Dien ward). These canals are among the seven key lakes, canals, and streams within Ninh Kieu district that are protected from land reclamation or land leveling (People's Committee of Can Tho city, 2022b). Play key roles on environmental and infrastructural functions, these waterways contribute to micro-climate regulation, drainage, and flood control in the area. The entire basin stretches approximately 8.1 km, beginning at the Can Tho river near Ninh Kieu quay (belong to Ninh Kieu district) and ending at the Binh Thuy river (belong to Binh Thuy district). The Ngong - Cai Khe canal basin receives water from the Hau river at Ninh Kieu quay. During high tide, water enters the canal network through the Cai Khe sluice gate on the Cai Khe canal, then flows into the Ngong canal. Up to the North, it connects to the Sao canal in Phong Dien district before discharging into the Binh Thuy river. During low tide, the flow is reversed, water moving back toward the Hau river (Figure 1).

The waste status in the water body of study basin indicates significant negative impacts on both urban aesthetics and surface water quality. According to Trinh (2019), waste in the canal is composed of roughly 55% organic waste, 35% recyclable plastic waste, and 15% non-recyclable waste. Besides that, improperly discarded wastes found beneath the Ngong canal bridge, contributes to visual degradation of the urban landscape (Ly, 2023). Additionally, uncontrolled garbage collection points, such as the one located under Binh Thuy 2 bridge, have resulted in severe pollution and unpleasant odors, directly affecting the health and daily lives of nearby community (Quang, 2024).

Monitoring waste collected by litter traps

Litter trap design and installation

The litter trap, constructed from recycled plastic, is a passive floating system designed to capture plastic waste in the river. The device has dimensions of 5.7 meters in length (L), 2.3 meters in width (W), and 2.4 meters in height (H),

Figure 1. Cai Khe – Ngong canal basin

as shown in Figure 2. Positioned at the front of the trap, two floating buoys aid in waste collection: one 30 meters long is placed near the canal bank, while the other 10 meters long is positioned outside the canal. When fully extended, the total width of the two buoys is 15 meters.

In the location where the litter trap is installed, the width of the Ngong canal is approximately 40 meters, meaning the device occupies more than one-third of the canal's width. The trap is placed after a bend in the canal where floating debris is naturally carried by the water flow.

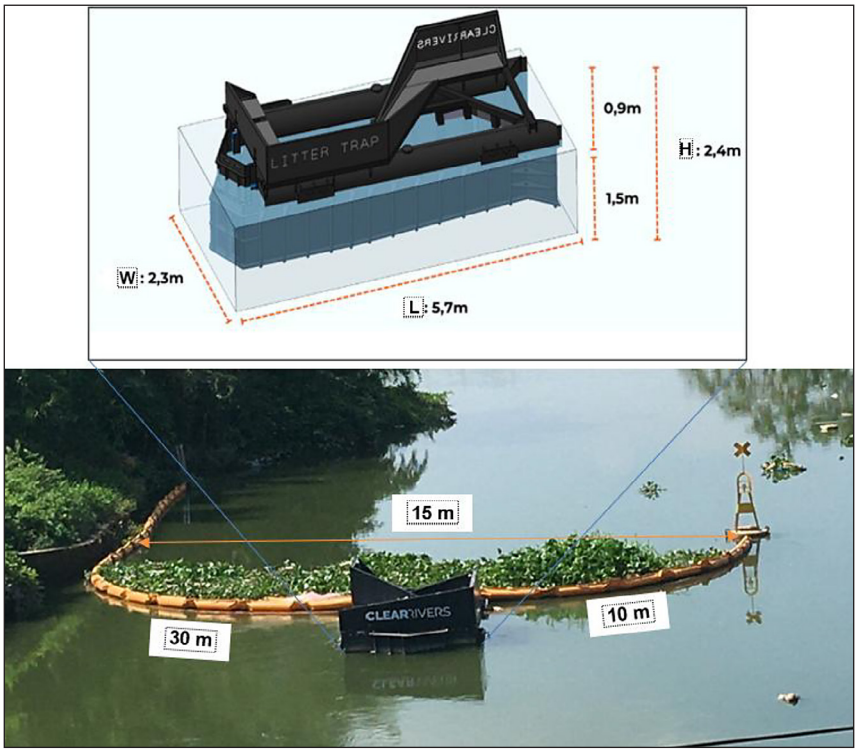

Figure 2. Structure of litter trap – container (upper) and collection part (lower)

