



Adoption of organic waste sorting behavior at home: who recycles and which barriers exist for non-recyclers? A representative survey

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ABSTRACT

Organic waste sorting impacts greenhouse gas emissions and energy consumption. Because the recycling rate of organic waste is often lower than other types of waste (e.g., paper, glass), behavioral sciences are needed to promote this behavior. Relative to general recycling behavior, which has been more often studied, literature is scarce on the psychological determinants of organic waste sorting behavior. This study aims to fill this gap and examine the perspectives of non-recyclers and recyclers on using a publicly funded kitchen scraps recycling bin called P'tite Poubelle Verte (PPV, French for Small Green Bin). A representative survey was conducted on more than 1,200 respondents. Sociodemographic characteristics associated with the behavior were tested, as was the association between organic waste sorting behavior and knowledge and beliefs. The main barriers to the behavior among non-recyclers are the associated smells, gnats/midges, and liquids. Results also showed that young people/students sometimes did not own the PPV but were willing to use it if received for free. Among recyclers, a lack of knowledge of what could be put in the PPV was clear; thus, the sorting quality can be improved. This paper concludes with suggestions for promoting the behavior in each group: improve correct sorting among recyclers, distribute the PPV to people willing to use it, and help non-recyclers to improve the convenience of this recycling behavior (e.g., by providing aerated bins, resistant bags, and communicate tips and encourage emptying the bag every few days even if not yet filled).

1. Introduction

Waste management is an important issue related to climate change (O'Neill, 2019). Therefore, as the literature converges in its focus on anthropogenic climate change (Cook et al., 2016) and waste management's environmental impact has been established, it becomes highly relevant to induce appropriate recycling behavior through behavioral sciences. As an example, Williamson et al. (2018) estimated that large-scale adoption of composting from 2020 to 2050 could reduce carbon dioxide-equivalent greenhouse gas emissions by 2.3 to 3.6 gigatons, the equivalent of greenhouse gas emissions by nearly 600 million passenger vehicles driven for one year.¹ Food waste can also be integrated into a circular economy scheme (Rashid & Shahzad, 2021): instead of dumping, bioprocessed food waste is then used to produce compost and used as soil enrichment to replace chemical fertilizers. The authors advocate that moving from a linear economy process to a circular economy con-

tributes to industrial development and job creation, in addition to reducing pollution. Another benefit of food waste composting is the production of heat, making it a source of renewable energy for air heating, floor heating and domestic hot water service, among other possibilities (Fan et al., 2021).

However, the recycling rate of organic waste depends on people's behavior, and this rate is often lower than that of recycling glass or paper. Food is the largest component of landfills in the US: 24% of all waste is food waste (United States Environmental Protection Agency, s. d.). In Geneva, Switzerland, where the study took place, statistics are similar, with one-third of incinerated waste being kitchen waste (GESDEC, 2019). At the country level, recycling rates are high for waste such as glass (94%), paper (82%), and PET (81%) (OFEV, 2019), while organic waste is only sorted at around 52% (OFEV, s. d.). Hence, organic waste emerges as a central issue when it comes to improving recycling.

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¹ Equivalence calculated for 3 gigatons using the Greenhouse Gas Equivalencies Calculator <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>.

1.1. Our contribution

This paper will investigate why individuals tend to recycle organic waste less and provide recommendations on the key issues to focus on. The literature on the determinants of organic waste recycling is scarce compared to other types of recycling, and this is problematic for two reasons. First, because the recycling rate for this type of waste is lower than for other type of materials. And second, because studies suggest that behavioral determinants do not have the same predicting power for all types of recycling (Andersson & von Borgstede, 2010).

