REVERSE VENDING MACHINES VS. OTHER WAYS OF SELECTIVE WASTE COLLECTION – RESEARCH RESULTS

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Purpose: The paper presents outcomes of the qualitative research on the use of reverse vending machines (RVMs) as equipment to facilitate the segregation and disposal of beverage packaging in Poland, in comparison with other ways of selective waste collection. The topic of innovative tools to support waste management gains particular importance in the context of the introduction of the deposit system for packaging in Poland.

Design/methodology/approach: Our qualitative research aimed at identifying consumer behaviour and preferences regarding the selective waste collection. Simultaneously we evaluated experiences with the RVMs and related incentive programs. The research technique was focus group interview, supported by perceptual mapping. 5 interviews were conducted with citizens of Malopolska & Silesia Provinces, in localities where recyclomats from the pilot program were installed.

Findings: The results show positive attitudes towards the RVMs among participants of pilot testing of such devices. RVMs are perceived as easy-to-use and environmentally friendly. Compared to other methods of selective waste collection, the highest rated in terms of cost to the user and suitability for the user were the containers for segregated waste. When evaluating incentive systems, respondents accepted only financial benefits. It can be assumed that RVMs can support the newly introduced deposit system for beverage packaging in Poland.

Research limitations/ Most of the focus group participants had been familiar with RVMs from the pilot program, but the mobile app dedicated to the devices was inactive during the study. This affected the overall user experience.

Practical implications: The outcomes suggest that the comprehensive waste collection and recycling system in Poland should be supported by RVMs, and that such devices should be popularized.

Social implications: RVMs could play an important role in environmental education for children and young people. The dissemination of recyclomats by retail chains and local governments will increase their availability and influence the formation of pro-environmental behavior of other consumer groups.

Originality/value: The originality of our study is based on identifying Polish individuals' views toward innovative waste management technologies and demonstrating their influence on sustainable consumption.

Keywords: reverse vending machines, recyclomats, consumer behavior, selective waste collection, research, Poland.

Category of the paper: research paper.

1. Introduction

Municipal waste management continues to be a focus of the European Commission (EC), particularly in the transition to a circular economy (CE), which is a priority of the European Union's (EU's) economic policy (Smol et al., 2020).

Countries that want to enhance their waste management systems should also focus more on promoting sustainable consumption and manufacturing (Chow et al., 2017). This requires the cooperation of various stakeholder groups: business, administrative and individual, as well as coordination of actions taken at the local, regional and national levels (Dagilienė et al., 2022; Puntillo, 2023). A substantial amount of study has been conducted on the practical elements of municipal waste management (transport, treatment, and disposal), as well as how individuals feel about waste segregation, recycling or incineration (Wilson et al., 2001, Alwaeli, 2015; Minelgaitė, Liobikienė, 2019). Understanding the factors that explain individual acceptance of different waste management policies and circular economy in general is essential for implementing proactive approaches to improve sustainable consumption and consumer involvement (Triguero et al., 2016; Puntillo, 2023).

The result of unsustainable consumption is the overproduction of packaging, which requires the implementation of effective and widespread tools for its disposal (Siddiqui, Pandey, 2013; Idumah, Nwuzor, 2019; Khan et al., 2022; Hordyńska et al., 2023).

The purpose of the study is to obtain an answer to the question of whether and to what extent the Comprehensive Waste Collection and Recycling System in Poland (Kutyna-Bakalarska et al., 2020) should be supported by reverse vending machines for selective waste collection (RVM, 'recyclomats'), and whether the dissemination of such equipment should be expanded on a regional scale (Małopolska-Silesia), and in the long term, throughout the country.

Based on currently available knowledge, it can be concluded that reverse vending machines (Kaplan et al., 2016), are already supporting waste collection and recycling systems in the European Union (Scandinavian countries, Lithuania, among others). It should be noted, however, that these solutions operate in conjunction with the deposit system for bottles or cans, so the motivation for residents to use RVMs is the expectation of deposit recovery for the packaging, previously paid in the price of the product. Deposit systems are already in place in countries such as Croatia, Denmark, the Netherlands, Iceland, Finland, Germany, Norway, Sweden, Lithuania, Estonia, Slovakia and Latvia, and work is underway in another 15 countries. (Spiller, 2022). In Poland the system, under which a certain deposit will be added to the price of a bottle or can, is due to come into force at the beginning of 2025. Customers will be able to reclaim the deposit upon returning the packaging (Wiński et al., 2023).

