Domestic waste management: a survey for the design of an innovative compactor

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Abstract:

Integrated waste management requires considerable resources in terms of both materials and energy, thereby constituting a significant item of expenditure for local administrations. Thus, the correct management and disposal of home waste imperatively pursue innovative strategic objectives to reduce the environmental impact. European policies aim at reducing the overall impact of domestic waste on environment and public health by promoting an efficient use of the resources and reducing the quantities of the unsorted waste produced. Encouraging the reuse of recyclable fractions as resources, increasing the levels of separated waste fractions, and implementing a safer waste disposal system are crucial goals nowadays. Moreover, the active involvement of citizens through information, accountability and rewarding approaches has generally shown to increase the amounts and the quality of recyclable fractions. The aim of this study is to develop an innovative system to help users optimize domestic waste management. A survey has been designed and submitted to citizens of a Town in the South Italy in order to investigate their habits and behaviours in managing home waste as well as the difficulties and wished supports to appropriately separate waste fractions. Non-parametric analyses have been carried out on the 385 answers received, and the outcomes of the survey analysis are presented in this paper. They have been adopted in the design of an innovative home waste compactor device. The compaction of paper, plastic, and metal fractions and sealing of organic waste are suited by the interviewed to improve the management of separated waste fractions. The steady municipal implementation of such a system will allow the reduction of both the logistic and economic expenditures required for waste collection and the disposable quantities of unsorted waste.

Keywords: Integrated waste management; domestic waste compactor; non-parametric analysis

1. Introduction

Nowadays urban and household wastes management is characterized by several criticalities involving environment, energy, and health. The amount of global wastes is expected to triple by 2100 (*World Bank, 2013*) due to urbanization, industrialization, and enhance of world population. Around 70-80 % of the costs associated to waste management are due to collection and transport *(UN-HABITAT, 2010*). The vehicles adopted in waste collection system contribute to greenhouse gas emissions, summing up with ones generated by both incineration and landfilling *(Hoornweg and Bhada-Tata, 2012)*. Globally, 1.3 billion tonnes of food per year are wasted *(Gustavsson, J. Cederberg, C. & Sonesson, 2011)*, thereby dangerously affecting global environment, due to food production, storage and transportation processes *(Mourad, 2016)*. Because of these multiple issues related to waste management and the growing concerns derived from climate change, the problems of food wastes have been strongly tackled by the European Union *(European Commission, 2011)*.

EU legislation strictly regulates waste production and management and introduces new key targets to be achieved. The directive 2008/98/CE defines the fundamental principles and obligations, including the "polluter-pays" principle, to appropriately manage wastes in order to avoid negative impacts on both environment and human health. The concept "polluter-pays" establishes that waste disposal costs should be addressed to the holder or producer of the waste. The targets fixed by the EU regard the reduction of food waste (30% by 2025 and 50% by 2030) and the quantity of material to be recycled and prepared for reuse (55% in 2025, 60% in 2030, 65% in 2035). In scientific literature, studies are available on the internalization of external costs of transport *(Digiesi et al., 2016a, 2016b)* and on strategies for the improvements of energy efficiency in urban areas (*Carli et al., 2015*).

The Waste Framework Directive (2008/98/CE) also introduces the theoretical model of Circular Economy, which is based on five pillars: prevention of waste production, reuse, recycling, energy recovery and disposal of waste. According to Nainggolan *et al. (Nainggolan et al., 2019)*, in order to create a circular structure, citizens' motivations, efforts and problems regarding sustainability and separate waste collection should be of major interest. An efficient management and decrease of the wastes produced can generate multiple advantages: greenhouse gas emission prevention, pollutant reduction, energy saving, resource conservation, job creation, and development of green technologies *(Cucchiella, D'Adamo and Gastaldi, 2014) (Ranieri et al., 2018)*