The litter trap operates by using a floating pipe in front of it to create a barrier that directs trash along the water flow into the trap, where it is retained. When the trap is full, the collected trash is retrieved, and its quantity and weight are monitored. The waste is then sorted into recyclable and non-recyclable materials. This study only monitors the floating trash which collected during low tide when water flows downstream to Hau river.

Waste monitoring

All plastic waste carried by the ebb tide into the litter trap is collected and placed into storage bags, then classified by type. Items with no value are categorized as "non-recyclable," while other valuable items are classified as "recyclable." Complex items that consist of multiple components and cannot be separated are classified as "other." Each item type is weighed using a digital scale with a minimum scale of 50 grams.

Waste collection were carried out continuously over a 6-day period, from September 30 to October 5, 2024. Samples were collected twice per day during low tide as detailed in Table 1.

The Hau river's average flow velocity ranges from 0.60 to 0.80 meters per second, with peak velocities reaching up to 1.25 meters per second (Tien, 2015). Tidal fluctuations in the Hau river were recorded by the Hydrological Station located in Thoi Binh ward (10°2'0.0"N; 105°47'0.0"E). During the sampling period, the hourly water levels of the Hau river clearly shows a semi-diurnal tidal pattern, characterized by two high tides (flood tides) and two low tides (ebb tides) each day. The tidal cycle - from the lowest ebb tide to the highest flood tide - lasts approximately 5 hours, and the reverse cycle from high to low tide also takes about 5 hours, indicating a regular and predictable tidal measure in the study area (Figure 3).

The flow in Ngong – Cai Khe canal basin is primarily influenced by the tidal regime from Hau river. However, the operation of the Cai Khe sluice gate which built to prevent high tides intruding into the city center, significantly affects the hydrodynamics of Ngong – Cai Khe canal basin. When the gate is closed during high tide, water movement is restricted, limiting flow within the canal. Conversely, during low tide, the lock is opened to allow water drainage from Ngong – Cai Khe canal basin into Hau river. As a result, the litter trap installed in the canal functions effectively only during these low tide periods, when the water flows out toward the Hau river and carries floating waste along the current.

Table 1. Information on litter trap sampling times

Date	Sep 30	Oct 01	Oct 02	Oct 03	Oct 04	Oct 05
Sampling time	10:22 AM	10:40 AM	12:30 AM	13:00 AM	13:12 AM	13:30 AM
	22:24 PM	20:00 PM	20:12 PM	2:24 PM	3:00 PM	3:24 PM