RMV is a device which automatically sort packaging (plastic bottles and beverage cans) and the central IT system records data about waste and rewards the user for segregation by assigning the appropriate number of points to user's account (Stronczek, Waksmundzki, 2020).

"Eco-Points" are exchanged for prizes and discounts offered by business partners, as part of municipal loyalty systems or crowdfunding campaigns. To be able to use the system in a given area, it is enough to install a mobile app dedicated to the RVM. The first observations of the pilot testing of RVMs in Poland indicate a favorable attitude of Polish users towards this type of device (in the context of evaluation of technical solutions).

Preliminary assessment of the preferences and attitudes of the residents of the Malopolska and Silesian provinces allows us to conclude that from the perspective of individual users, such technical solutions seem promising (among other things, thanks to the possibility of reducing the amount of unsegregated waste and linking the devices to a bonus system, attractive to young people and young adults (up to about 26 years of age), who are rather "resistant" to traditional ways of influence).

Currently, one of the motivations for using recyclomats is the measurable gratification for the collected packaging, which would otherwise simply be thrown to traditional segregated waste bins - without any compensation. Other motivations for using such devices need to be verified through social research.

It is necessary to verify how the transition to a deposit system in Poland (e.g., for food and primary product packaging) will affect Poles' attitudes and preferences with regard to waste management and attitudes toward selective packaging collection and recycling facilities.

Features of the national waste collection and recycling system, such as the universality and general availability of waste collection outlets, stability of collection, costs for the user and the public sector, externalities (impact on the landscape and nature), etc. have a holistic impact on the quality of the functioning of the economy, society and the environment. Therefore, taking into account the potential target group of the study's participants from the Małopolska and Silesian Provinces, it is important to recognize that society as a whole can gain from the development of new, reliable, attractive, user-friendly and environmentally friendly waste collection solutions.

2. Research methodology

The study was aimed at assessing the knowledge and experiences of residents from the Małopolska and Silesian provinces related to the use of reverse vending machines (RVMs, recyclomats), which are intended to support the Comprehensive Waste Collection and Recycling System in Poland.

The subject of the study, therefore, was users' experiences and attitudes toward innovative devices (recyclomats) supporting selective waste collection.

The purpose of the survey was to obtain an answer to the question of whether the Comprehensive Waste Collection and Recycling System in Poland should be supported by innovative reverse vending machines for selective waste collecion (so-called recyclomats), what incentive programs associated with recyclomats are attractive to users, and whether such devices should be popularized - in the context of the respondents' perceptions of the possibilities and limitations of selective waste collection. Consequently, the following specific objectives were identified:

- comparative assessment of the societal satisfaction with currently available segregation and waste management solutions,
- assessment of social acceptability of RVMs (recyclomats) and the perceived benefits and limitations associated with their introduction in the whole country,
- comparative assessment of RVMs and other currently available waste collection solutions,
- assessment of the propensity and willingness to use RVMs - depending on their location and supporting incentives,
- evaluation of incentive programs associated with RVMs - with reference to current programs and the possibility of introducing a deposit system and philanthropic programs.

In the research we used qualitative and quantitative research methods build an in-depth picture of citizens' behavior and preferences towards selective waste collection, as well as expectations of innovative solutions to support Circular Economy. This article presents the result of the qualitative study on the evaluation of recyclomats against other methods of separate waste collection.

The qualitative research and its results described in this article were directed at identifying routines and preferences concerning selective waste collection. At the same time, RVMs and related incentive programs were evaluated. The qualitative research also aimed to recognize the experience of using recyclomats and mobile applications dedicated to these devices, and to prepare a cognitive platform for conducting quantitative research.

