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Potential Benefits of Mixed Waste Collection Methods

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Abstract

It is difficult to determine the ideal way for collecting selective waste since calculations must be made taking into account a variety of collection vehicles, containers, city regions, and verifying vehicles. Additionally, we need to keep in mind that acquiring some statistical information on container filling is crucial for organizing the gathering process. The majority of the vehicles used for the gathering operate on fossil fuels like gasoline, which releases carcinogens into the atmosphere. Since the engine drives a hydraulic pump that generates power to lift the container when it is being emptied, the exhaust emissions are not solely coming from the vehicles when they reach the container. As a result, it is crucial to describe the entire gathering process. On the one hand, we want to safeguard the environment by utilizing selective gathering, but on the other hand, there are gathering vehicles that emit carcinogenic exhaust gas. In order to reduce unneeded pollution from the gathering vehicle, we aim to identify the best solution in this paper for choosing the appropriate selective material collection method.

Keywords

selective waste, waste gathering, route optimizing, mixed selective waste

1 Introduction

Plastics (like PET) are preferred because of their excellent qualities, corrosion resistance, low cost of production, and compatibility for the food business. (Gu et al., 2017). Studies indicate that the use of PET bottles will increase over time (Benavides et al., 2018). Reusing PET bottles is crucial to battling climate change and water shortages. Finding the most appropriate form of a selective waste gathering strategy is really difficult nowadays. We may claim that there are containers that are either overfilled or partially empty almost anywhere there is a gathering path. Most countries collect selective waste using vehicles powered by fossil fuel. It is crucial to create innovative, practical strategies for reducing unnecessary pollution. It is necessary to look at the past, statistical data, and social practices in order to establish new methodologies and future predictions.

The placing and collection of PET bottles must be done correctly, poor placement could result in utility operation issues (Foolmaun and Ramjeeawon, 2012).

1.1 Examining the significance of the topic

The statistical information reveals that the issue is still extremely important. Domestic garbage contains a 1/3 of recyclable materials that can be collected and reused (Ladányi, 2013). In 2017, plastic waste accounted for 19% of the packaging waste generated by packaging material in the EU (Eurostat, 2020). It is crucial to carefully collect trash, and in particular, to recycle plastic food packaging (Antonopoulos et al., 2021, Andreasi Bassi et al., 2017). In order to obtain accurate data, we must look at how PET bottles, the most significant home waste component, are collected. Only a small portion of collectors have never used a selective PET bottle collector. 23.33% of the collectors sometimes collect the PET bottles selectively (according to a survey of 150 persons). We believe that we need to encourage them more to reconsider their collecting behavior.

According to statistics information, Hungary collects 30,000 tons of PET bottles each year for selective waste disposal. Paper, for instance, is about 90,000 tons per year. Of course, the values of metal and glass are excellent.

1.2 Examining the gathering habit

To increase the numbers of the selective waste collecting percentage, it is very important to elevate the service levels. When the container for selective waste is full, just 18% of people look for another container to put the rubbish in, 48% utilize alternative methods, and 34% leave

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the waste next to the container that is fully loaded (Fig. 1). (According to a survey of 150 persons).

Fig. 2 demonstrates that 7.33% of selective trash collectors do not compress the PET bottle in any way (according to the previously mentioned survey). The inflated, closed PET bottle is the largest issue for the garbage collecting vehicle.

2 Gathering selective waste

Al-Jubori and Gazder (2018) provide a report on the flight plan optimization. The most significant actions taken at this point are outlined in the article. It is noted that Péter et al. (2013) deviated from the ideal course of action when they reported on closures brought on by the failure of utilities under the road's surface in their study. The following steps need to be taken for the optimal gathering strategy (Fig. 3).