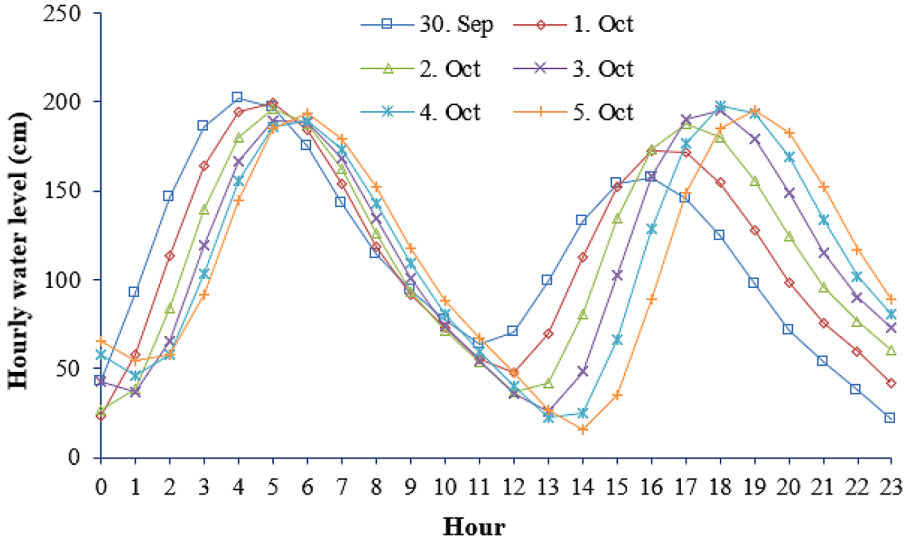

Figure 3. Hourly water level on Hau river, ICOE, 2024

Data processing

Data was input and processed using Microsoft Excel 365.

RESULTS AND DISCUSSION

Monitor of waste collected by litter trap

Frequency of occurrence of non-recyclable items

The presence of non-recyclable items is illustrated in Figure 4. The results indicate that there are six groups of non-recyclable items that appeared consistently across all six days of sampling, including foam boxes, foam containers, plastic bags, rubber shoes/slippers, and other components, with a frequency of occurrence of 100% compared to other components. These items are common pollutants, likely due to their widespread use and improper disposal.

In contrast, there are seven items that appeared only once, with a frequency of occurrence of 17%. These include face masks/pill organizers, insect spray bottles, fabric shoes, plastic flowers, fruit packaging bags, laundry detergent bags, and air conditioning insulation cords. Their infrequent presence suggests occasional or situational usage and disposal. The second most frequently appearing items of 67% include three types: shock-absorbing plastic film, fabric, and glass medicine bottles, each of which was recorded over four sampling days. Following this, items like bamboo chopsticks, paper, and aluminum foil appeared on three days, with a frequency of 50%. Meanwhile, bags, leather/rubber shoes, and leather bags were observed on two days, accounting for 33%. The occurrence frequency of these non-recyclable items indicates that foam boxes and foam containers are made from PS (polystyrene) plastic, plastic bags are made from LDPE (low-density polyethylene), rubber shoes/slippers are made from EVA (ethylene vinyl acetate), and other components consist of single-use items that are discarded directly or indirectly into the water body after serving human needs. These types of plastics are particularly problematic as they are easily degradable and disposed to fragmenting into smaller pieces. Furthermore, they are lightweight and easily float on the water's surface, causing significant environmental landscape loss.

This demonstrates that the effectiveness of litter trap in capturing plastic items has significantly contributed to reducing the pollution of floating plastic waste in Cai Khe canal, where they have the potential to drift into Hau river. The data highlights the importance of such interventions in intercepting waste before it causes further environmental harm.

Frequency of occurrence of recyclable items

The composition of recyclable items collected from the litter trap over six consecutive days