Despite these undeniable advantages, the level of citizens' participation and motivation to recycle are not always elevated. Gilli *et al. (Gilli, Nicolli and Farinelli, 2018)* show that the probability of recycling increases when people are motivated by the possibility of receiving an external reward for their action. Following this line, other authors *(Schanes, Dobernig and Gözet, 2018)* underline that households feel mainly guilty about wasting food when it is related to economic loss rather than environmental and social consequences. Results of Mwanza *et al. (Mwanza, Mbohwa and Telukdarie, 2018)* indicate that households are influenced in the recovery of waste by multiple levers, such as demographic factors, awareness and knowledge on recycling, waste collection systems (Fig. 1).

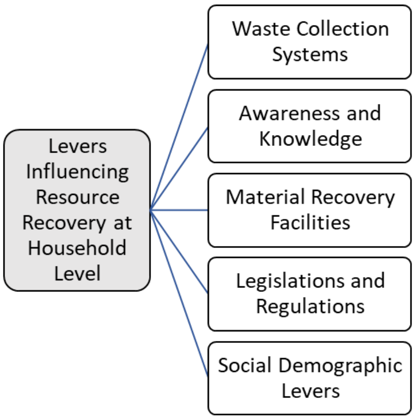

Figure 1: Key factors affecting home waste management
Modified from Mwanza *et al.*, 2018.

Citizens should be more aware of the consequences of a badly waste management in order to increase their willingness to participate *(Digiesi et al., 2015b)*. Certainly, people can be educated to be more sensitive to the environmental issues related to waste management, but, as some authors have stated, (*Gilli, Nicolli and Farinelli, 2018; Schanes, Dobernig and Gözet, 2018*) the perspective of an economic reward for a better waste recycling could have an important impact.

In 2017, the amount of municipal waste collected in Italy was 488.7 kg per inhabitant *(ISTAT, 2019*) with 55.5% resulting from separate waste collection. The levels of separate waste collection are different across the Italian peninsula: a very high percentage is registered in Trento (74.6%), Veneto (73.6%) and Lombardy (69.6%), whereas lower values characterize the southern regions of Italy. ISTAT statistics reveal that in 2018 87.1% of households separate plastic refuses, 71.3% aluminium, 86.6% paper and 85.9% glass. These percentages are promising, although the quality of the collection performed is a crucial issue because, as stated by Thøgersen, the willingness to recycling is moved by a positive attitude on the topic, but this is not enough to reach a high quality of source separation. An appropriate design of the system can increase the motivation and participation of citizens *(Thøgersen, 1994)*. Thus, citizens can be further motivated to produce purer separate home wastes not only with the support of focused educational programmes *(Romano, Rapposelli and Marrucci, 2019; Knickmeyer, 2020)*, but also with the introduction of a high-technological domestic waste compactor to support the users in home waste management.

A great goal of development and a possible method to increase waste recycling can be the use of an intelligent home waste compactor. This solution can bring citizens an important economic reward by increasing both the quality and quantity of separate home waste fractions. The amount of mixed household waste would decrease and might allow a final reduction of the municipal waste taxes according to the "Polluter Pays" principle. Reduction of taxes will originate in the increase of incoming obtained from the second raw material sale and in the reduction of collection and transport costs by municipalities. The adoption of logistics models developed for industrial fields could further improve environmental gains (*Digiesi, Mossa and Mummolo, 2013; Digiesi, Mossa and Rubino, 2015a*). In this perspective, such a device can be a valuable tool to both reach the targets established by the EU and get citizens further involved in a greener waste management.

The purpose of the current study is to empirically investigate on the main difficulties that citizens from a city in the south of Italy have in relation to the management of the separate waste fractions produced at home. This will also give some insights into the suitable support they would require, in order to appropriately separate waste fractions. In the end, the outcomes of the survey analysis will also help design an innovative domestic waste compactor device, as part of a research project funded by European Regional Development Fund and European Social Fund of Apulia Region (POR Puglia FESR FSE 2014-2020 - Sub-Azione 1.4.B "Bando INNOLABS").