The research was conducted in the form of focus group interviews with residents of Malopolska province: in Krakow (FGI1) and Klucze (FGI2), and with residents of Silesia province in Zawiercie (FGI3) and Ruda Śląska (FGI4). In each group, the participants were diverse in terms of age, gender and socioeconomic position, while adhering to the condition that each group included students and people over 60 (seniors). In addition, one focus group interview (FGI5) was conducted only with a group of students in Krakow. In each group there were respondents who previously had been users of EcoTech recyclomats. The research scenario included a multimedia presentation with an explanation of the idea of RVMs, followed by a video presenting the incentive system connected to recyclomats. Supportively, a perception mapping and other heuristic techniques were used during these focus groups (Maison, 2020; Glinka, Czakon, 2021). The interviews were conducted in June 2022.

During the evaluation of the innovative solutions supporting the use of the recyclomats, a text mining technique was also used to extract data from comments and opinions of app users, available in the Google Play store and App Store.

During the research period (May-August 2022), 10 EcoTech recyclomats and dedicated ECO-wallet mobile application (as a pilot program for the project: Comprehensive Waste Collection and Recycling System in Poland) were tested in Poland These recyclomats were available in Silesia and Małopolska provinces. According to Prymon-Ryś et al. (2022) several brands or retail networks also conducted their pilot testing of RVMs i.e. Coca Cola's (Warsaw), Żabka retail network (Poznan and Warsaw), Lewiatan retail network (Włocławek), Decathlon stores (Legnica). These programs used a variety of incentive and reward programs that could be obtained for the points collected.

In the first stage of the research, we obtained information on the waste management and segregation systems used in Silesia and Małopolska provinces, we gathered respondents' opinions on recyclomats and the incentive systems currently in use, as well as suggestions for their own new solutions.

3. Research results

According to the interviewers, waste segregation is *good*, *important* and *beneficial to the environment*. The statements are dominated by positively-oriented opinions on the need or even *necessity of segregation*, which, according to respondents, is *is in high demand*. Negatively-oriented statements occur much less frequently - there are individual opinions that it is "inconvenient" or even unnecessary – which is justified by the lack of knowledge about the waste sorting and recycling processes.

In the Silesian province, the waste collection system was evaluated positively, *nothing is missing in it*. In respondents' households waste is segregated. Several interviewers claimed that in their settlements, garbage had to be thoroughly segregated. Otherwise, the garbage would not be collected by the cleaning-service providers.

The waste collection system in Małopolska is not evaluated very positively due to the high price of the services, higher than in other municipalities or provinces. However, it is worth noting that the perception of high costs is very subjective - a comparison of waste collection prices in Małopolska and Silesia provinces shows that there are no significant differences between regions.

There is a belief that *by segregating waste, residents increase their workload without any benefit*. Nevertheless, citizens generally encourage their children to sort waste. Teachers also pay attention to educational projects in this area.

A major problem for residents is the lack of space for waste separation bins. This is a practical and challenging aspect of sorting. In many individual households, containers for segregated waste require a significant amount of space to be set aside. This is a problem that occurs in both apartments and homes. Therefore, respondents note that, *not everyone segregates waste. People throw garbage into forests*. This behaviour is perceived as harmful by all focus participants.

The overall assessment of the solutions available in Poland is positive: "Despite everything, waste management in Poland is also changing. In the past, there was no segregation at all".

3.1. Evaluation of recyclers based on presentations during focus groups

Recyclomats are perceived by focus participants as a trendy, modern solutions environmental-friendly; they should be universally available, but the list of material benefits should be expanded. According to interviewers, positive aspects of RVMs include an incentive system for segregation, simplicity of the solution, positive impact on the environment, speed and automation of operation, 24/7 availability, ability to retrieve the deposit without contacting a shop assistant.