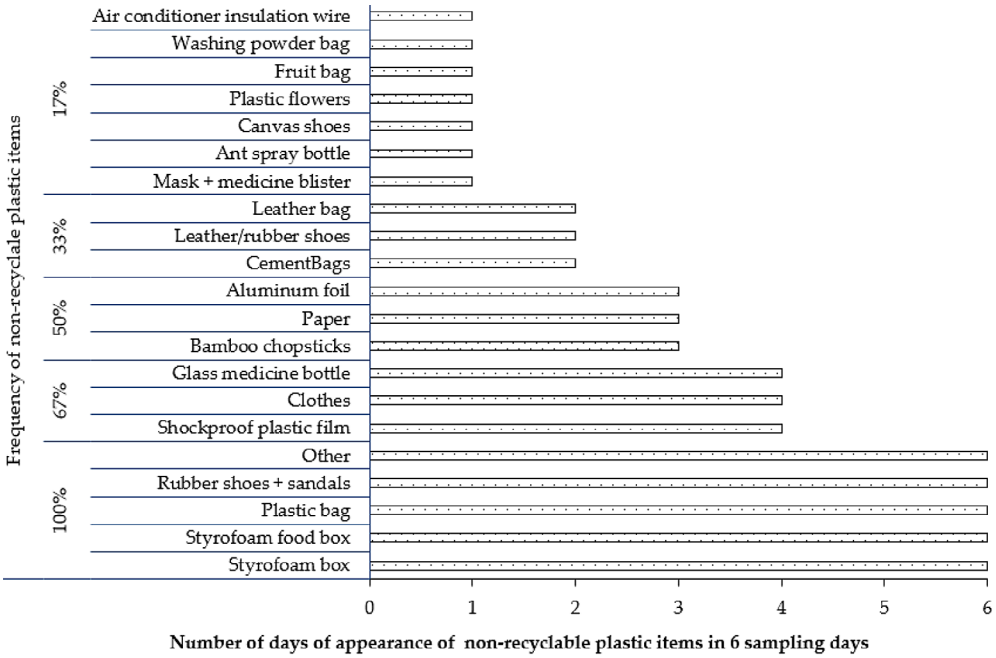

Figure 4. Frequency of occurrence of non-recyclable items in 6 days collected from litter trap

is illustrated in Figure 5. The results indicate that 19 types of recyclable items were collected. Among these, four types appeared consistently across all 6 sampling days: plastic cups, plastic water bottles, metal cans, and plastic straws, each with a frequency of occurrence of 100%. These items are commonly used, single-use products, and their consistent presence suggests high consumption and frequent disposal into the environment. Following this, plastic caps appeared on four sampling days, accounting for a 67% frequency of occurrence. Items such as plastic slippers, plastic containers, plastic trays, and plastic spoons appeared three times, or 50% of the time, while plastic sheets were found twice, with a 33% occurrence rate. Lastly, there were nine recyclable items that appeared only once during the sampling period (17%), including plastic buckets, toy cars, plastic bowls, face wash bottles, plastic bottles, plastic fishing rods, broken plastic pots, oil-based markers, and eyeglass cases. These items may be linked to specific activities or individual events, making their occurrence less predictable.

Notably, the most frequently found recyclable items of plastic cups, plastic water bottles, metal cans, and plastic straws are all single-use items. However, despite their frequent disposal, they have economic value due to their recyclability. According to a World Bank's report, Vietnam recycled about 33% of its plastic, with PETE bottles having the highest collection rate among the various types of plastics (World Bank, 2019). Additionally, a report from the Global Plastic Action Partnership noted that approximately 10 to 15% of Vietnam's plastic waste is collected for recycling (GPAP, 2022). These findings highlight both the prevalence and the recovery potential of recyclable items in urban water bodies. The presence of economically valuable recyclables in litter traps emphasizes the importance of improving collection and sorting systems to enhance resource recovery and reduce environmental pollution.

Amount of plastic waste

Over six consecutive days of collecting waste from the litter trap, the number of non-recyclable plastic pieces ranged from 374 to 522 pieces/day. In contrast, recyclable plastic waste collected ranged from 42 to 130 pieces/day. Overall, the total amount of plastic waste collected daily ranged from 416 to 607 pieces, with an average of 544.67