In order to build effective behavior change interventions, knowledge regarding the determinants of behavior is necessary and psychological theories can contribute to mapping those determinants (Gifford, 2014; Schmuck & Vlek, 2003). Except for the studies by Pickering et al. (2020) and Allison et al. (2022), there is no recent research on the topic using a large and representative sample. In a different approach from those two studies, we also examined how to improve recycling rate and quality among people already recycling and measured the willingness of non-recyclers to start recycling organic waste if provided with a bin for free. Thus, this study allows, on the one hand, to replicate and extend existing results on reasons for not-recycling among non-recyclers, replication that is important for building cumulative knowledge in the context of the replication crisis (Mischel, 2009). On the other hand, it also provides novel insights on how to improve the quality of sorting among already motivated individuals and quantify the margin of progress among non-recyclers willing to start. The objective is to provide for each target group tailored recommendations, in the same vein as Mosler and Martens' (2008) recommendations based on agent-based computer simulation according to the individual characteristics (e.g., environmentally concerned, non-green population) in order to increase attitudes towards environmental protection. It is also important to note that recycling behavior largely depends on the local scheme (González-Torre et al., 2003). Existing studies were conducted in the UK (Allison et al., 2022), Canada (Pickering et al., 2020), Sweden (Linder et al., 2018), and Vietnam (Loan et al., 2017), with varying schemes and incentives to recycle. This study was conducted in Switzerland, more precisely in the Canton of Geneva. Even within the country, there are variations between regions in terms of waste management (Erhardt, 2019): in some regions, people have to pay a fee on garbage bags, while in the region where the study was conducted, there is no such fee. Thus, collecting local data is important to inform future campaigns happening locally, or in places with similar recycling scheme (no fees on garbage bags and provision of free aerated bins for organic waste).

1.2. Determinants of organic waste recycling

According to the pilot study reported by Linder et al. (2018, supplementary material), lack of information is the main barrier. To a lower extent, the same barrier was cited by participants in the study by Allison et al. (2022). In the study by Linder et al., respondents considered that not everybody was informed about the new sorting stations. In contrast, in the study by Allison et al., lack of knowledge referred to not understanding why organic waste recycling is environmentally beneficial for some respondents or, for others, not knowing how to go about it. Related reasons cited by Linder et al. were the difficulty in differentiating the sorting stations and the belief that waste was not sorted by the garbage truck.

Another barrier cited by respondents in three studies (Allison et al., 2022; Linder et al., 2018; Pickering et al., 2020) was that sorting organic waste is inconvenient. The smell of storing organics was the main reason for not participating in waste diversion in Pickering et al. (2020), while this reason was more secondary in the studies by Linder et al. (2018) and Allison et al. (2022).

The cost of purchasing compostable bin liners is also among the often mentioned reasons for not participating in the waste diversion program in Pickering et al. (2020) and to a minor extent in Allison et al. (2022).

It is important to note that in the study by Allison et al. (2022), the most frequently cited reason was to use another method (e.g., home composting or feeding animals with leftovers), while those respondents were excluded from the analysis by Pickering et al. (2020) because they did not need the waste diversion program.

In a study by Loan et al. (2017), attitude toward the recycling program, moral norm (i.e., the belief that it is morally correct to sort organic waste), and system trust in local authority's effective program implementation positively predicted the behavior. On the other hand, situational factors (lack of time or space, perceived difficulty in sorting waste, and lack of cooperation of family members) negatively predicted the behavior.

Ultimately, various determinants emerged in the literature regarding organic waste recycling behavior. However, because the studies are not numerous and provide various findings, it seems relevant to study organic waste sorting behavior in an exploratory manner to identify or confirm tendencies and patterns related to knowledge, attitudes, and other variables.

2. Method

2.1. Design and procedure

The data was collected in the context of an applied research project commissioned by the canton of Geneva on the use of the publicly funded organic waste recycling bin called P'tite Poubelle Verte (PPV) (French for Small Green Bin).² Participants were invited by postal mail to participate in the survey, either using the enclosed paper questionnaire or via a web-based questionnaire. Using parallel web and paper options was chosen to increase the response rate and representativity. In addition, as the survey invitation came from the public authorities, it would not have been acceptable to exclude potential respondents unable to complete an online survey. One invitation and two reminders were sent between the 1st and 28th of July 2020. A prize draw was mentioned in the communication where participants could win one out of 15 gift boxes of local products (valued at 55 Swiss Francs) to boost participation further. Finally, due to the international nature of the population living in Geneva, the online survey was made available in English to include non-French-speaking residents.