On the other hand, the disadvantages of recyclomats pointed out by focus participants include low availability of RVMs (*There is an inconvenience here, because if I have a Coke bottle with me I'll throw it in, and that's not a problem, but if I had to bring a bag of uncrushed bottles from home, it's more difficult. I wouldn't want to do so*), low popularity, large space occupied by recyclomats and possible breakdowns. Several people pointed to the high cost of purchasing/implementing and maintaining RVMs. Several seniors noted that it is a problem for the elderly to operate the recyclomats, as well as to use the app. They also noted that dropping a package into the recyclomat requires scanning a barcode, which is a hassle. *The recyclomat will accept a bottle without a barcode - but it won't charge a point -* which automatically limits the attractiveness of using RVMs. There were frequent statements that without tangible benefits, there is no point in using such devices.

The target audience for recycling solutions according to participants is basically everyone, but the most common suggestions are young people, smartphone owners who can handle the technological side of the solution, buyers of beverages in plastic bottles; but also stores and local governments.

According to respondents, interest in recyclomats depends on *the size of the city, the population and the amount of waste generated*, on environmental awareness and on the individual mobility. Thus, the aspect of the availability of recyclomats and the reluctance of users to *walk around town with a bag of bottles* resonates again.

According to interviewees, the best motivation for using recyclomats would be awareness of the need for selective waste collection. Several people suggested that in order to increase interest in recyclomats, the public should be made more aware of them. One person suggested something like a state law that would make segregation mandatory, thereby increasing the

demand for RVMs. In general, interviewers suggested introducing a deposit system and supported this idea.

A suggestion from respondents was to educate the younger generations, and that *they [recyclomats] should be better promoted*. Suggestions for an advertising and information campaign appeared quite often - the example of a school where a RVM was installed on a pilot basis was given as an argument: *Before, the children didn't even know what a recyclomat was. Now everyone in and around the school knows*.

3.2. RVMs vs. other ways of selective waste collection

Participants in the focus interviews were asked to mention the most convenient ways of selective waste collection. Opinions varied widely. In addition, there was a divergence between convenient and eco-friendly solutions. For example, many young people consider ordinary trash cans as environmentally friendly *Why? Because they are available everywhere, if there are a lot of them it is more likely that someone will not throw in the bushes, if I have some papers to throw away, I will not look for a container for segregated waste*. The responses of young adults shows that ease of use is the biggest advantage of *user-friendly* ways of segregation: *what is suitable for students must be easily accessible*. Older people, on the other hand, emphasize more the economic aspect: *Thrash bags are not accepted because they are not very environmentally friendly and the average cost is so high*.

The use of the perception map technique (Glinka, Czakon, 2021) made it possible to compare recyclomats with other methods of separate waste collection. Participants were asked to evaluate the following methods of waste disposal:

- K - Trash cans (available to the public, e.g., on streets, at stores).
- PZ - Containers for mixed waste - next to a residential building or inside.
- PS - Containers for segregated waste (green, yellow, blue) next to a individual family house or multi-family residential building, e.g., next to chutes or separate containers for residents.
- D - Publicly accessible containers for segregated waste so-called "dzwony" – bells.
- SK - pick-up points for recycling materials.
- R - RVMs (recyclomats).
- L - Garbage sorting plant/[in Polish "lamusownia", KSZOK].
- W - Thrash bags in different colors (yellow, green, blue).

The respondents' task was to mark on the map the evaluation of each way of separating and collecting recyclable waste (plastic, metal, glass) according to the following criteria:

- A1. Environmentally friendly/ Not environmentally friendly.
- A2. Very user-friendly/ Little user-friendly.