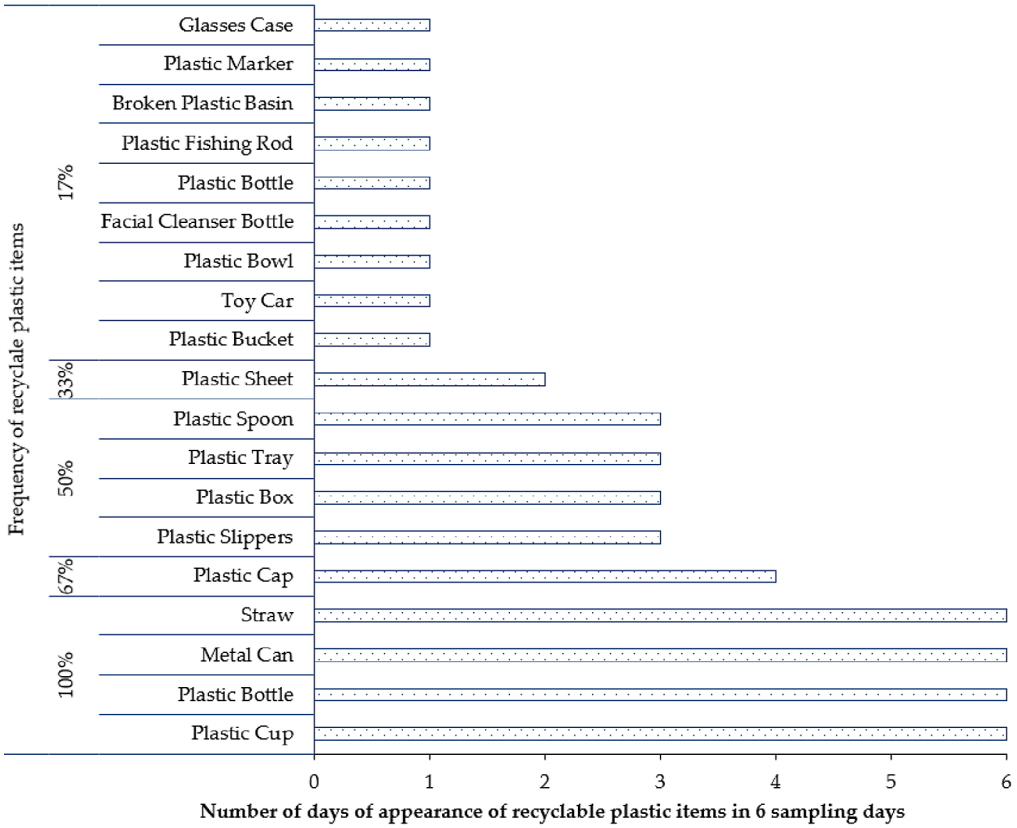

Figure 5. Frequency of occurrence of recyclable items over 6 days collected from litter trap

pieces/day. The variation in daily collection totals is influenced by several environmental factors, including plastic waste density, travel routes, and external forces such as water flow speed, wind, waves, or floating debris like water hyacinths in Ngong canal that carry waste into the trap.

Despite these variables, the litter trap captured a substantial amount of floating plastic waste each day during two low-tide cycles (Figure 6). Suppose all floating plastic waste is transported to the Hau river – this scenario would significantly impact the environmental quality and visual landscape of Can Tho city. This is especially concerning given the city's emphasis on water-based tourism, with Ninh Kieu quay serving as a central hub for tourism development.

According to a report by SIWI (2020), plastic waste discarded in the environment in the Vu Gia - Thu Bon river basin has negatively affected local economic development, particularly tourism and business in Hoi An. As a response, many restaurants, tour operators, and hotels have reduced or eliminated plastic use in their operations. Similarly, the floating plastic waste captured in Can Tho's waterways poses a risk of entering the Hau river system and eventually reaching the ocean. According to Khang (2022), Vietnam ranks 4th among 20 countries contributing plastic waste to the ocean through river outlets, with approximately 0.28–0.73 million tons/year, representing about 6% of the global total plastic waste entering the ocean.

These findings demonstrate that the litter trap is highly effective in intercepting plastic waste before it enters downstream ecosystems. Specifically, the number of non-recyclable plastic collected daily was significantly higher than that of recyclable plastics. This gap may be explained by the fact that recyclable plastics often have economic value and are collected either at the point of disposal or while in transit. In contrast, non-recyclable plastics, which are usually low-value, single-use items - are frequently discarded directly or indirectly into water body. Without value for recovery, they tend to persist and accumulate, fragmenting over time and contributing to long-term environmental degradation. Therefore, the number of non-recyclable pieces is overcoming higher than that of recyclable plastic waste.