2. Current technologies applied to waste compactors

Different types of home waste compactors are available on the market and differ each other for technical characteristics, technology, dimensions and functions. As regards the mechanisms and technologies used in the domestic waste compactors currently available on the market, compacting and shredding / crushing systems are prevalently used (Appendix A).

Devices such as *CleanCUBE*, *KRÜSHR 12* and *Broan Trash Compactor* compact mixed wastes inside an internal basket by crushing it through a press moving vertically through an X-frame mechanism. Alternatively, the devices *Whirpool Trash Compactor*, *Maytag* and *Kitchenaid* use a screw-nut mechanism to compact mixed refuses a basket; in addition, a ball screw mechanism, which transforms a rotary motion into a translational motion, can improve, if adopted, the accuracy and efficiency of the "screw-nut" mechanism up to 90% approximatively. Also, using a ball screws mechanism allows higher efficiency and durability, higher wear resistance, further axial rigidity, and additional friction reduction between adjacent components.

The newest compaction solutions are designed to fit within home living spaces for their small size. Such devices facilitate waste disposal operations and optimize waste delivery time. These domestic compactors provide automatic integrated controls and security systems through the use of specific software programmes with a functional and user-friendly design. These devices can check compaction processes, volume reductions, battery capacity and possible failures in real time through a wireless connection. The information collected by the compactor can be then consulted on smartphones or other devices through appropriate informatic applications.

3. Research design

During a time-frame of four months (June-September 2019), an online questionnaire was published on the project website www.e-codom.com. It consisted of 3 different sections dealing with personal data, personal problems in sorting waste fractions, and the support suited for an accurate separation of the refuses.

The questions were designed on the basis of three elements: the current weekly planning of the door-to-door waste fractions collection in Altamura (Table 1), the state-of-the-art analysis on available home waste compactors, and a preliminary description of the needs and critical issues that both citizens and public administration had regarding the management of their waste fractions (data not shown).

Table 1: Weekly planning of waste collection in Altamura

Waste fractions	Town centre	Town districts	Out-of-town areas
Organic	Mon.-Wed.-Fri.	Mon.-Wed.-Fri.	Mon.-Wed.-Fri.
Mixed	Tues.-Sat.	Tues.-Sat.	Tues.-Thurs.- Sat.
Plastic/ metal	Thurs.	Thurs.	Thurs.
Glass	Mon.	Mon.	Mon.
Paper/ cardboard	Fri.	Fri.	Fri.

Of all the 47 questions of the survey, only 29 were investigated for the purpose of the current study (**Appendix B**). 385 usable questionnaires were sent back by anonymous Altamura citizens, as expected to be the most knowledgeable people in providing the desired information on aspects such as critical issues and desired support in home waste management.

4. Statistical analysis

Following the scrutiny of the answers received, answer frequencies have been represented for each question on appropriate tables or histograms (Results are shown in **Appendix B**). Then, contingency tables have been prepared, and chi-square and Fisher's test of independence have been used to investigate the possible dependency between two nominal variables (all questions except q.21), each resulting from a single question with two or more possible values. In the case that the chi-square test for contingency tables larger than 2x2 is significant, post-hoc tests have been carried out either by using pairwise comparisons or by testing each value of one nominal variable *versus* the sum of all the others; a Bonferroni-adjusted P value was then applied to assess the significance of the test. In order to compare different unmatched groups of numerical variables (q.21), given that they have not got a normal distribution according to the Shapiro-Wilk normality test ($p<.0001$), non-parametric tests have thus been used: the Mann-Whitney test to compare two unpaired groups, and the Kruskal-Wallis test three or more groups. The results obtained are summarised in **Appendix C.**

5. Survey results and discussion

The examination of the answers received about personal data reveals that people younger than 40 years (67.4%) have mainly responded to the online survey (q.2), the majority of the overall respondents are workers (56.5%) followed by students (29.0%) (q.3), and the general educational level is mostly around A-level (41.7%), then University degree (28.5%) and then lower-school level (19.7%) (q.4). In order to further characterise the population of the respondents and possibly identify subgroups usable for further analyses, questions 6 to 11 were submitted. Most of the interviewed people belong to households of 4 to 6 members (63.0%) (q.6), and nearly 50% of the respondents have declared to personally manage the separation of waste fractions home (q.5).