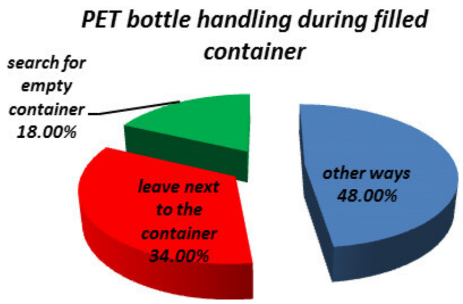


Fig. 1 PET bottle handling in case of filled container

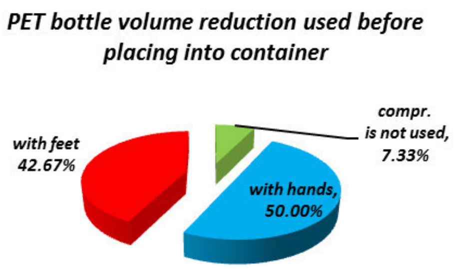


Fig. 2 Different PET bottle volume reduction methods

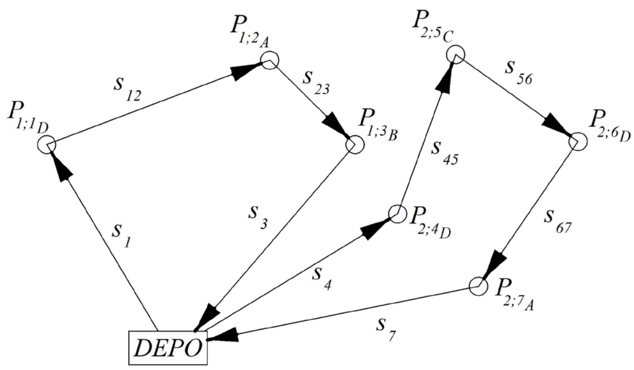


Fig. 3 Optimal gathering plan

As be seen in Fig. 3:

- s: distance;
- P: container,
- $P_{[A,\,B,\,C,\,D]}$: A (empty), B (25% filled), C (50% filled), D (75% filled), E (100% filled).

For the best performance, the route with not full containers (Q90%) need to be planned. The rubbish is not placed next to the container in this case, and the truck capacity will be filled after the termination of all planned routes.

In optimal container gathering there will be no overfilled container (see in Eq. (1)):

$$Q_1 \cong Q_2,\ Q_1 \le Q_v,\ Q_2 \le Q_v, \tag{1}$$

where:

- Q_v: capacity of the garbage vehicle;
- Q_1: sum capacity of the container gathering in 1st route;
- Q_2: sum capacity of the container gathering in 2nd route;

This type of path cannot be used, as shown by the statistical analysis of the data.

Fig. 4 shows that the container filling/overfilling is not constant across different locations or settlements. The loading rarely repeats, it is constantly changing. We might conclude that the overfilling of the container cannot be estimated.

2.1 Defining solution

An info-communication system was used to describe intelligent garbage collection by Titrik et al. (2015), however the system was never used because of the high costs. As a result, a more affordable solution needs to be created. We must identify solutions for container overfilling so that we can choose the most suitable option (Fig. 5).

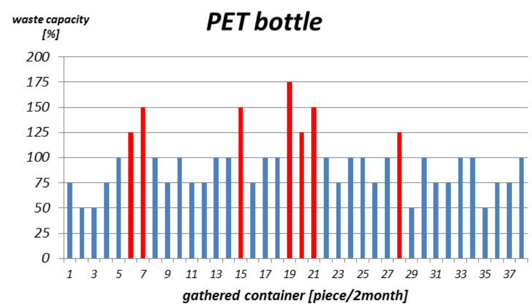


Fig. 4 PET bottle gathering* (2.5m³ container) (* data source: the data are randomly chosen from database from a waste handling company data, no further parameters can be published)

Fig. 5 Solution for overfilled container

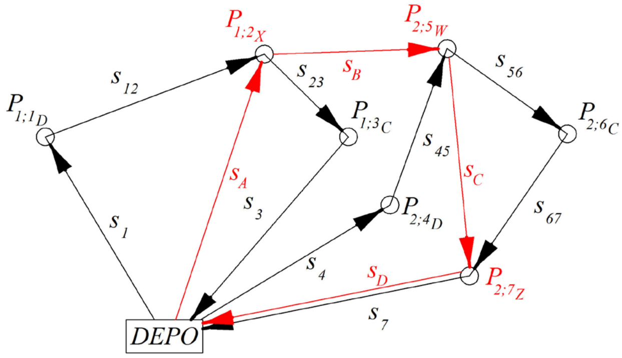


Fig. 6 Gathering plan for the overfilled container

2.2 Defined solutions

2.2.1 Apply more frequent container gathering

According to Fig. 4, the average container filling rate is a respectable 95%. There were just 7 cases of overfilled containers during the 2-month collecting. +75% was the maximum overload. Container overflowing occurred in 3 situations (+50%) and 3 additional occurrences (+25%).