The survey began with a categorization of the respondents based on their possession and usage of the bin. Then, depending on these categories, participants were asked questions about their sorting habits and reasons for not using the bin. Finally, participants answered basic sociodemographic questions. At the very end of the questionnaire, the participants could decide whether they wanted to enter the prize draw.

2.2. Respondents

The gross sample for the survey consisted of a simple random sample of 3'000 residents from the canton of Geneva, Switzerland, coming from a commercial sample provider, AZ Direct. From the original sample, 89 cases were deleted for reasons rendering participation impossible (e.g., deceased, unknown address, no longer residing in Geneva).

From the 1,365 responses received, five blank questionnaires and seven duplicates were deleted. Regarding duplicates, the most complete response was kept. When the level of completion was equal, the first response was kept. Out of the total of 2,911 valid contacts, 1,353 valid unique responses were recorded, amounting to a 46.5% response rate. Fifty-nine responses for which important information was missing (e.g.,

² Formally introduced in 2016 by distributing almost 180'000 PPV to Geneva residents.

answered they did not know what was the P'tite Poubelle Verte, thus could not answer further questions about it, or the respondent did not indicate if they owned the P'tite Poubelle Verte) or not were excluded. Participants who indicated composting via other means than the dedicated bin ($n=70$) were not included in the present paper. The remaining 1,224 constituted our final sample. More information on representativeness is provided in the appendix (see Appendix A).

2.3. Measures

The questionnaire contained six sections. The first section assessed the usage and possession of the bin with the question: Do you have the PPV? Participants could choose between five responses: No, I don't; Yes, but I don't use it; Yes, I use it; Yes, but I don't know what it is for; I don't know what it is.

In section two, respondents who did not have the bin were asked under which conditions they would be willing to get one: Would you be ready to take the following steps to obtain the PPV and a set of compostable bags free of charge? To answer this question, they had to rate two items on a five-point scale ranging from Not ready at all to Absolutely ready. The two items were Pick it up in a public place (e.g., at the post office or municipality) and Order it online and have it delivered (free of charge). Additionally, they were asked if they would use the bin if they had one: If you had the PPV, would you use it? Replying with Yes; Maybe (please specify why); No (please specify why).

In section three, participants who had the bin but did not use it were first asked about their use of another means of composting: Do you have your own composting system? (e.g., compost pile in the garden, vermicompost). They could reply by Yes or No. In this section, participants who had the bin but did not use it were also asked: You said earlier that you do not use the PPV. Have you tried to use it at all since you received it? They could reply with No, I have never used it (please specify why) or Yes, I tried and stopped. Participants responding that they had stopped using the bin were then asked to indicate why they had stopped with a multiple-choice question. Proposed reasons all began with I stopped because.... The proposed reasons were: It had to be emptied too often; it was filling up too slowly; we were not producing enough waste of this type to make it worth using; I did not know where to throw the bag; I did not know where to put the trash can in my house / not enough room; I often forgot to use the PPV; the smells were bothering me; the gnats/midges were bothering me; the liquids were bothering me; I stopped for another reason (Please specify). Respondents were then asked if they would be willing to use the bin again if offered more robust composting bags for free (Yes and No responses).

In section four, participants who used the bin were asked about the proportion of organic waste they recycled in two different settings: at home and outside of home (e.g., meals eaten at work). Both questions could be replied to on a ten-point scale ranging from None 0% to All 100%. Then, the frequency of being unsure about the correct use of the bin was assessed. Participants rated the frequency with which the four following statements applied to them on a five-point scale ranging from Never to Very often. All statements began with How often do you.... The statements were: ...put organic waste in the trash because you are unsure if it can be put in the PPV?; ...put organic waste in the trash because your PPV is already full?; ...put organic waste in the PPV without being sure that it is correct?; ...not know in which container to put your organic waste bag because the indication was not clear? In the same matrix, a final item measured the frequency of the container being too full. The statement was: ...do you find that you cannot put your bags in the organic waste bin because it was too full?