Volume of plastic waste

Like the quantity, the volume of waste collected from the litter trap also varied daily, ranging from 24.16 to 34.55 kg, with an average of 28.23 kg/day. This total volume includes both recyclable and non-recyclable materials (Figure 7). However, because each plastic item has a different density and mass, the daily waste volume does not always correlate directly with the number of pieces collected.

For instance, on September 30, the trap collected 24.16 kg of waste with a total of 558 pieces. On October 1st, although the volume slightly increased to 25.25 kg, the number of pieces was lower (524 pieces), indicating that bulkier or heavier items were collected that day. Similarly, on October 2nd, 591 pieces were collected – more than the 572 pieces on October 3rd – yet the volume was lower of 26.45 kg compared to 31.97 kg on October 3rd.

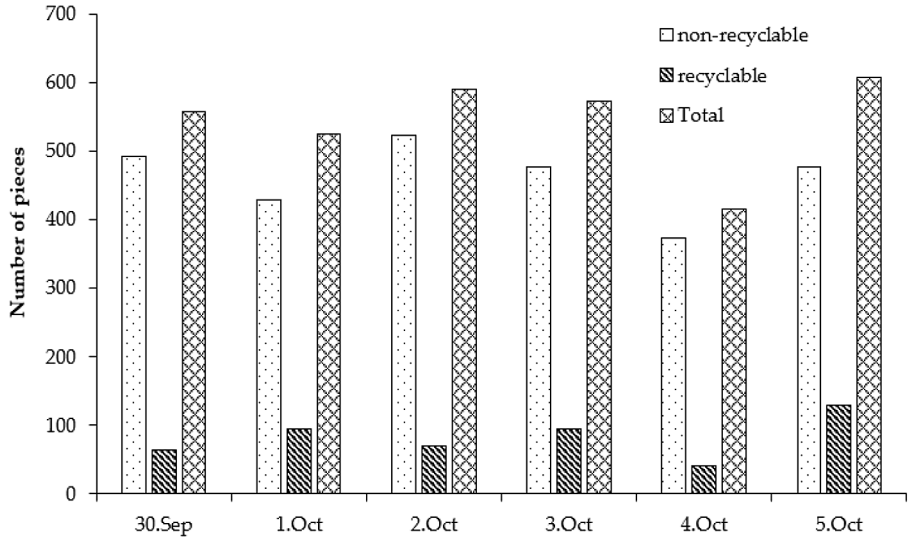

Figure 6. Amount of plastic waste collected from litter trap

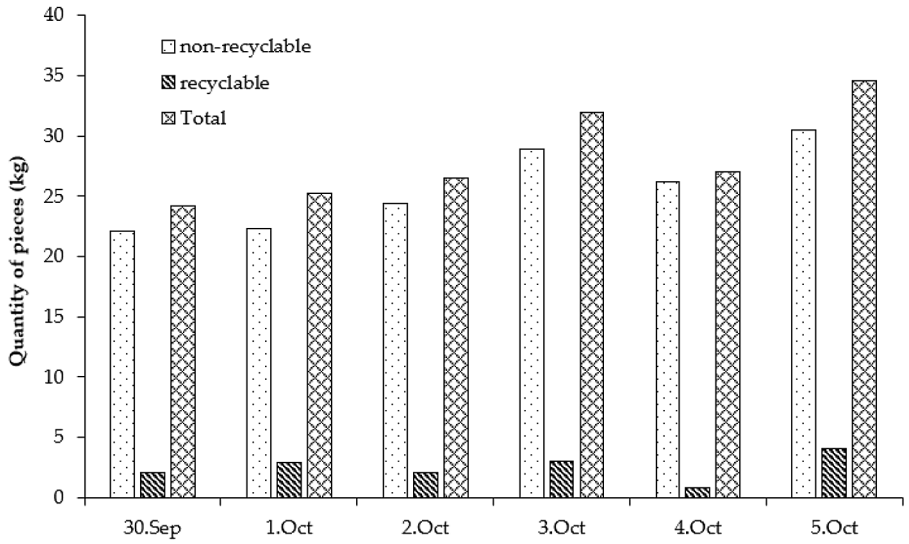

Figure 7. Amount of plastic waste collected from the litter trap

These differences highlight how item composition and material density affect the total collected mass. The recorded volumes demonstrate that the floating plastic collected in litter traps represents only a portion of the total waste present in the canal network. Plastic waste can be distributed throughout the water column based on its density and buoyancy, and only the portion that floats or is carried near the surface can be captured by the traps. The daily volumes indicate that a substantial amount of floating plastic waste can be intercepted, reinforcing the scale of pollution present in urban waterways.

However, the effectiveness of the litter traps depends greatly on several dynamic environmental factors such as water flow speed, wave action, the density of the plastic waste, and the presence of floating vegetation or debris (e.g. water hyacinths) that may transport plastic waste toward or away from the traps. According to the data in Figure 9, the volume of non-recyclable plastic waste collected by the traps ranged from 22.05 to 30.45 kg/day, with an average of 25.73 kg/day. In contrast, recyclable plastic waste ranged from 0.8 to 4.1 kg/day, averaging 2.5 kg/day. These figures confirm previous findings that non-recyclable waste dominates both in quantity and mass due to its abundance, low recovery value, and tendency to remain in the environment longer than recyclable materials.