The family units involved in the survey mainly have their hearths in town districts (76.4%), while 14.8% live in the out-of-town area and the rest (8.8%) live in the town centre (q.7). In more details, 28.2% of the respondents live in blocks with at least 8 flats and 35.2% in blocks with less than 8 flats, while 24.4% live in single-family houses without garden and the remaining 12.2% in small houses with a garden each (q.8). Consistent with the real estate situation in Altamura, no blocks with more than 8 flats ($p<.01$) and less outdoor balcony (terrace/veranda, $p<.01$) are reported in the town centre compared to other town areas. In general, most of the lodgings where the interviewed live are large 90 to 120 m^2 (42.9%), whereas the dwellings smaller than 90 m^2 or larger than 120 m^2 count 29.1% and 28.1% respectively (q.9).

Finally, as nowadays expected, 90.1% of the respondents to the survey have a Wi-Fi connection home (q.11); nevertheless, the possession of such a wireless connection is still related to the age of the interviewed ($p<.01$) with people older than 40 years having less router devices home than younger people. The utility of a Wi-Fi connection home might be of valuable interest to design a home waste compactor able to acquire the data obtained from home waste collection for a potential cloud network to supervise and improve the overall municipal system.

The second section of the survey was designed to investigate around the possible problems that the citizens from Altamura have in their daily task to separate and collect waste fractions. Most of the respondents think that the small bins provided to separately collect each waste fractions home (30 dm^3) are just a little cumbersome and uncomfortable in relation to their size (q.12), although the encumbrance is considered more impellent in town districts than elsewhere ($p<.001$). In addition, these small bins are considered too capacious for glass waste (35.7%) (q.13), but have insufficient capacity for plastic/metal (32.2%) and paper wastes (22.9%) respectively (q.14). That's the reason why most of the citizens usually try to reduce the volume of these two waste fractions (plastic/metal 39.1%, paper 35.3%, p<.01) (q.15).

If the interviewed people do not know in which specific waste bin a single refuse should be thrown, most of them accurately look for information on apposite smartphone applications or brochures (44.7%) or on specialized (17.7%) or non-specialized (5.2%) websites to get a final decision, whereas the remaining 32.5% usually throw the refuse into the unsorted garbage bin (q.16).

The third section of the survey questions the citizens about the potential support they would require in order to appropriately sort the different waste fractions home. In particular, the large majority of the interviewed declare to find very (40.5%) or quite (44.9%) useful to be supported in properly preparing waste fractions by meticulously separating or cleaning the different materials (q.17).

As regards the waste fractions for which such a support is the most demanded (p<.0001), plastic/metal fraction is the most impellent (59.5%), followed by organic waste (24.7%) (q.18). The interviewed would prefer to use a technological device to get useful information for a profitable quality of waste fractions, such as a smartphone application (50.7%) or a bar code reader (31.9%), rather than a comprehensive paper guide with a list of all possible types of refuse (17.4%) (q.19); people younger than 40 years would prefer using more technological devices for this purpose (p<.05). Thus, conceiving a home waste compactor provided with technological device to support users in home waste separation would be a priority.