In section five, all participants, except respondents who did not know what the bin was for, answered a quiz about what can and cannot be recycled. The items were: Meat and fish bones; Meat leftovers; Animal litter; Tea leaves and ground coffee; Diapers; Apartment flowers and plants; Cork; Compostable tableware (e.g., cornstarch or potato plates, cutlery, and cups); Eggshells; Egg cartons; Vacuum cleaner bags and

sweepings; Objects with the label biodegradable; Cigarette butts; Expired / spoiled products; Small wooden trays. At the end of the online version of the survey, participants received feedback on how well they did in the quiz and which were the right and wrong answers.

Section six was addressed to all participants. It contained three items measuring the attitude towards recycling organic waste: I think I have an individual responsibility to recycle my organic waste; In my opinion, it is morally unacceptable not to recycle one's organic waste; I consider it a great effort to recycle. Participants rated them on a five-point scale ranging from Strongly disagree to Strongly agree. Then, they were asked whether they knew about their nearest organic waste collection point (Yes and No responses). Finally, the following sociodemographic characteristics were measured: gender, age, number of people living in the household, mother tongue, zip code, education level, occupational status, and type of housing (house, apartment with or without a garden, a balcony). (see Appendix B for the full survey material).

2.4. Statistical analysis

Associations between organic waste sorting behavior and sociodemographic characteristics were tested using chi-square as both variables are categorical. A nonparametric correlation (spearman correlation) was selected to analyze the association between organic waste sorting behavior and the antecedents of behavior measured in the survey. Analysis group by group is descriptive and presents the frequency of response in each group using percentages.

3. Results

3.1. Organic Waste Sorting Behaviour Depending on the Sociodemographic Characteristics of Respondents

Gender was significantly associated with organic waste sorting behavior, $\chi^2(2, N=978) = 21.17, p < .001$. Female respondents were more frequently using the PPV than male respondents (see Table 1). The type of home (living in a house or apartment with a garden / having a terrace or a balcony, or no outdoor access) was not significantly associated with the use of the PPV, $\chi^2(4, N=978) = 4.92, p = .295$ (results presented in Table 1). It has to be noted that respondents who do backyard composting were excluded from the sample.

Age categories were also significantly associated with sorting behavior, $\chi^2(12, N=963) = 22.70, p = .030$. Among the respondents who mentioned having the PPV and using it, the percentage of older respondents is larger than the percentage of younger. The youngest (20-29) are the most frequent age group in the category reporting not having the PPV but considering using it if they had it, and middle-aged respondents (age groups: 30-39; 40-49; 50-59) were more numerous than others in the group not being interested in using the PPV (see Fig. 1).

Professional status was significantly associated with using the PPV, $\chi^2(8, N=978) = 24.15, p = .002$. Students are over-represented among those who do not have the PPV but are interested in using it. Homemakers and retired individuals are the most represented among the group that does use the PPV. Results are presented in Fig. 2.

3.2. Association between organic waste sorting behavior and knowledge and beliefs

Spearman correlation shows that the quiz score was significantly and positively associated with sorting behavior, $\rho = .104, p < .001$. Believing in having an individual responsibility to recycle one's organic waste was significantly and positively associated with sorting behavior, $\rho = .384, p < .001$, and this was the case also for considering it morally unacceptable not to recycle one's organic waste, $\rho = .350, p < .001$. Conversely, thinking that sorting organic waste is a great effort was significantly and negatively associated with sorting behavior, $\rho = -.390, p < .001$.

Table 1
Organic waste sorting behavior according to gender and type of home.