These will be the outcomes if we employ more frequent gathering:

- The optimal filling level will decrease.
- The unnecessary container lifting will increase.
- The unnecessary travel will increase.

2.2.2 Apply more containers for the same waste component

We can all agree that it is not fair to use two containers (plus one more) for the same selective rubbish. The price of the container is extremely high (300–500€), and only 5–20% of it is actually used (applying same route plan). It is essential to consider that we have to operate the engine of the vehicle, while dangerous gases are leaving the exhaust during the container-emptying procedure.

2.2.3 Use +1 smaller cleaning-gathering garbage vehicle

In this case the regular garbage vehicle is gathering the containers and another cleaning-gathering vehicle is collecting the selective waste which was placed next to the overfilled container (Fig. 6).

As be seen in Fig. 6:

- $P_{[W, X, Y, Z]}$: W (125% filled), X (150% filled), Y (175% filled), Z (200% filled).

$$Q_{c-g} \leq Q_o, \quad (2)$$

where:

- $Q_{c\text{-}g}$: capacity of the cleaning-gathering garbage vehicle;
- Q_o: sum capacity of the overfilled waste in first route.

In a typical gathering route, every container is inspected and its contents are all unloaded. In this case, the overfilled rubbish won't be collected. The data from the overflowing containers will be noticed and gathered using a different cleaning-gathering method.

In cleaning-gathering route only the overfilled containers are inspected. The problem is that no volume reduction can be used for the collected waste. 2–3 employees should be used for waste collection. In the cleaning-gathering route there is no way to unload containers if they are overfilled at that time.

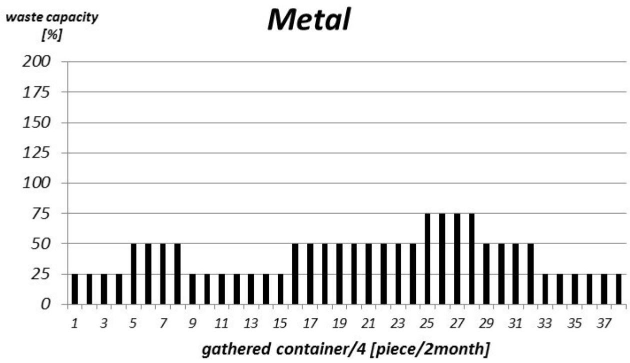
2.2.4 Collect the overfilled container waste with garbage truck workers

It is a significant issue to stop for additional minutes during container gathering to gather all the waste that has been placed next to the container. The concept is reasonable since there is no need to return to the overloaded container. Using this method of gathering could provide a difficulty because the unexpected waste volume could force the gathering vehicle to empty up before taking the planned route, preventing the last containers from being unloaded.

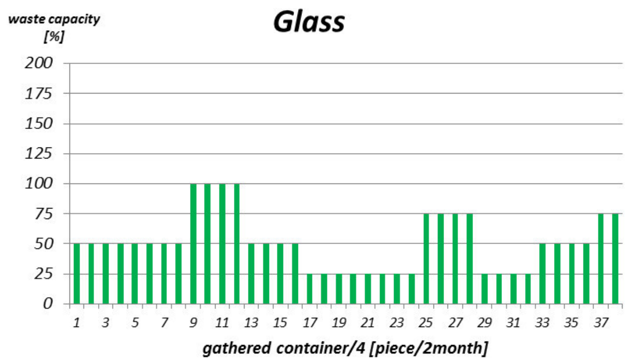
2.2.5 Mix the various forms of selective garbage

We should study the statistics data as a first step. Glass and metal should be used as two additional containers for selecting waste (Fig. 7). The metal container hasn't been completely filled for the same period of time.