Map A (Figure 1) shows the summary of all responses concerning recyclomats. A size of circles is determined by number of repeated ratings.
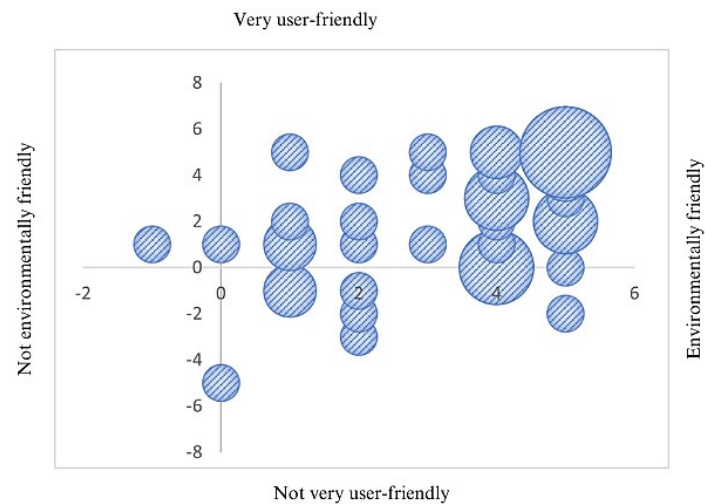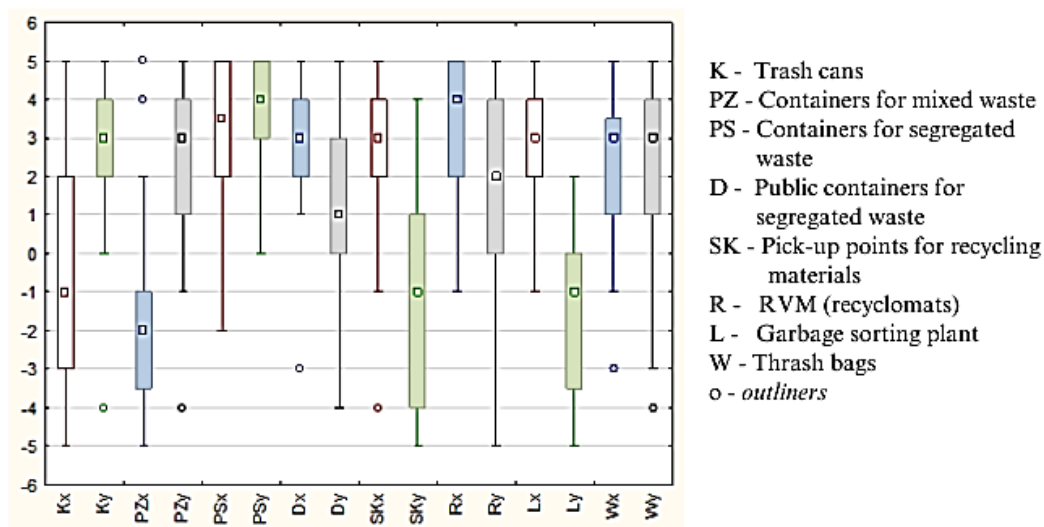
Figure 1. Perception map (A) for recyclomats - summary of findings of focus participants, [rating scale from -5 to +5; circle size determined by number of repeated ratings].

Source: own research – using software available at www.perceptualmaps.com

According to the combined criteria in this group, recyclomats are rated as both environmentally friendly and user-friendly (see Figure 1), as the overwhelming number of ratings fall within the range of positive ratings.

With SPSS software, an analysis of the ratings of the focus participants was carried out, creating scatter plots. However, when compared with other ways of waste collection, recyclomats (Rx, Ry) do not dominate in areas of positive perception. By far the best perceived are containers for segregated waste (PSx, PSy).

Compared to other waste sorting and disposal methods, recyclomats according to environmental friendliness are rated quite positively - and better than other solutions (see fig. 2) - Rx-median = 4.0. Containers for segregated waste (PSy) are rated highest here in terms of "user friendliness". The analysis conducted using the multidimensional scaling method confirms the convergence of the survey participants' ratings.
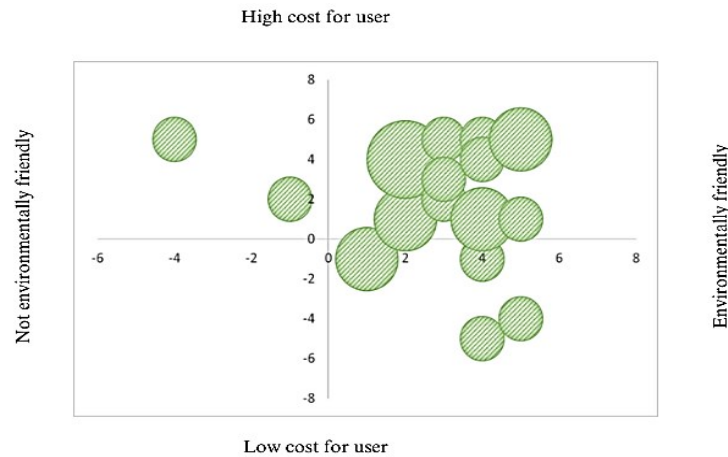

Figure 2. Box-and-whisker chart for the variables environmental friendliness (x) and user friendliness (y).