		Organic waste sorting behavior		
		Does not have the PPV and is unwilling to use it (%)	Does not have the PPV but is willing to use it (%)	Uses the PPV (%)
Gender	Female	18	14	68
	Male	22	21	57
Type of home	House or garden	20	19	61
	Terrace or balcony	19	16	65
	No outside access	24	21	56

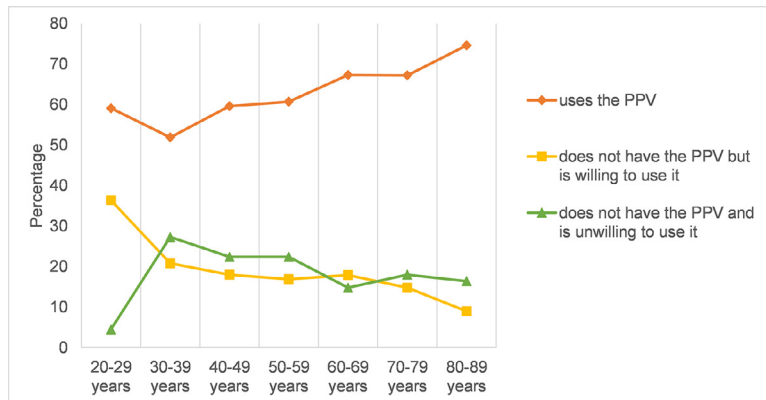


Fig. 1. Line graph representing organic waste sorting behavior according to age.

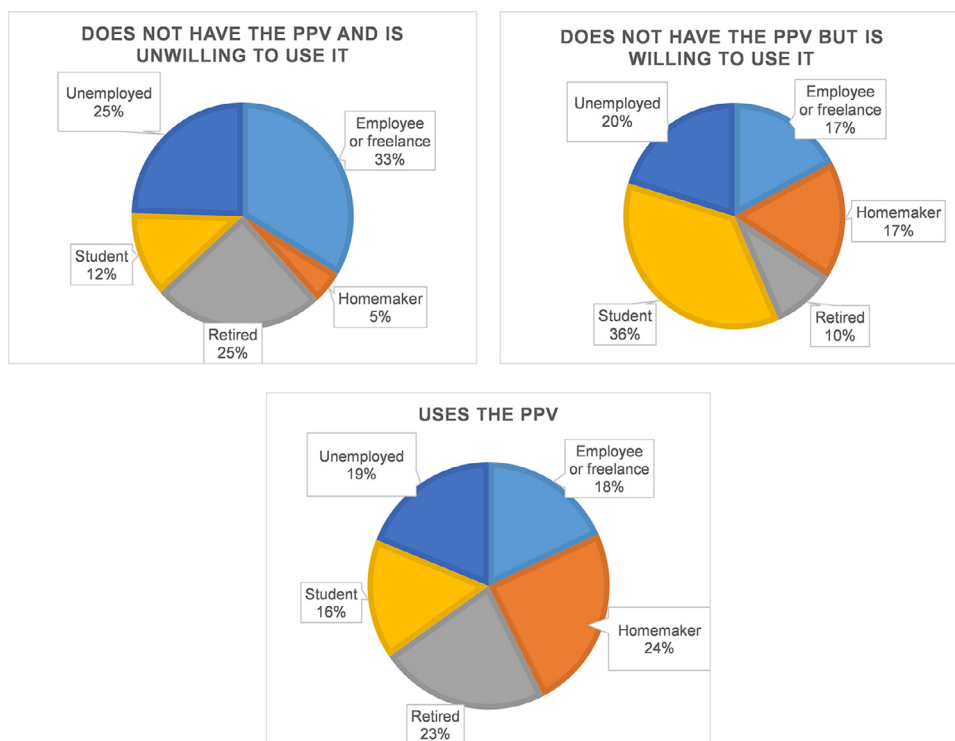


Fig. 2. Pie chart representing organic waste sorting behavior according to professional status.

Respondents who did not know where the nearest organic waste collection point to their home was were significantly less likely to sort their organic waste, $\rho = -.388, p < .001$.