Also, a home waste compactor seems to be a highly (43.9%) or almost (34.3%) suitable device to be included amongst the pieces of home furniture (q.20). Those citizens actually improvising the compaction of plastic/metal and paper waste refuses home would demand further help by using a mechanical device (p<.01); however, people older than 40 years perceive such a device less useful (p<.05). In addition, the high utility of a technological device to support the user in managing the preparation of home waste fractions is strongly related to the usefulness of a domestic waste compactor (p<.01). Therefore, the combination of a waste compactor with a technological support to help users appropriately prepare separate waste fractions in a single device would be a major goal for designing an innovative home waste compactor.

Non-parametric tests have been used to compare the degree of priority to compact 4 distinct home waste fractions (paper/cardboard, plastic/metal, organic, glass) home. As a result, both paper and plastic/metal fractions are the most compelling to compact home compared to glass and organic fractions (p<.0001) (q.21, Fig. 2). The number of family members does not affect this result, while the location of the dwellings appears to slightly vary the significance of the comparisons at various extents in relation to the town area, but not the overall results. In addition, the insufficient capacity of both paper (p<.0001) and plastic/metal (p<.05) bins seems to support the priority of these two waste fractions to be compacted home. Whether the respondents would have different degrees of priority in relation to their current habits to compact single waste fractions manually, was investigated; in particular, those already compacting paper and plastic/metal wastes require further reduction of these two fractions compared to both wet and glass wastes (p<.0001). The overall need of a domestic waste compactor home is strongly related also to the exigency of further compressing paper (p<.01) and plastic/metal (p<.001) refuses.

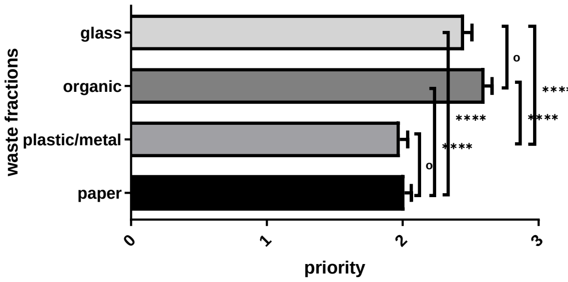

Figure 2: Degree of priority to compact separate waste fractions home.
Legend: 1 = the most impellent fraction, 4 = the least impellent fraction; **o** stands for p>.05, ******** for p<.0001. Means ± standard error means are represented.

Additionally, glass wastes seem to be the less frequently collected fractions in a month time in Altamura (data not shown), and safety and technological concerns about a potential domestic compactor of glass refuses have come out in relation to noises, splinters, forces and stocking. Therefore, on the basis also of the survey results, the compaction of glass wastes would not strictly crucial to be envisaged in the compactor design.

In relation to the usefulness of the decomposable bags used to collect wet wastes, the majority of the interviewed consider them little (43.6%) or even at all (16.4%) practical (q.22). Among the 385 interviewed people, only 302 use specific small bins for wet wastes, and the majority of them usually fill their organic waste bins completely (61.0%), before delivering them outside the house for door-to-door collection. Quite obviously, the more these bags are filled, the less resistant they appear to be (p<.05).

The potential utility of an organic fraction sealer to reduce the possibility of unpleasant smells home was also explored; the large part of the respondents think that such a device is very (57.7%) or (28.1%) quite suitable (q.23), in particular for those filling the compostable bags at their maximum capacity (p<.0001) and those wishing to also dispose a waste compactor home (p<.0001). Therefore, the combination of a wet waste sealer with a waste compactor in a single device would be ideal.

At the end of the survey, three questions were submitted to understand how much and in which way Altamura citizens feel comfortable about home waste collection. In particular, a good number of the interviewed people, based on their knowledge, thinks that it is very (56.4%) or rather (34.5%) useful to personally separate high-quality waste fractions (q.24). Indeed, a very large part of the respondents finds that a rewarding system proportionate to the quality of the waste fractions delivered is very (56.1%) or quite (32.2%) favourable (q.25), in particular for those aged more than 40 years (p<.001).