Recoverability of recyclable plastic from the litter trap

The results from the litter trap show that recyclable plastic waste accounted for 44%, while non-recyclable plastics made up 56% of the total plastic waste collected (Figure 8). This indicates a relatively balanced ratio, with a notable presence of recyclable plastics among the captured debris. According to Trinh (2019), floating plastic waste collected by passive traps in the Cai Khe canal showed that 35% of the waste was recyclable, and 15% was non-recyclable. Comparing these figures, the collection efficiency for recyclable plastic waste in the present study - conducted at Ngong canal - is 9% higher (44% compared to 35%), demonstrating a significant improvement in the performance of the current litter trap. In the context of waste management in Can Tho city, the collection and treatment rate of urban solid waste reached 98.5%, totaling 238,673.5 tons/year, or approximately 653.9 tons/day (Nam, 2023; cited from Can Tho's Department of Natural Resources and Environment, 2022). Forecasts indicate that by 2025, this figure will surpass 900 tons/day (Ha, 2023). According to Thanh et al. (2023), plastic waste constitutes 10.86% of the total municipal solid waste. From this, it can be calculated that plastic waste generation in Can Tho city currently averages 71.01 tons/day and 25,919.94 tons/year in 2023, with a projected increase to 97.74 tons/day by 2025.

These figures highlight the substantial recycling potential of plastic waste in Can Tho city. Although the volume of recyclable plastic collected by the litter trap is relatively modest – an average of 2.5 kg/day, its significance lies in its dual benefits. First, it contributes directly to the removal of floating waste from waterways, improving environmental aesthetics and reducing pollution. Second, it facilitates the recovery of valuable