3.3. Group-by-group results

3.3.1. Respondents who do not have the PPV

Respondents who mentioned at the beginning of the survey that they did not own the PPV were asked if they would be willing to do two things to obtain the PPV and compostable bags free-of-charge: pick them up

in a public place (e.g., at the post office or municipality), and order them online and have them delivered free of charge. The latter option received a higher score of agreement (43% of respondents saying they were absolutely ready to do it) compared to the former option (pick it up) (29% of respondent being absolutely ready to do it). However, in both cases, most respondents were willing to do the steps needed to obtain the PPV, suggesting the potential to convert new users to the PPV easily. Corroborating this finding are the answers to the question “if you had the PPV, would you use it?” to which 54% of respondents said yes, 25% maybe, and 21% answered no.

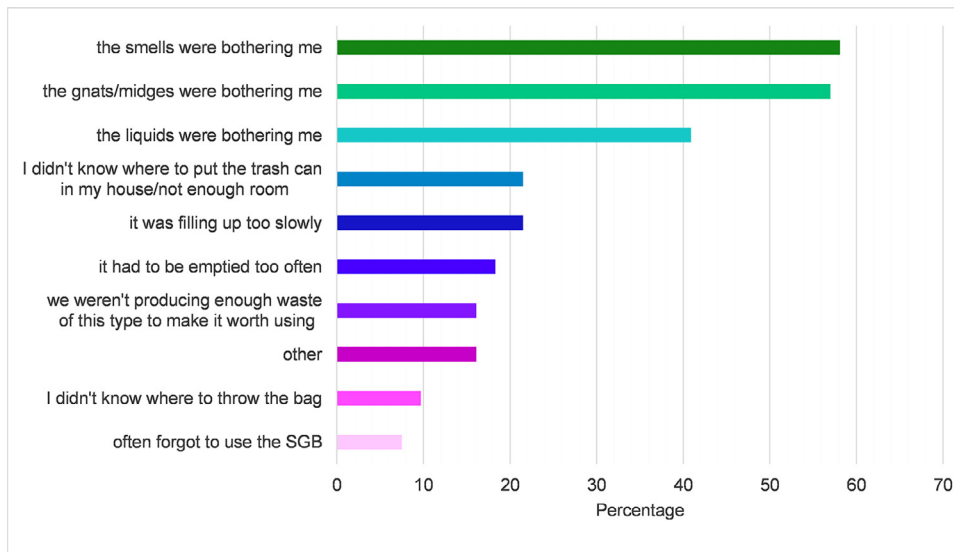


Fig. 3. Reasons for having stopped using the PPV.

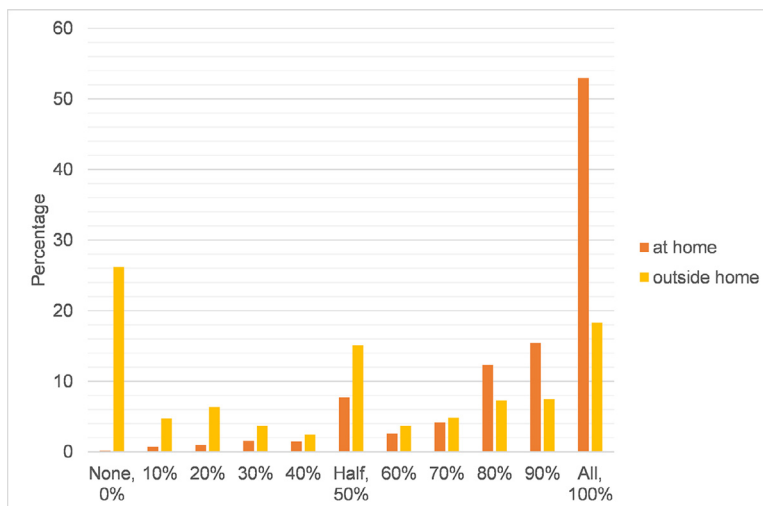


Fig. 4. Percentage of organic waste recycled at home and outside the home.