Finally, more than three quarters of the population interviewed think that it would be very (36.6%) or enough (41.0%) useful to increase the number of fractions to be separated home (q.26) in order to improve the quality of the waste collected upon receiving a consequent reward. Those interested in using a home waste compactor seem to be further captivated by the idea of adding other fractions to separate home (p<.001), whereas those living in town districts appear to be less interested (p<.05).

For instance, since polyethylene (PET) is daily used to contain beverages and foods and is one of the first plastic materials to be separated in industrial processes, sorting PET at home might be of sustainable utility. As regards the symbol used to identify recyclable plastic objects in PET (Fig. 3), 72.5% of the interviewed know it (q.27), especially people younger than 40 years (p<.0001), but the largest part of the respondents (58.0%) admit not to pay enough attention to that symbol on plastic items before throwing them as waste products into the appropriate bin q.28).

Figure 3: Commercial PET symbol.

6. Prototype design of a novel waste compactor

On the basis of the results obtained from the online survey, key technological features will be implemented on the design of a smart home waste compactor. Firstly, most of the citizens interviewed already try to reduce the volume of plastic/metal and paper refuses (q. 15) and consider these two waste fractions as the most compelling ones to be compacted at home compared to glass and organic fractions (q. 21). Accordingly, the device prototype will be designed in order to support users to more correctly manage following home waste fractions: PET, other plastic/metal, paper/cardboard and organic. Glass fraction won't be treated in this compactor according to both the results of the survey and the safety issues related to the production of cracked glasses in a domestic environment (q. 21).

As a result of the survey carried out, a home waste compactor seems to be a suitable device to be included in home furniture (q. 20) in order to help people compact dry fractions (q. 15), reduce the possibility of unpleasant odours by sealing wet fractions (q. 23) and support people through a technological device included within the home waste compactor and providing useful information for a correct sorting of wastes (q. 17 and 19). The user support will be implemented for: (i) reducing volume of dry fractions, (ii) sealing wet fractions, and (iii) helping users in reducing errors and be further involved in the identification of waste fractions through an embedded device including a touchscreen and a camera connected to a web platform in order to improve the quality of the fractions collected. The adoption of a visual detection system will allow a more correct identification of dry refuses, and also a specific separation of PET from other plastics.

The dimensions of the compactor are defined for easy integration in modern modular kitchens, since a home waste compactor would be suitable by potential users within home furniture (q. 20). For safety reasons, all mechanisms to reduce volume of dry fractions will be powered through a hydraulic transmission, so that electric powered devices will be separated from the main component of the compactor. A conceptual drawing of the compactor is shown in Figure 4. On the basis of the survey respondents' claim that the dimensions of the small bins provided for home waste separation are not generally suitable to collect appropriately each waste fraction (q. 12), as not enough capacious for plastic/metal and paper wastes (q. 14.), the compactor is designed as having a plant dimension of around 600 x 600 mm^2 and a height of around 1100 mm, which are standard dimensions of a kitchen-oven column.

Except for the steel-covered front part, all vertical sides of the compactor will be coated with a bioplastic (flax fibre mixed with a biocompatible resin) which has already been patented by a company from the project team. In the top surface of the device will be the inlet of three dry fractions (plastic, metal, paper). In the middle inner part of the device, the volume reduction of these three fractions will be obtained by means of crush rollers (i). In the lower part of the device, fractions will be stored into two steel waterproof removable drawers. This will allow the temporary collection of residual liquids inside the drawers without requiring the connection of the whole device to a drain network.

Fig. 4 – Conceptual draw of the smart waste compactor

As shown in Figure 4, the left drawer will be used for the storage of both PET and other plastic/metal refuses, according to the collection rules established by the municipalities. In both cases, the drawer will be internally organized to separately store the two fractions. A part of the top surface of the device will rotate in order to let the user access to the area for wet fraction sealing and dry waste identifications. Indeed, most of the respondents appear to be interested in having a wet waste sealer within a home waste compactor to reduce unpleasant smells (q. 23); thus, for the sealing of wet waste, a continuous double-layered compostable film and an anchor point to introduce wet waste before film sealing will be available (the sealing device is not represented in Fig. 4). The final sealed bag containing the wet fraction will be discharged through a chute under the anchor point (ii). The wet fraction won’t be stored in the device in order to avoid contamination of dry fractions.