Source: own research.

The following factors evaluated were the eco-friendliness of the studied solutions and the cost of use, see Map B (fig. 3) with criteria:
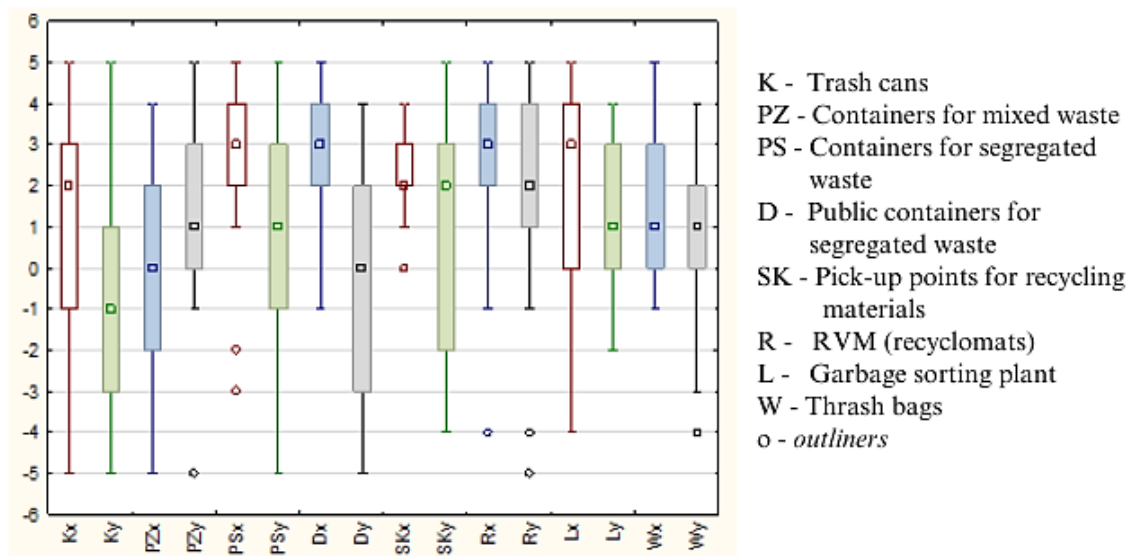
- B1. Environmentally friendly/Not environmentally friendly.
- B2. High cost of sorting for the user/Low cost of sorting for the user (ie., cost of waste collection, cost of trash bags, cost of getting to the bin, opportunity cost of time, etc.).

Figure 3. Perception map (B) for recyclomats - summary of findings of focus participants, [rating scale from -5 to +5; circle size determined by number of repeated ratings].

Source: own research – using software available at www.perceptualmaps.com

Again, the evaluation of RVMs' environmental friendliness was positive, while in terms of cost, recyclomats were rated as expensive solutions; respondents' evaluations were located in the 1st quadrant of the map: positive – high (see fig. 3).

Figure 4. Box-and-whisker chart for the variables environmental friendliness (x) and cost (y).
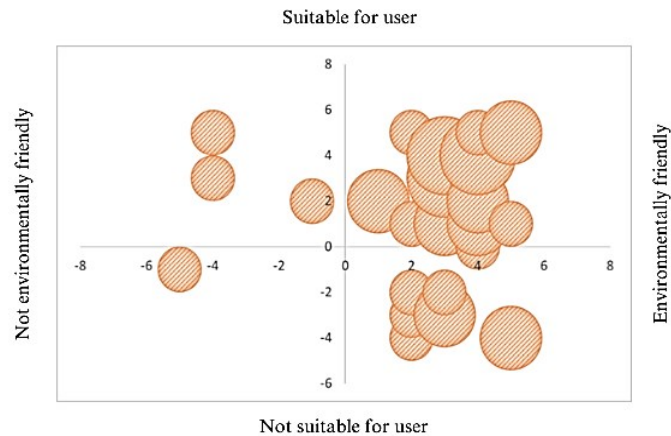
Source: own research.