3.3.2. Respondents who have the PPV but do not use it

Respondents who mentioned having the PPV but not using it were asked if they had tried to use it and then stopped or never tried. Those who mentioned having tried in the past but stopped were asked to select a list of reasons (multiple choices were possible). Those reasons are presented in Fig. 3 in order of frequency. The most frequent reasons mentioned by participants are the inconveniences such as smells, gnats/midges, and liquids.

The same participants were then asked if they would be willing to recycle their organic waste again if they received a set of more robust bags for free: 63% of them answered yes, and 37% no.

3.3.3. Respondents who have the PPV and use it

Participants who mentioned using the PPV were asked the proportion of their organic waste they recycle at home and outdoors (e.g., meals eaten at work). Results are presented in Fig. 4. While a majority answered that they sorted all of their organic waste at home (52%), this is much less the case outside the home, where the percentage of people saying they sorted all of their waste is only 19%.

Five further questions were asked to respondents using the PPV to assess obstacles they might encounter. As displayed in Fig. 5, most participants are rarely confronted with these obstacles. Nevertheless, the

most common obstacle is not being sure if something can be put in the bin.

4. Discussion

This study examined the use of the PPV recycling bin for recycling organic waste among a representative sample of residents of the canton of Geneva in Switzerland. First of all, it is important to note the non-negligible proportion of the population who is willing to use it if they would have it. The second group of respondents was those not interested in using the PPV, whether they had it or not. These respondents mentioned reasons for this lack of willingness, the most notable being the inconveniences specific to organic waste sorting (smells, gnats/midges, liquids). Those reasons relate to the dimension of convenience replicating past research (Allison et al., 2022; Linder et al., 2018; Pickering et al., 2020). The last group of respondents indicated already owning the PPV and using it. For this group - the majority of our sample - the objective is to improve sorting quality. The survey results highlighted that those respondents were sometimes unsure of what could be put in the PPV and that when in doubt, they put the waste in the trash.

The study's results offer practical implications. As mentioned above, some respondents would be willing to use the PPV if they owned it.

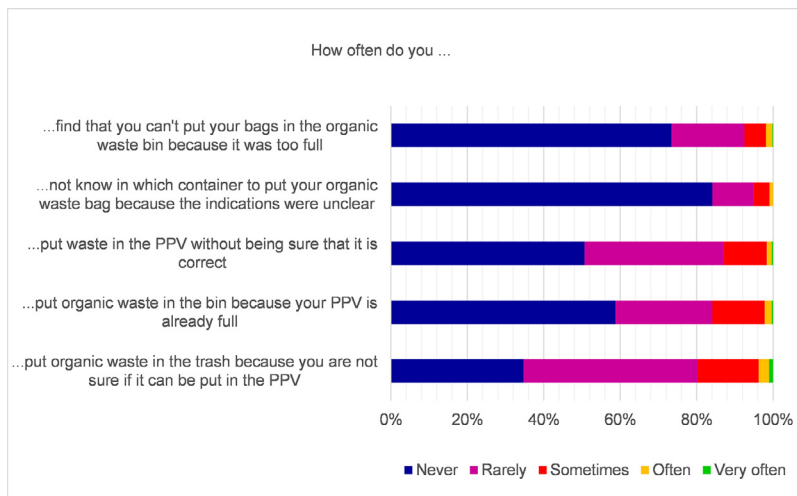


Fig. 5. Obstacles related to the use of the PPV.