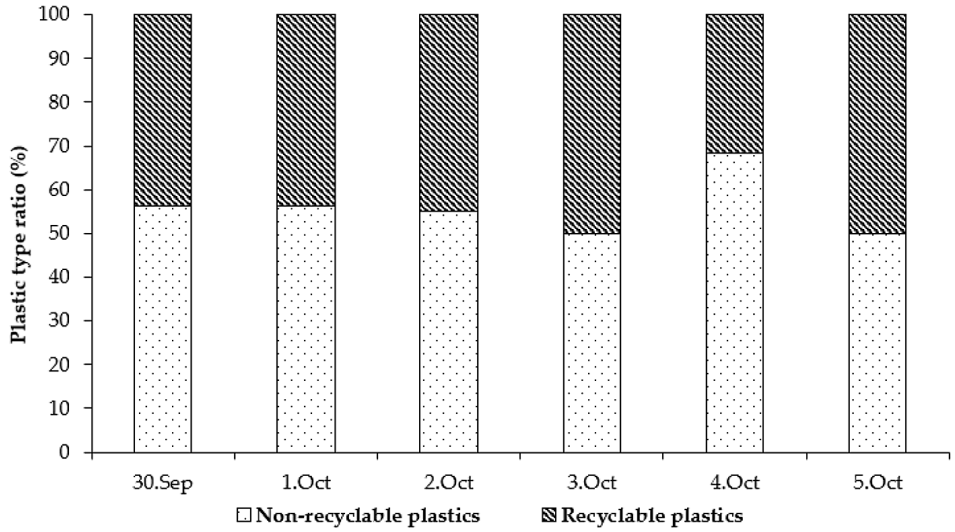

Figure 8. Percentage of plastics collected from the litter trap

recyclable materials, which can be reintegrated into production systems, thereby extending product lifecycles, reducing the volume of waste, and aligning with principles of the circular economy.

This potential underline the importance of expanding and optimizing the litter trap as part of an integrated waste management approach that not only removes visible pollution but also promotes material recovery and long-term sustainability.

Improve the efficiency of litter trap

The findings from litter trap regarding the quantity and volume of plastic waste in Can Tho city reveal a complex environmental challenge that demands a multifaceted strategy. Floating plastic waste in urban waterways not only threatens the local ecosystem but also undermines the aesthetic and functional roles of the city's canal systems. These canals are crucial for microclimate regulation, drainage, flood prevention, and water tourism, making their cleanliness vital to the city's sustainability and economic development.

There are some limitations in the presented method of waste collection should be consider. The litter trap effectively functions and monitors only floating plastic waste and primarily operates during low tide periods when the water flows downstream towards the Hau river. This means it captures only a portion of the total waste present in the canal network, specifically what floats or is carried near the surface, and does not account for submerged or benthic plastic. Furthermore, its efficiency and daily collection amounts are subject to variation due to dynamic environmental factors such as plastic waste density, water flow speed, wind, waves, and the presence of other floating debris like water hyacinths, which can influence how waste is transported to or away from the trap. Additionally, while the trap occupies a significant portion of the canal's width (more than one-third), it does not cover the entire canal width for interception, suggesting potential for waste to bypass it.

Given this context, it is essential to enhance the efficiency of waste capture systems, especially in high-flow areas. A recommended approach is to combine the Cai Khe sluice gate with litter trap along the Cai Khe canal. This integration would allow for better interception of floating waste across the entire canal width, preventing it from reaching the Hau river and, eventually the ocean. Such a system would serve as both a preventive and remedial solution, targeting floating debris before it disperses further downstream. In parallel, it is crucial to strengthen recycling infrastructure. This includes investing in and upgrading existing facilities to handle a wider variety of plastic types, particularly those currently considered non-recyclable due to their complexity and contamination. Improving the infrastructure will directly increase recycling rates and reduce landfill reliance.

Equally important is community education. Raising awareness about the importance of proper waste sorting and recycling can greatly improve household participation in waste reduction efforts. By empowering residents with knowledge and accessible systems, Can Tho city can achieve higher rates of recyclable waste recovery, which

supports both environmental goals and the broader transition toward a circular economy.

CONCLUSIONS

The findings of this study underscore the urgent need for a comprehensive, community-driven approach to improving plastic waste management in the Ngong – Cai Khe canal basin of Can Tho city. Litter trap has proven to be an effective technical solution, intercepting significant amounts of plastic waste, especially low-value, non-recyclable materials - before they enter the Hau river and ultimately the ocean. The recovery of recyclable plastics from these traps not only reduces pollution but also contributes to resource efficiency and aligns with Vietnam's shift toward a circular economy. Therefore, scaling up litter trap, improving recycling infrastructure, and fostering informed community participation are essential strategies to mitigate plastic pollution and promote sustainable urban water management in Can Tho city.

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