Overall, however, most solutions tend to be rated lower (see Figure 4). In any case, the median does not exceed the value of 3. As for the variables PSx, PSy (containers for segregated waste), Rx and Ry (RVMs), they are rated quite well in comparison, although there

are a few outlier observations. Lx (garbage sorting plant) and Dx (publicly accessible containers for segregated waste) in terms of environmental friendliness also received good ratings.

The last perceptual map C (as seen on fig. 5) covered the following criteria:
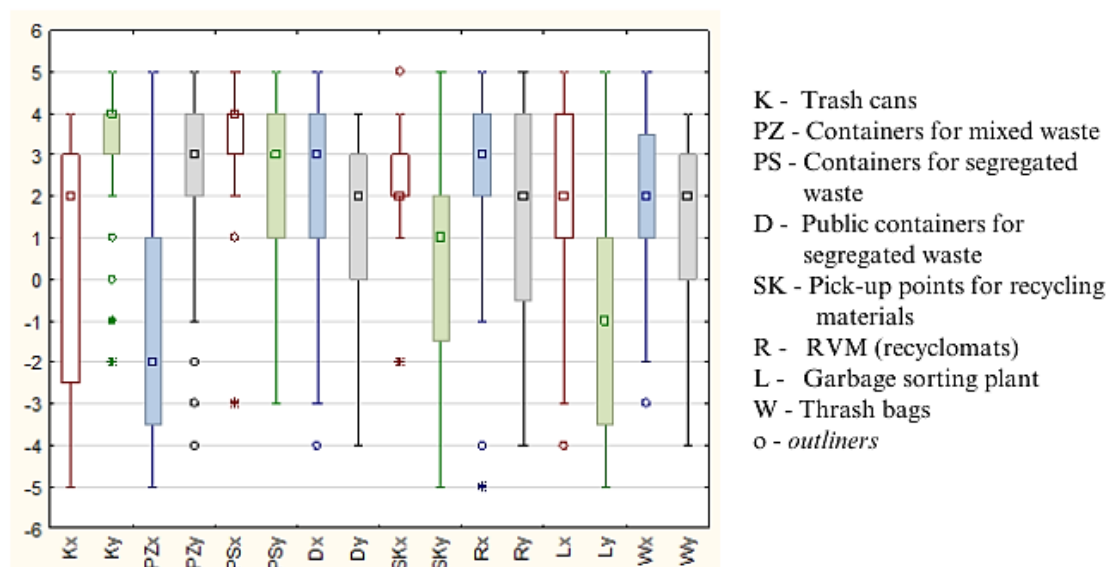
- C1. Environmentally friendly/Not environmentally friendly.
- C2. Suitable for me form of sorting/Not suitable for me form of sorting.

Figure 5. Perception map (C) for recyclomats - summary of findings of focus participants, [rating scale from -5 to +5; circle size determined by number of repeated ratings].

Source: own research – using software available at www.perceptualmaps.com

As shown in Figure 5, the ratings of the focus group participants are less clear and the range of ratings is wider. There were more negative responses – some respondents felt that recyclomats were unsuitable for them and therefore less environmentally friendly. At the same time, there were more very positive statements (ratings of 4 and 5), which ultimately confirmed similar results to the analysis of Map A (see Figure 6).

Figure 6. Box-and-whisker chart for the variables environmental friendliness (x) and suitability for user (y).

Source: own research.

In this part of the study, the responses obtained give a similar picture to the results of the perception map A. The best ratings were given to the PSx (containers for segregated waste) and Ky (trash cans) variables (with a few outliers and extreme responses). The high ratings for regular trash cans confirm the results of the focus interviews, where particularly young respondents indicated ordinary trash cans as the most user-friendly. Recyclomats in this evaluation were rated quite positively (Ry-median = 2.0).