The amount of metal collection is four times lower than that of the PET bottle. The typical container filling is only

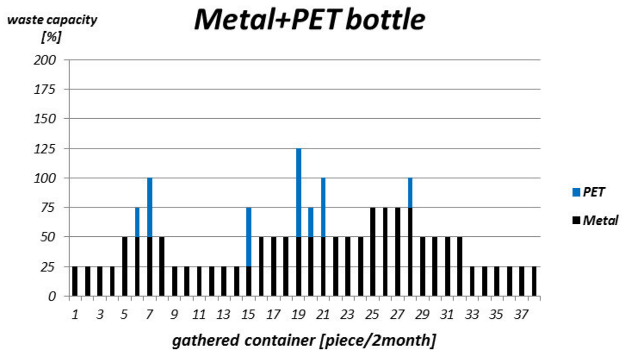


(a)

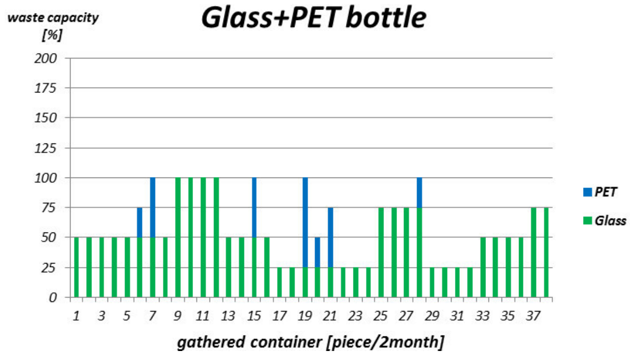


(b)

Fig. 7 Container filling trend* (2.5m^3 container); (a) metal waste; (b) glass waste (* data source: the data are randomly chosen from database from a waste handling company data, no further parameters can be published)



(a)



(b)

Fig. 8 Used mixed solution (2.5m^3 container); (a) for metal+PET bottle; (b) for glass+PET bottle

about 40%, which is not ideal. It is common procedure to empty every container during container gathering, regardless of whether it is empty or not.

Glass is collected four times less frequently than PET bottles. The typical container filling is only about 50%, and this is insufficient. No matter how partially loaded a container may be, the employees must empty it during container gathering. Those garbage cans may also include other types of waste, according to statistics.

In order to maximize the use of containers, it is possible to mix different types of selective waste, according to statistical data (Fig. 8).

In the waste handling process, it is simple to separate the various types of selective waste, such as glass+PET bottles and metal+PET bottles (De Gisi et al, 2020). Utilizing mixed gathering has shown positive results for the tested period. After evaluating the results, the container wouldn't be overfilled.

For mixed collecting we would get:

- "no more overfilled" PET container,
- no need for extra work,
- no need for extra gathering.

For the gathering we can recommend the further solution. It is not necessary to mix the selective waste inside the city for short distances and often or rarely overfilled containers; simply changing the collection time will be sufficient since the collection vehicle won't have to travel far to get to the container. The drawbacks of this collection procedure (expense, pollution) are less noticeable over short distances. Outside of the city, container delivery can be very challenging, so we advise that it would be preferable to combine the selective waste. Because cities vary in size and infrastructure and because similar scenarios can occur there, there may be an opportunity to mix certain types of waste there after this method has been tested.

The advantages of this new method of gathering data are quite difficult to quantify, but they also include the protection of the environment, human life, and health care as priorities. Cleaning-gathering issues and a distorted townscape are caused by the overfilled containers. It's essential to apply test procedures in actual situations and evaluate their merits.

3 Conclusion

A major environmental goal is to increase the use of recycled materials, however it is crucial to reduce any negative effects while collecting these carefully chosen resources.

The good outcome can occasionally be worse than the poor since we release more exhaust gas into the atmosphere, which can be more harmful than if we didn't collect garbage selectively. The optimal gathering path and the best waste collecting case should be determined in order to prevent these adverse effects. This report emphasizes the different ways that mixed waste collection can be used to reduce the pollution that gathering vehicles produce.

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