For this first group of respondents, delivery, if free of charge, the PPV would be a simple way to nudge them toward recycling their organic waste. A policy strategy could be to systematize the distribution to new residents of a welcome pack containing the PPV, bags, and information on the local recycling programs (Knickmeyer, 2020). In addition, a targeted distribution campaign could also take place where the population is accessible. In our study, the respondents willing to use the PPV if they had it were, in the majority, the young ones and students. Thus, distributing the PPV in places such as universities and higher education institutions could reach them. For the group of respondents who already own and use the PPV, one policy suggestion is to improve awareness of which type of waste goes in the organic waste. Another possibility for improvement in this group would be to promote organic waste sorting at the workplace, as data suggest that only a minority sort their waste outside the home (results also confirmed by McDonald, 2011). Authors have shown that behavior's determinants at home and the workplace can vary (Blok et al., 2015; Whitmarsh et al., 2018); thus, further analysis of the behavior is needed if the objective is to generalize the sorting behavior to the workplace. Finally, the last respondent group is the most challenging, those who do not want to sort organic waste. For this group, a campaign promoting organic waste recycling must target the main barriers expressed by respondents. A widespread one is the fear of smells, gnats/midges, and liquids. For this specific barrier, there are two possible ways to proceed: first, providing materials that reduce inconveniences (aerated bins, resistant bags) (Puyuelo et al., 2013). In the survey, two-third of respondents currently not using the PPV said they were willing to try recycling again if provided with more robust bags for free, suggesting there is a margin of progress. Second, targeting the same barrier, communicating tips and ways to manage waste in order to avoid inconveniences, such as emptying the bag every few days even if it is not yet full, is a promising option to help simplify organic waste recycling (for example, see the video by Recycle Now, 2017). In addition, other reasons cited by this group for not recycling need to be addressed, for example the perception that one's does not produce enough waste of this type to make it worth using. Making it clear that the accumulation of small quantities still constitutes a large impact can be done using the aggregation effect (Camilleri & Larrick, 2019) to counteract the drop in the bucket perception.

A limitation of this study is that respondents to a survey on the theme of organic waste might be biased toward individuals already sorting their organic waste. The most reluctant individuals might thus not have answered the survey. In addition to using a probability-based sample, we used a prize draw to motivate participation among those least interested in the theme, included a paper questionnaire, and sent two reminders.

We can see that the share of people owning the PPV and using it decreased at the first and second reminder, suggesting the importance of reminders to include non-users of the PPV in the survey. Notwithstanding, biases can subsist, and it is possible that the proportion of users in the general population is lower than the two-thirds found in the survey. Even though the survey was provided in English, it is possible that less socially integrated individuals, part of them not proficient in any of the two languages, are, as in most studies, probably underrepresented. These same groups could also be those less likely to use the PPV. Another limitation is that, despite having more than 1,000 respondents in total, the sample size became much smaller when analyzing subgroups (e.g., the unemployed respondents (N=30)). Future studies with an even bigger sample size are needed to investigate differences in predictors among subgroups.

Future studies might tackle other aspects of organic waste sorting, such as the issue of people correctly sorting their food and kitchen waste but throwing it in a plastic bag in the organic waste container. Furthermore, it could be helpful for policymakers and communicators if future studies validate procedures to change barriers identified in this study, for example, how to change people's perception of the inconvenience. Behavior change techniques (such as the ones listed by Kok et al., 2016; Michie et al., 2013) could be used. Notably, behavioral experiments (4.4 in the BCT Taxonomy, Michie et al., 2013) and enactive mastery experiences (Table 7 in Kok et al., 2016) could be employed by encouraging people to start with waste such as coffee grounds and orange peel, to counter their perception that sorting organic waste smells. Then, gradually they would be encouraged to sort other types of waste (such as meat and fish leftovers), and, if accompanied by the correct advice (store in a cool place, empty the bag frequently), this might help people realize they can sort organic waste without having to endure the feared inconvenience. Those techniques and others are promising but, to the best of our knowledge, have not been tested yet with the specific aim of changing perceptions related to inconveniences of organic waste sorting. For that reason, small-scale controlled experiments are needed to validate that those techniques work to change individuals' perceptions before scaling up.

To conclude, we advocate relying on empirical evidence to build effective behavior change interventions (also argued by Allison et al., 2022). Data from this study was used to inform a local communication campaign to promote the use of the PPV. We observed a significant share of respondents using the PPV, the quality of sorting by whom could be improved through knowledge, non-users willing to start sorting if provided with a bin for free, and non-recyclers resistant for convenience reasons. Therefore, each group needs to be targeted with messages and

actions tailored to their specific barriers to increase organic waste recycling.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.envc.2022.100541.

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