4. Conclusions

Improving waste management strategies through more collaborative participation of consumers and the introduction of innovative tools is of increasing concern to researchers and policy makers. Obtained results, combined with the outcomes of our quantitative research (Prymon-Ryś et al., 2022), indicate the extent to which recyclomats can support the implementation of a deposit system in Poland. The presented research is innovative not only because of the technical novelty of the described devices, but also because of the relevance of the use of RVMs in selective waste collection systems.

Waste sorting, according to respondents, is both required and beneficial to the environment. Waste is separated in the majority of Małopolska and Silesia households. Respondents indicate that they sort rubbish in accordance with the guidelines established by the municipality in which they live. Those who do not follow standard sorting criteria explain this mostly through practical factors: a lack of segregation conditions in the household and a lack of separated waste bins in the region. Young people (students) prefer easily accessible ways to dispose of trash - whether they use selective waste collection or simple trash cans placed by the sidewalk.

For the majority of focus participants, the most environmentally friendly form of trash selection was the containers for segregated waste. Similarly to recyclomats, they were also described as user friendly. Negative eco-friendliness ratings were given to containers for mixed waste. In terms of cost to the user, the RVMs received the highest ratings, although, obviously, interviewers did not refer to the cost of installing the devices or servicing them. Recyclomats are the only devices that provide tangible gratification for disposed waste. Interestingly, ordinary trash cans were indicated by respondents as the most convenient form of garbage disposal. Also, containers for mixed waste and containers for segregated waste received high scores. The small number of recyclomats, long distances to these facilities and the need to install a mobile app contributed to RVMs' lower ratings.

According to respondents, increasing residents' willingness to segregate requires the following incentives: material benefits (e.g., free garbage containers or garbage bags) and financial benefits (deposit system), more solutions to facilitate segregation and publicly available equipment/containers, financial penalties for those who evade segregation and

consistent enforcement of selective collection, and supporting citizens' awareness and knowledge through educational programs and information campaigns. While the study results revealed favourable opinions regarding separate waste collection, respondents claimed that they would be more likely to do so if they received tangible benefits, such as discounts or financial bonuses, and if it was cheaper and simpler.

Recyclomats, as devices supporting the waste collection and recycling system, have a very positive image among those who have had the opportunity to get to know the idea of their operation. At the same time, however, not all respondents who rated the RVMs positively considered them suitable or necessary in their local community.

Recyclomats are seen as easy to use, encourage separation and are environmentally friendly. Respondents indicated that the availability of these devices and their ease of use were the most important factors in persuading them to use recyclomats. An analysis of the following responses shows that the possibility of receiving cash is more attractive to respondents than other material rewards. This is indeed an expected attitude, in the context of the introduction of a deposit system in Poland. Consequently, the spread of recyclomats will require them to be adjusted to pay a deposit for disposed beverage packaging.

Although these devices are unlikely to become the primary method of waste disposal, given the interest in gamification-based programs (Santti et al., 2020; Hsu, Chen, 2021), it is crucial to note that recyclomats may play an important role in the environmental education of children and young people.

Surveys show that residents are favorably disposed to recyclomats as devices that could support the Comprehensive Waste Collection and Recycling System.

Features of the national waste collection and recycling system, such as the universality and general availability of waste collection sites, stability of collection, costs for the user and the public sector, externalities (impact on the landscape and nature), etc. have a holistic impact on the quality of the functioning of the economy, society and the environment. Therefore, regardless the sample of the survey participants from the Małopolska and Silesian provinces, it can be suggested that the whole society can gain from the development of new, reliable, attractive, user-friendly and environmentally friendly waste collection solutions.

As with any innovative solution, reverse vending machines require a number of improvements to be a significant alternative to "traditional" means of selective waste collection. However, the basic condition here is the widespread availability of these devices. A cost-benefit analysis (Cygler, Dubel, 2022) and an analysis of the financial effectiveness of the investment associated with the expansion of the network of reverse vending machines should answer the question of the economic sense of such an investment from a national perspective. However, based on the research conducted, it can be concluded that there is a "green light" for such solutions.

Acknowledgements

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