The majority of the interviewed would like to be supported in properly preparing sorted waste fractions (q. 17) and to get useful information for separating waste fractions with a profitable purity through the setting of a technological device within the home waste compactor (q. 19). Therefore, a two-level user support system will also be developed to help users appropriately prepare and separate waste fractions in a single device. For the first-level support, a decisional support system (DSS) will be implemented to help the user correctly manage dry fractions autonomously. In case the user is not able to identify the dry refuse, the user will be guided in positioning the refuse on the shelf in front of the camera; the refuse type will be identified through image acquisition and processing through appropriate visual detection algorithms. Once the dry refuse is identified, a light will lead the user to select the appropriate inlet (iii).

A good number of the interviewed people find useful separating high-purity recyclable waste fractions (q. 24) and would wish the favourable implementation of a rewarding system proportionate to the purity of the waste fractions delivered (q. 25). In order to improve the involvement of the user in correctly managing domestic waste fractions, the data collected upon interaction of the user with first and second-level support systems and the amounts (in kg) of the dry fractions separated will be recorded on the web platform, thanks to the wide availability of a domestic Wi-Fi collection (q. 11). In order to improve the involvement of the user in correctly managing domestic waste fractions, the data collected upon interaction of the user with first and second-level support system s and the amounts (in kg) of the dry fractions separated will be recorded on the web platform. The estimation of the quantities of separate dry fractions will be performed by using load cells under the drawers. Data can then be used in a serious game which will simulate the possible economic advantages derived from a correct management of domestic waste fractions. Data on the web platform will then be accessible to corresponding municipalities to possibly adopt rewarding policies.

7. Conclusions

The analysis of questionnaire's results has shown that citizens are keen in increasing the purity of the waste fractions sorted at home and would welcome the opportunity of using a technical support to reduce the number of errors for performing an efficient domestic waste separation. Respondents have claimed through the survey that they would prefer a technological device for that purpose, which can be included into household furniture and can provide information about the correct modalities to separate home wastes. According to the desires made by the respondents, we have therefore proposed the design of a domestic waste compactor prototype which would be useful to reduce the volumes of some waste fractions, especially paper and plastic/metal refuses as being the most critical to manage, correctly identify waste fractions through an embedded device, and also reduce unpleasant odours by sealing the organic fractions.

The use of domestic and commercial waste compactors finds wide application on the market. The reduction of waste volumes allows the optimisation of bin capacity and a consequently higher efficiency of the waste collection and transportation systems. The use of these devices gives advantages throughout the whole chain of waste management.

Waste compaction would allow the reduction of collection times by the municipal waste service, with subsequent possible benefits on the overall waste management economy. A lower use of vehicles brings to lower emissions of pollutants and a possible reduction of waste taxes upon minor fines to the Municipalities for impure separate fractions. The use of such an innovative compactor might help citizens change their daily habits and behaviours in relation to home waste management and become more sensitive to global environmental issues. Thus, multiples advantages can be obtained from a sustainable waste management, from an economic reward and a correct behaviour of citizens to a reduction of waste expenditure and lower environmental impact.

The e-CODOM project has been developed in this context and the prototype of a domestic eco-compactor will allow the reduction of waste volumes home and a higher quality of separate waste fractions upon specific high-tech support.

Appendices A, B and C can be downloaded from the following link: https://politecnicobari-my.sharepoint.com/:f:/g/personal/andrea_lucchese_poliba_it/Ek06HiLGYypAhHeqNpOiqGwBqjRkKAJgywpaUEcQMfQzvQ?e=5f4OZ3

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